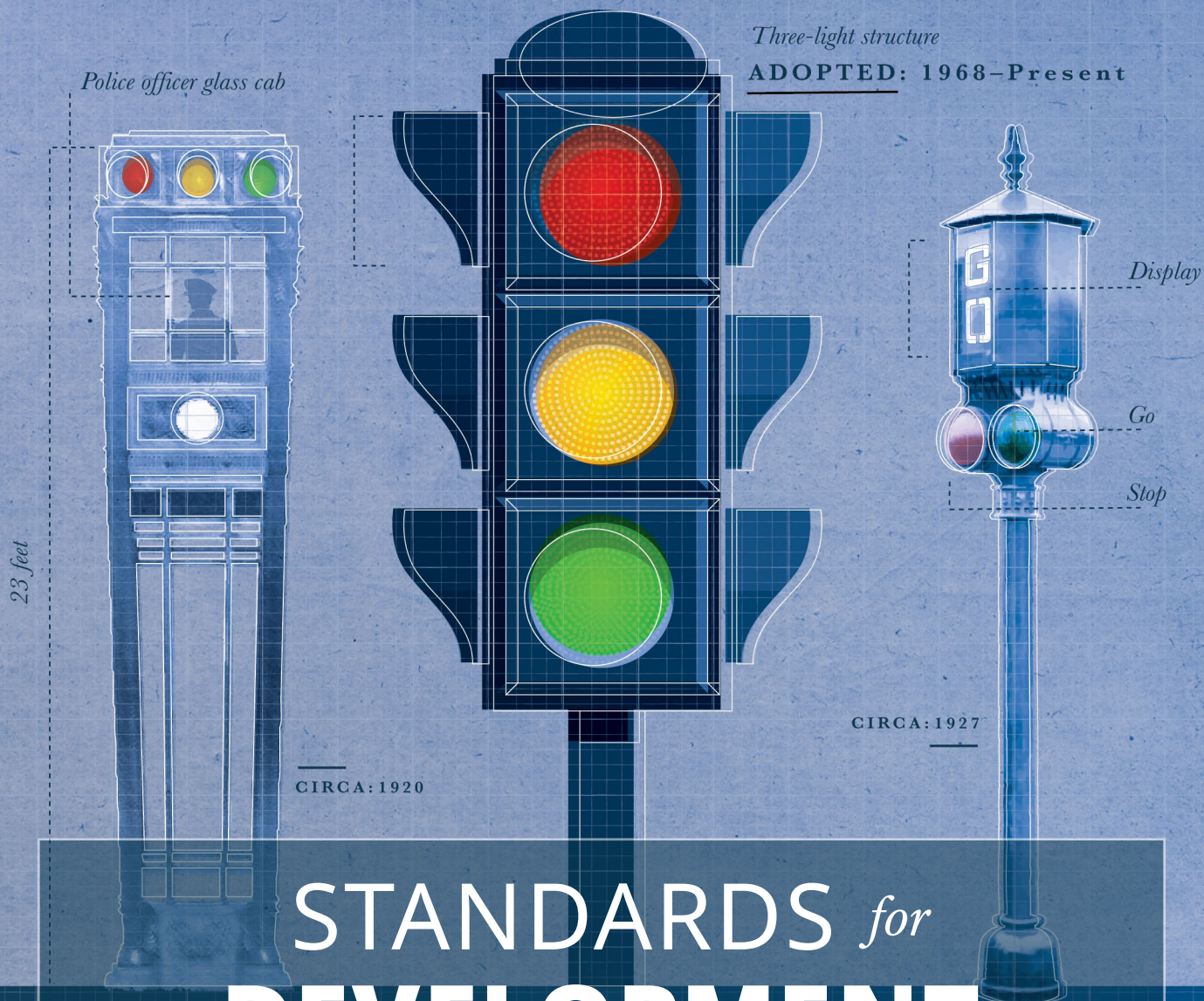




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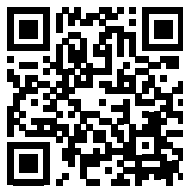
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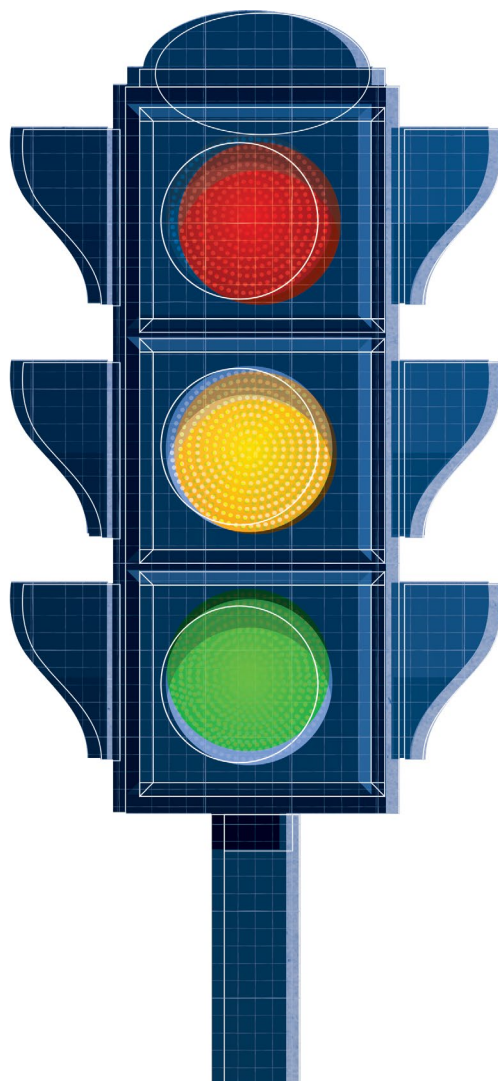


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WORLD DEVELOPMENT REPORT **2025** 

STANDARDS *for* **DEVELOPMENT**



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ISSN, ISBN, e-ISBN, and DOI:

ISSN: 0163-5085

ISBN: 978-1-4648-2275-9

e-ISBN: 978-1-4648-2288-9

DOI: 10.1596/978-1-4648-2275-9

Cover and interior design: Design team, Global Corporate Solutions unit, World Bank.

The Library of Congress Control Number has been requested.

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Foreword

The world runs on silent agreements. You do not notice them when they work: the socket that fits the plug, the kilogram that weighs a kilogram in Nairobi as surely as in Nagpur, the barcode that rings up a carton of milk or registers a container at sea. Standards—the shared rules that underpin consistency, compatibility, and quality—are not mere technicalities. They are part of the invisible infrastructure of modern economies, as vital to prosperity as roads, ports, or power grids. Treat them as a springboard, and they propel development. Make them a straitjacket, and they will stifle it.

The global appetite for standards has surged. Most international standards have been minted since the turn of the century. Nontariff measures, often related to standards, now cover nearly all global trade. This reflects the complexity of supply chains, the digitalization of commerce, and the rising demand for safety in high-income countries. Complying with standards—and shaping them—has become a prerequisite for export growth, technology diffusion, and resilient public services.

Yet the bar for meaningful participation in the development of international standards remains high. Developing countries are often absent from the process. On average, they sit on less than one-third of the technical committees that determine global standards at the International Organization for Standardization (ISO) and even fewer of those committees in organizations that are not intergovernmental bodies. Absence amounts to acquiescing to the priorities of advanced economies. When lower-income countries do not participate, they relinquish vital opportunities to advance their priorities. They forgo crucial options to speed up job creation and economic growth.

This Report offers the first comprehensive analysis of the global landscape of standards today. It outlines how countries can use them to accelerate economic development, providing a practical policy framework for countries at all stages of development. Its lessons could not be more timely. Technological and geopolitical shifts are making standard setting a matter of urgency. Artificial intelligence and other innovations are racing ahead of the rulemaking capacity of countries and international standards development organizations. The result is a dangerous paradox: a cornucopia of standards for relatively inconsequential products like packaged potato chips and huge gaps for transformative, high-stakes technologies like biotechnology and artificial intelligence.

Standards are a policy instrument with a dial. Voluntary standards, led mostly by industry, can spread good practice in flexible ways. Mandatory standards, used in government regulations, can protect health, safety, and the environment. Blending mandatory and voluntary standards—and tiering them by the capacity of countries, businesses, and consumers to comply with them—maximizes efficiency while safeguarding the public interest. Tiered standards can widen participation: Small firms can start from a basic tier and climb, rather than face a cliff that only dominant incumbents can scale.

To turn standards into a springboard, governments in low- and middle-income countries must resist the urge to overregulate and instead focus on building the enablers for raising quality. Doing this includes improving their “quality infrastructure,” which comprises metrology (the existence of reliable and internationally aligned measurements), conformity assessment (testing, inspection, and certification), accreditation (“checking those who check”), and standardization itself. Get this quality infrastructure system working, and businesses and consumers need not worry about quotidian routines. Firms can

focus instead on demonstrating quality at reasonable cost. Consumers can trust what they buy. Regulators can focus on outcomes.

Avoiding the potential straitjacket effect of standards requires matching ambition and capacity. It might be tempting for a country's regulators to copy the most stringent international standards on pollution, for example, to signal their sincerity and seriousness. But standards that are not aligned with a country's capacity to comply are a recipe for uneven enforcement, rampant corruption, and market concentration. Where capacity for compliance with standards is strong, governments should raise their ambition and align standards with global norms. Where it is weak, they should adapt standards to local realities while instituting mechanisms to build capacity, with full alignment of standards as the eventual goal.

Countries—and sectors within countries—should chart a realistic trajectory for standard setting that matches their stage of economic development. This Report proposes a progressive framework: *adapt-align-author*. For countries at an early stage of development, in which compliance capacity is typically low, the smartest course is to *adapt* international standards to suit domestic conditions as needed. At more advanced stages, they should aim to *align* domestic markets with international standards. At all stages, countries should *author* international standards in priority areas in which they have developed the requisite expertise. They should show up in meetings of committees of international standards development organizations, comment on drafts of standards, and convene domestic stakeholders so learning flows both ways.

Higher-income countries and international bodies have their own share of work to do. First, they need to create seats at the standard-setting table for low- and middle-income countries—and give them the support they need to succeed. Second, they should cut the duplication in the notorious “spaghetti bowl” of overlapping voluntary standards. And third, they must cooperate to minimize divergence, especially in instances in which the public interest is shared and the costs of fragmentation are high. In frontier technology, leading economies should press their top firms to set baseline standards and stress-test them with diverse stakeholders before markets harden around proprietary defaults.

This work is vital, because standards are how societies make the unseen obvious and governable. Standards reduce transaction costs, diffuse know-how, and enable scale. In low-trust environments, they substitute for reputation; in high-tech ones, they are the only way complex systems interoperate safely. When crafted well, standards lower entry barriers, expand opportunity, and protect the vulnerable. When crafted badly, they entrench incumbents and stymie progress.

Low- and middle-income countries are in a race against time. Several middle-income countries have set their sights on becoming high-income countries in a generation or less. To win the race, they will need to run a relay. Standards are the baton, passed from laboratory to factory to regulator to border and back again through feedback and learning. When standards are designed and implemented well, the whole team runs faster.

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Acknowledgments

World Development Report 2025 was prepared by a World Bank team led by Xavier Giné. Devesh Kapur (The Johns Hopkins University) served as the Academic Lead. Laurent Porte served as the Report Manager from July 2024 to January 2025, and Joyce Antone Ibrahim served as the Report Manager from January 2025 to publication. Overall guidance was provided by Indermit S. Gill, Senior Vice President and Chief Economist of the World Bank Group, and Somik Lall, Senior Adviser in the Office of the World Bank Group Chief Economist. The Report was sponsored by the Development Economics Vice Presidency.

The core team comprised Claudia Berg, Milo Bianchi, Arlan Brucal, Miriam Bruhn, Maria Arnal Canudo, Xavier Cirera, Siddharth Dixit, Nisan Gorgulu, Philip Grinstead, Galileu Kim, Margaux Lucrece Lelong, Penny Mealy, Claudia Ruiz Ortega, Ryan Milan Rafaty, Dorothe Singer, Ruozi Song, Melvin Spreij, and Lucas Zavala.

Aya Aboul Hosn, Christian Castano Bonilla, Ma. Charmaine Robles Crisostomo, Sonam Gurung, Muhammad Raza Mustafa Khan, Bailey Marsheck, Meritxell Martinez Ruiz, Prakhar Misra, Bilal Moin, Ansh Motiani, Bolor Erdene Munkhbayar, Shyam Patel, Alexander Rand, Danjing Shen, and Linyi Zheng served as research assistants.

Sandi Soe Lwin provided administrative support.

Nicolas Acevedo-Rebolledo, David Alzate, Saher Asad, Faisal Ali Baig, Tania Begazo, Alexandre Borges de Oliveira, Dipan Bose, Conor Boyle, Eileen Burke, Ana Campos Garcia, Eliana Carranza, Shreya Chandra, Claire Chase, Marie-Hélène Cloutier, Said Dahdah, Tobias Diergardt, Matthias Gouthier, Amber Gove, Srinivas Gurazada, Beliyoun Haile, Zahid Hasnain, Spencer Henson, Sabine Hertveldt, George Ioannou, Irene Iodice, Silpa Kaza, Tanu Kumar, Diego Luna-Bazaldua, Kimberly N. Lyon, Rocco Macchiavello, Daniel Mahler, Ana Maria Munoz Boudet, Siobhan Murray, Mohit Jitendra Negi, Ivan Anton Nimac, Antoni Albert Nogués Comas, Alexandra Norris, Sara Nyman, Johan Andrey Ortega Hernandez, Alvaro Enrique Pedraza Morales, Hongqing Qiu, Juan Quicana, Manuel Ramos Maqueda, Camille Reverdy, Jamele Rigolini, Capucine Anne Veronique Riom, Daniel Rogger, Stuart Russell, Keiko Saito, Keiko Sakoda, Lina Sawaqed, Hulya Marie Sehidoglu, Shane Sela, Ramprakash Sethuramasubbu, Jayashree Srinivasan, Immanuel Frank Steinhilper, Marion Stoldt, Ko Takeuchi, and Yana R. Ukhaneva provided inputs to the Report at various stages.

Bruce Ross-Larson provided developmental guidance in the drafting of this Report.

Binyam Reja and Matthias Plavec authored box 1.2 on railway gauges. Nobuo Yoshida provided inputs for box 2.1 on standards for measuring poverty. Lucy Jacob, Kristin Komives, Karin Kreider, and Vidya Rangan from ISEAL Alliance and Shemina Amarsy, Regina Taimasova, and

Joseph Wozniak from the International Trade Centre (ITC) provided inputs for box 3.1 on understanding the high costs of complying with standards in low- and middle-income countries. Louise Twining-Ward authored box 4.1 on tourism standards. Staff members at the United Nations (UN) World Food Programme authored box 4.4 on how regulations can undermine international responses to humanitarian crises. Flor Hernandez Reyes, Lizbeth Mendoza Chavez, Klaus Oppermann, Ornsaran Pomme Manuamorn, Rekha Reddy, Chandra Shekhar Sinha, Sandhya Srinivasan, and Gabriel Yorio Gonzalez contributed to box 6.4 on the importance of standards in increasing financing for adaptation to climate change. Prakhar Misra authored box 7.4 on the administrative costs of implementing recruitment standards.

The communications and engagement strategy was led by a team comprising Kristen Milhollin, Karolina Ordon, Joseph Rebello, Shane Romig, and Mariana Teixeira. Roula Yazigi provided web and online services.

Special thanks are extended to Stephen Pazdan, who coordinated and oversaw formal production of the Report, and to the World Bank's Formal Publishing Program, including Cindy Fisher and Patricia Katayama. Mary C. Fisk facilitated the multiple translations of the overview and main messages by the Translations and Interpretation team, coordinated by Wendy Wei Chang Spadavecchia. Deborah Appel-Barker managed the printing and electronic conversions of the Report and the many ancillary products.

The Report was edited by Michael Harrup and Nancy Morrison and proofread by Gwenda Larsen and Catherine Farley. Robert Zimmermann verified the Report's extensive citations and assisted with the copyediting. The design team of the World Bank's Global Corporate Solutions unit designed the cover and the interior layout. Kirsten Dennison helped design some of the Report's figures and infographics. Datapage supplied typesetting services.

Van Thi Hong Do, Dayana Leguizamon, and Nishtha Vaswani provided the team with resource management support. The team would also like to thank colleagues at various World Bank country offices who assisted with logistics and stakeholder engagements. Special thanks to Marcelo Buitron, Gabriela Calderon Motta, and Grace Soko for their help with coordination and high-level engagement strategies.

The team is grateful for the guidance, comments, and inputs provided by other World Bank Group colleagues, particularly Deon Filmer (Director, Research Group, Development Economics Vice Presidency), Carolyn Fischer (Lead Economist, Sustainability and Infrastructure Team, Development Research Group), all managers in the Development Economics Research Group, and all Chief Economists of the World Bank vice presidencies and regions. The team is also grateful for the guidance, comments, and inputs provided by World Bank Group colleagues from the Centre for Financial Reporting Reform (CFRR); Development Finance; Digital Transformation Vice Presidency; East Asia and Pacific Region; Eastern and Southern Africa Region; Europe and Central Asia Region; External and Corporate Relations; Information and Technology Solutions; Infrastructure Vice Presidency; International Finance Corporation; Latin America and the Caribbean Region; Legal Vice Presidency; Middle East, North Africa, Afghanistan, and Pakistan Region; People Vice Presidency; Planet Vice Presidency; Prosperity Vice Presidency; South Asia Region; and Western and Central Africa Region. The team thanks

the many World Bank colleagues who offered written comments during the formal World Bank Group-wide review process. These comments provided invaluable guidance at a crucial stage in the production of the Report.

The team gratefully received suggestions and guidance from a High-Level Advisory Panel: Andrea Maechler (Deputy General Manager, Bank for International Settlements [BIS]), Sergio Mujica (Secretary-General, International Organization for Standardization [ISO]), Nandan Nilekani (Cofounder and Chairman, Infosys Technologies Limited), Monika Weber-Fahr (Chair, Board of Directors, ISEAL Alliance), Adil Zainulbhai (Chairman, Capacity Building Commission [India]), and Yongmei Zhou (Professor, National School of Development and Institute of South-South Cooperation and Development, Peking University).

The team received suggestions and inputs from an Academic Advisory Committee: Emmanuelle Auriol (Toulouse School of Economics), Henk de Vries (Erasmus University Rotterdam), Zonglai Kou (Fudan University), Adair Morse (University of California, Berkeley), Tim Simcoe (Boston University), Eric Verhoogen (Columbia University), and Cheryl Xiaoning Long (Xiamen University). The team consulted other academics, including Justus Baron (Northwestern University), Vittorio Bassi (University of Southern California), Katherine Bersch (Davidson College), Sarah Besky (Cornell University), Solveig Bjørkholt (University of Oslo), Antonio Botelho (Instituto Universitário de Pesquisas do Rio de Janeiro), Tim Büthe (Technical University of Munich), Salo Coslovsky (New York University), Jishnu Das (Georgetown University), Richard Doner (Emory University), Juan Carlos Hallak (Universidad de Buenos Aires), Stephen Jarvis (London School of Economics and Political Science), Benedict Kingsbury (New York University), Rocco Macchiavello (London School of Economics and Political Science), Giovanni Maggi (Yale University), Gerald A. McDermott (University of South Carolina), Monika Mrazova (University of Geneva), Mariana Rangel Padilla (Tecnológico de Monterrey), Paola Perez-Aleman (McGill University), Rebecca Perlman (University of California, Berkeley), Carlo Pietrobelli (Roma Tre University), Tommaso Porzio (Columbia University), Raghuram Rajan (University of Chicago Booth School of Business), Francesco Salustri (Roma Tre University), Steve Samford (University of Michigan), Andrew Schrank (Brown University), Ken Shadlen (London School of Economics and Political Science), Eswaran Subrahmanian (Carnegie Mellon University), Harsha Thirumurthy (University of Pennsylvania), Antonio Vezanni (Roma Tre University), Shaoda Wang (University of Chicago), Paul Wiegmann (Eindhoven University of Technology), and Veronika Wirtz (Boston University).

Thanks are due to the following people who participated in presentations during a series of seminars hosted by the *World Development Report 2025* team: Stefan Ambec (Toulouse School of Economics), Solveig Bjørkholt (University of Oslo), Colleen A. Dunlavy (University of Wisconsin–Madison), Jean-Baptiste Fressoz (Centre National de la Recherche Scientifique), John Gong (University of International Business and Economics), Ulrich Harmes-Liedtke (Mesopartner), Spencer Henson (University of Guelph), Anupam Kaul (independent consultant), Benedict Kingsbury (Institute for International Law and Justice, School of Law, New York University), Heejin Lee (Yonsei University), Osondu Ogbuoji (Center for Policy Impact in Global Health, Duke Global Health Institute, Duke University), Kate O'Neill (University of California, Berkeley), Ann-Sara Ramkissoon (University of Florence), Camille Reverdy (Graduate Institute of

International and Development Studies), Abhishek Sankritik (Finternet Labs), Christian Schoen (Mesopartner), Christian Schuster (University College London), Siddharth Shetty (Finternet Labs and Finternet), Admasu Shiferaw (College of William & Mary and Columbia University), Eric Veerhoogen (Center for Development Economics and Policy, Columbia University), Gavin Yamey (Sanford School of Public Policy and Duke-Margolis Institute for Health Policy, Duke University), and Vanessa Y. Zhang (Compass Lexecon).

The team would like to extend a special thanks to ISO for its collaboration throughout the process, especially on the joint ISO–World Bank survey distributed to all ISO members worldwide. The team also thanks the Peking University National School of Development (China) for organizing and hosting a roundtable discussion with academics, as well as ITC and UN Trade and Development (UNCTAD) for providing data that served as the basis for analysis in the Report.

The team benefited from the inputs of international and regional standards development organizations, national standards bodies, think tanks, research institutes, academic institutions, civil society organizations, private sector organizations, and other organizations, including African Organisation for Standardisation (ARSO); AirVironment Canada; ASTM International; Beijing Rongzhi Corporate Social Responsibility Research Institute; Bless Agri Food Laboratory; BSI Group; Bureau of Indian Standards; Bureau of Philippine Standards; Bureau Veritas; CARICOM [Caribbean Community] Regional Organisation for Standards and Quality (CROSQ); Central Bank of Armenia; China Agricultural University; China Auto Information Technology Company; China Jiliang University; China National Institute of Standardization; Codex Alimentarius Commission; Comisión Panamericana de Normas Técnicas [Pan American Standards Commission] (COPANT); Deutsches Institut für Normung [German Institute for Standardization] (DIN); DQS Management Services; Edget Garment PLC; Environmental Protection Authority, Ethiopia; Ethiopian Beverages Manufacturing Industries Association; Ethiopian Coffee and Tea Authority; Ethiopian Conformity Assessment Enterprise; Ethiopian Metrology Institute; Finternet; Food and Agriculture Organization (FAO) of the United Nations; Gansu Longcuitang Nutrition and Health Food Company; Gates Foundation; GCC Standardization Organization (GSO); General Administration of Customs of the People's Republic of China; Haimer Technology (Group) Co.; Hangzhou Juxing New Material Technology Company; Institute of Electrical and Electronics Engineers; Institute of Ethiopian Standards; International Accreditation Forum (IAF); International Civil Aviation Organization (ICAO); International Electrotechnical Commission (IEC); International Laboratory Accreditation Cooperation (ILAC); International Labour Organization (ILO); International Organization for Standardization (ISO); International Telecommunication Union (ITU); International Trade Centre (ITC); Internet Corporation for Assigned Names and Numbers (ICANN); ISEAL Alliance; Korea International Cooperation Agency (KOICA), Ethiopia office; Labor Mobility Partnerships (LaMP); Malawi Bureau of Standards; Ministry of Business, Innovation, and Employment, New Zealand; Ministry of Economy and Trade, Lebanon; Ministry of Economy of Armenia; Ministry of Environment and Ecology, People's Republic of China; Ministry of Finance of Armenia; Ministry of Foreign Affairs and Trade, New Zealand; Ministry of Trade and Regional Integration, Ethiopia; National Institute of Standards and Technology, United States; Newland Food;

Organisation for Economic Co-operation and Development (OECD); Pacific Islands Standards Committee (PISC); Peking University; People's Bank of China; Philippine Accreditation Bureau; Physikalisch-Technische Bundesanstalt [German Metrology Institute] (PTB); Standards Australia; State Secretariat for Economic Affairs, Switzerland; THEDAY Agro Industry; TIC Council; United Nations Economic Commission for Europe (UNECE); United Nations Industrial Development Organization (UNIDO); United Nations World Food Programme (WFP); World Health Organization (WHO); World Intellectual Property Organization (WIPO); and World Trade Organization (WTO).

The team apologizes to any individuals or organizations inadvertently omitted from this list. It is grateful for the help received from all who contributed to this Report, including those whose names may not appear here. Team members would also like to thank their families for their support throughout the preparation of this Report.

Key Takeaways

- **Standards are the hidden foundations of prosperity.** They are the shared rules that make plugs fit sockets, medicines work safely, and digital systems connect seamlessly. Standards embody collective knowledge, build trust, and enable economies to function efficiently. When they fail, markets fragment; when they work, prosperity follows.
- **For low- and middle-income countries, standards have never mattered more.** Nearly 90 percent of world trade is now shaped by nontariff measures, most linked to standards. From digital systems for payment to charging stations for electric vehicles, new technologies can deliver economywide benefits only when standards exist. Mastering them can enhance national competitiveness and protect against technological, financial, and environmental risks.
- **There are three types of standards.** *Measurement standards* ensure comparability and accuracy, *compatibility standards* enable interoperability, and *quality standards* define acceptable performance.
- **Most standards start as voluntary efforts, but governments make them count.** Private actors draft voluntary standards to address market or social needs. Governments amplify them by convening stakeholders and embedding critical standards into regulation when public safety is at stake.
- **Standards are a versatile tool of economic policy.** Governments can use voluntary standards to drive innovation and give technical guidance on compliance with regulations. They can also make them mandatory when uniform compliance is necessary to protect health, safety, or the environment. In addition, governments can deploy standards as an instrument of industrial policy without reference to specific technologies or firms.
- **Ambition must match capacity.** Countries should follow a trajectory that takes into account their stage of economic development, first *adapting* international standards to local realities when needed, then *aligning* with them as institutions mature, and actively participating in *authoring* standards in priority areas as capabilities grow. Rwanda's Zamukana Ubuziranenge ("Grow with Standards") program exemplifies this path, helping micro, small, and medium enterprises progress step by step toward compliance with international standards.
- **Investing in quality-enhancing infrastructure makes standards work well.** The system of testing, certification, metrology, and accreditation in a country is what makes standards effective. Such systems are expensive to build and easy to neglect. Countries should start with public provision of quality-enhancing services in key sectors, then gradually open up these services to private participation. In many places, capacity gaps are stark: Ethiopia has fewer than 100 accredited auditors for compliance with standards of the International Organization for Standardization (ISO), compared with 12,000 in Germany.

- **Adoption pays, but high costs and complexity hold firms back.** Costs of compliance and certification can amount to as much as *US\$425,000 per firm* in low- and middle-income countries. Simplifying certification, recognizing regional equivalence, and reducing overlapping regulations can break the low-quality trap in which many of these countries find themselves. Harmonization and mutual recognition can dramatically cut trade costs and unlock countries' export potential.
- **Standards make services in health care and education work better.** Standards make efforts in these areas reliable, by ensuring that doctors are properly trained, vaccines are effective, and medicines and schools meet quality benchmarks. In health care, 60 percent of deaths in low- and middle-income countries stem from conditions that could be prevented or treated with high-quality care. Simple process standards like childbirth checklists for hospitals have reduced maternal deaths by nearly 47 percent in India. In education, clear standards for teaching quality helped Ceará, Brazil, lift literacy in early grades to near-universal levels within two decades of the standards' implementation.
- **Environmental and technological standards are essential for managing global risks.** Today, 99 percent of people worldwide breathe dirtier air than is considered safe under World Health Organization (WHO) guidelines, costing lives and productivity. Complying with these guidelines could add nearly two years to global life expectancy. Still, one-size-fits-all standards can burden governments that have low capacity for enforcing them. Tiered, affordable approaches, paired with monitoring and enforcement, are key to a just transition to a low-carbon economy.
- **Governance standards make governments more effective.** They are the hidden wiring that turns discretion into discipline in the public sector, now 373 million workers worldwide. Setting clear standards for hiring, pay, and procurement boosts transparency and efficiency.
- **To make standards a springboard for development, countries should do the following:**
 - Create incentives for firms to upgrade the quality of their exports rather than imposing unrealistic mandates.
 - Adapt and sequence standards to align with the national capacity to enforce them.
 - Participate actively in international forums for setting standards.
 - Invest in and share quality infrastructure resources regionally.
- **The global community, for its part, must do the following:**
 - Support participation by low- and middle-income countries in developing international standards and design tiered standards that reflect diverse capacities among countries.
 - Deepen regulatory cooperation and reduce fragmentation.
 - Develop credible standards for emerging technologies and actions to prevent or mitigate climate change.
 - Expand research and data on the economic and social impacts of standards.
- **Standards matter for development.** Countries that take them seriously are getting ahead. Countries that ignore them risk falling behind.

Abbreviations

3GPP	3rd Generation Partnership Project
AESC	American Engineering Standards Committee
AI	artificial intelligence
ANSI	American National Standards Institute
APTC	Australia-Pacific Technical College
AQG	Air Quality Guideline [World Health Organization]
AQLI	Air Quality Life Index
ARSO	African Organisation for Standardisation
ASCII	American Standard Code for Information Interchange
ASEAN	Association of Southeast Asian Nations
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AT&T	American Telephone and Telegraph Company
BCBS	Basel Committee on Banking Supervision
BIPM	Bureau International des Poids et Mesures [International Bureau of Weights and Measures]
BIS	Bank for International Settlements
BMW	Bayerische Motoren Werke Aktiengesellschaft
BRIC	Brazil, Russia, India, and China
BSJ	Bureau of Standards Jamaica
BSTI	Bangladesh Standards and Testing Institution
CARICOM	Caribbean Community
CASCO	Committee on Conformity Assessment [International Organization for Standardization]
CE	Conformité Européenne
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CERN	Conseil Européen pour la Recherche Nucléaire [European Organization for Nuclear Research]
CFRR	Centre for Financial Reporting Reform
CME	Chicago Mercantile Exchange
CNCA	Certification and Accreditation Administration [China]
CoDi	Cobro Digital [Mexico]

CONFEMEN	Conférence des Ministres de l'Éducation des États et Gouvernements de la Francophonie [Conference of Ministries of Education of French-Speaking States and Governments]
COPANT	Comisión Panamericana de Normas Técnicas [Pan American Standards Commission]
CROSQ	Caribbean Community Regional Organisation for Standards and Quality
CSC	Civil Service Commission [Philippines]
CSS	Cascading Style Sheets
DALY	disability-adjusted life year
DEVCO	Committee on Developing Country Matters [International Organization for Standardization]
DIN	Deutsches Institut für Normung [German Institute for Standardization]
EASA	European Union Aviation Safety Agency
EC	European Commission
ECAE	Ethiopian Conformity Assessment Enterprise
ECHA	European Chemicals Agency
EML	Model List of Essential Medicines [World Health Organization]
eMRTD	electronic machine-readable travel document
EPA	Environmental Protection Agency [United States]
ETSI	European Telecommunications Standards Institute
EU	European Union
EUDR	EU Regulation on Deforestation-free Products [EU Deforestation Regulation]
FAO	Food and Agriculture Organization of the United Nations
FATF	Financial Action Task Force
FCC	Federal Communications Commission
FDA	Food and Drug Administration [United States]
FDI	foreign direct investment
G20	Group of Twenty
GATT	General Agreement on Tariffs and Trade
Gavi	the Vaccine Alliance
GM	General Motors
GQII	Global Quality Infrastructure Index
GSO	GCC Standardization Organization
GSP	Global Skill Partnership
GSTC	Global Sustainable Tourism Council
IAB	Internet Architecture Board
IAF	International Accreditation Forum
IASB	International Accounting Standards Board
IATA	International Air Transport Association
IATF	International Automotive Task Force

ICANN	Internet Corporation for Assigned Names and Numbers
ICAO	International Civil Aviation Organization
ICD-11	International Classification of Diseases, 11th version
ICOLD	International Commission on Large Dams
IDEB	Índice de Desenvolvimento da Educação Básica [National Education Quality Index, Brazil]
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IFC	International Finance Corporation
IFRS	International Financial Reporting Standards
ILAC	International Laboratory Accreditation Cooperation
ILO	International Labour Organization
IMF	International Monetary Fund
IMO	International Maritime Organization
InetQI	International Network on Quality Infrastructure
INMETRO	Instituto Nacional de Metrologia, Qualidade e Tecnologia [National Institute of Metrology, Quality, and Technology, Brazil]
INN	International Nonproprietary Names
IPSAS	International Public Sector Accounting Standards
ISI	Indian Standards Institution
ISO	International Organization for Standardization
IT	information technology
ITC	International Trade Centre
ITU	International Telecommunication Union
IUPAC	International Union of Pure and Applied Chemistry
JHIC	Joint Health Inspection Checklist [Kenya]
J-PAL	Abdul Latif Jameel Poverty Action Lab
JSA	Japanese Standards Association
JUSE	Union of Japanese Scientists and Engineers
KATS	Korean Agency for Technology and Standards
KOLAS	Korean Laboratory Accreditation Scheme
KRISS	Korea Research Institute of Standards and Science
KS	Korean Industrial Standards
KSA	Korean Standards Association
KSRI	Korea Standards Research Institute
LaMP	Labor Mobility Partnerships
µg/m ³	micrograms per cubic meter
MIT	Massachusetts Institute of Technology

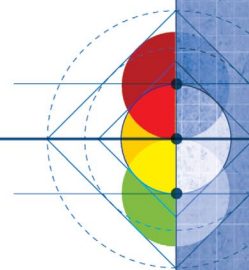
MITI	Ministry of International Trade and Industry [Japan]
MRTD	machine-readable travel document
MSC	Marine Stewardship Council
NATO	North Atlantic Treaty Organization
NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology [United States]
NML	national medicines list
NTEA	National Telephone Exchange Association
OECD	Organisation for Economic Co-operation and Development
OIML	Organisation Internationale de Métrologie Légale [International Organization of Legal Metrology]
oneM2M	one Machine-to-Machine Partnership Project
OSI	Open Systems Interconnection
PFAS	per- and polyfluoroalkyl substances
PIRLS	Progress in International Reading Literacy Study
PISA	Programme for International Student Assessment
PISC	Pacific Islands Standards Committee
PM _{2.5}	particulate matter with a diameter of 2.5 micrometers or less
PM ₁₀	particulate matter with a diameter of 10 micrometers or less
PTB	Physikalisch-Technische Bundesanstalt [German Metrology Institute]
QI4SD	Quality Infrastructure for Sustainable Development [index]
QSAE	Quality and Standards Authority of Ethiopia
REB	Rwanda Basic Education Board
RSPO	Roundtable on Sustainable Palm Oil
RTRS	Rountable on Responsible Soy
SAC	Standardization Administration of China
SACMEQ	Southern and Eastern Africa Consortium for Monitoring Educational Quality
SADC	Southern African Development Community
SADCAS	Southern African Development Community Accreditation Service
SAE	Society of Automotive Engineers
SAMR	State Administration for Market Regulation
SIG	Special Interest Group [Bluetooth]
SIMAP	Surgical Instrument Manufacturers Association of Pakistan
SMEs	small and medium enterprises
SPAECE	Sistema Permanente de Avaliação da Educação Básica do Ceará [Permanent Evaluation System of Ceará Basic Education]
SPEI	Sistema de Pagos Electrónicos Interbancarios [Mexico]
TAA	Tunisian Automotive Association
TaRL	Teaching at the Right Level [India]
TIMSS	Trends in International Mathematics and Science Study

TSDSI	Telecommunications Standards Development Society, India
TSE	Türk Standardları Enstitüsü [Turkish Standards Institute]
TTBS	Trinidad and Tobago Bureau of Standards
UIC	International Union of Railways
UL	Underwriters Laboratories (UL)
UN	United Nations
UN/CEFACT	United Nations Centre for Trade Facilitation and Electronic Business
UNCTAD	United Nations Trade and Development
UNECE	United Nations Economic Commission for Europe
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNIDO	United Nations Industrial Development Organization
UPI	Unified Payment Interface [India]
UPU	Universal Postal Union
USDA	United States Department of Agriculture
VW	Volkswagen
W3C	World Wide Web Consortium
WDR	<i>World Development Report</i>
WFME	World Federation for Medical Education
WFP	World Food Programme (United Nations)
WHO	World Health Organization
WIPO	World Intellectual Property Organization
WSC	World Standards Cooperation
WTO	World Trade Organization
WWF	World Wide Fund for Nature
XHTML	Extensible HTML

All dollar amounts are in US dollars unless otherwise indicated.

Overview

Who owns the standards, owns the market.
—Werner von Siemens



Standards: The quiet catalyst

Trade agreements have long greased the wheels of the global economy. They have smoothed out cross-border frictions, established predictable access to markets, and introduced standard rules into domestic regulation, so products can move at scale. But the real revolution came quietly—and relatively recently: from a US trucking entrepreneur named Malcom McLean in the mid-1950s.

Until then, goods were transported using methods that had hardly changed over the centuries. Cargo had to be loaded piece by piece, using crates, sacks, or barrels, onto carriages, trucks, trains, and ships. At each stage, everything was hauled off of one vehicle and then reloaded onto the next, usually with different types of specialized equipment. McLean standardized the humble steel box, readying it for easy loading and shipping across all forms of transportation: road, rail, air, and sea. In doing so, he crushed handling costs and delays: The cost of shipping fell by at least 25 percent. The risk of theft and damage eased. If treaties set the stage for the rise of globalization after World War II, McLean's container made the show possible.

McLean's standardization did not just tidy up shipping. Standard containers gave the world a

common commercial language. A container sealed in Shanghai could roll off a ship in Rotterdam and onto a truck, rarely opened or even touched by human hands. Standards turned chaos into order, unleashing the economic miracles of just-in-time manufacturing. Ships got bigger. Supply chains proliferated. Commerce surged. McLean then turbocharged the process by granting free licenses to his container patents to the International Organization for Standardization (ISO).

In 1965, ISO codified almost everything about the containers: dimensions, stacking rules, twist locks, strength, and lifting. Suddenly, there was a single playbook—and global interoperability.

The payoff was extraordinary. Containers delivered a permanent boost to trade: a 1,240 percent cumulative jump in trade among advanced economies after 15 years: by many estimates, more than the combined effect of all trade agreements of the previous half century.¹ Across 22 industrial countries, standardized containers lifted bilateral trade by 300 percent in just 5 years and nearly 800 percent in 20. That far exceeded the 45 percent from bilateral free trade agreements over the same 20 years and 285 percent from membership in the General Agreement on Tariffs and Trade (GATT), the precursor to the World Trade Organization (WTO).²

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Today, trade frictions are once more on the rise across the world, but tariffs are only the most visible form of the malignancy, not the most important. Standards, in the form of nontariff measures such as requirements for product labeling and safety testing, now affect nearly 90 percent of trade, up from 15 percent in the late 1990s. They often pile problems on developing countries, intensifying the downward drift in flows of international trade from and foreign investment to these countries.

Consider just one area: climate. The European Union (EU) Carbon Border Adjustment Mechanism is designed to ensure that not only European firms, but global suppliers to the EU as well, reduce their emissions. It imposes a carbon price on imports in six sectors: cement, aluminum, iron and steel, fertilizers, hydrogen, and electricity. Firms that export their goods to the EU must measure, report, and verify the emissions their products cause, in accordance with established standards. If they cannot provide credible data at the plant level, the EU uses default values that can overstate actual emissions levels.

The Carbon Border Adjustment Mechanism constitutes the most ambitious climate policy experiment worldwide to date, an earnest effort to reduce emissions that reflects EU values regarding sustainability, fairness, and consumer responsibility. Yet it threatens to widen the global divide between rich and poor countries.

It enables firms in advanced economies with a strong machinery for compliance to gain a big edge, while boxing in enterprises in less developed economies. Mozambique, which sends nearly 90 percent of its aluminum to the EU, is particularly at risk from the policy. So is the Arab Republic of Egypt, which exports almost half its nitrogen-based fertilizers to the EU market.

Here is another example: The Basel Committee on Banking Supervision is introducing the first

global standards for banks' exposure to crypto assets, covering Bitcoin, Ethereum, stablecoins, and more. Due in 2026, these standards will determine how banks calculate capital requirements for a US\$4 trillion market that has so far operated in a regulatory gray zone.

The Basel standards are rewriting the rule book for banking: By setting clear charges associated with financing capital expenditures and limits on banks' exposure to risk, they aim to bring order to a volatile system. The goal is not to stifle innovation, but to anchor it in prudence: a single global framework that replaces fragmented national rules. Like a container that keeps its cargo safe from port to port, these financial standards promise predictability in instances in which instability can spill across borders.

This process of using standards to manage risks goes beyond banking. Frontier technologies, from dopamine-driven social media and artificial intelligence (AI) to mirror organisms and quantum computing, carry profound risks yet lack even the most rudimentary global guardrails. Even as the arguments about standards are becoming more heated, geopolitics is killing off the coordination the world so badly needs. This Report points to standards as a quiet catalyst not just for economic development but also for international cooperation.

Standards as springboards

Standards anchor today's biggest policy debates. When they work, they are silent. When they fail or do not exist, you cannot miss the chaos.

As the examples in the preceding section highlight, standards fix coordination problems and solve market failures resulting from bad information and externalities. They build trust among consumers. They allow producers to trade and reap economies of scale. In short, they make markets work better.

The three dimensions of standards

World Development Report 2025 identifies three critical functions of standards:

- *Measurement*: Consistency in measurement that is essential for building, testing, and certification
- *Compatibility*: Interoperability and substitutability that power scale and order
- *Quality*: Baselines for performance, safety, and reliability.

These three functions are not just abstract principles derived from economic theory. Together, they make standards a building block—sometimes even the foundation—of economic development. Consider India, the United States, and the Republic of Korea: the world’s biggest democracy, its largest economy, and one of its most inventive societies, respectively.

India’s history after independence shows how measurement standards forge economic unions. As a new sovereign nation in 1947, India launched its first National Sample Survey of living standards in 1950. The survey revealed a striking lack of standardization of weights and measures in the country’s rural areas: 143 different systems for measuring weight, 150 different systems for measuring volume, and 180 systems for measuring land area.³ The lack of consistency that was hobbling India’s economic union paralleled the mayhem in France before the metric system established order there; in the 1700s, France had about 250,000 local weights and measures.⁴

What was the fix? “Indianize” the metric system, not cling to Imperial units or the colonial baggage associated with them. That required a massive effort: new technical standards, nationwide education, multilingual materials, and revamped curriculums.

India adopted the metric system in 1956, legalized it in 1958, and made it mandatory by 1962. The transition was painful but pivotal. Today, India is the world’s fourth-largest economic union, built on the bedrock of metrological consistency.

The United States has been the world’s largest economy for more than a century. Its rise as the global leader in manufacturing by the mid-twentieth century is often attributed to entrepreneurs like Henry Ford, whose models of mass production changed enterprises around the world.

But the US manufacturing edge was not just Ford’s assembly line. It was also the government’s drive for “simplification,” initiated during World War I, to push industry toward compatibility: standard (fewer) sizes and mass production. Industrial standards in the early 1900s were mostly in house; fragmentation was rampant, fed by a tangle of state and local rules and custom-made orders. Mattresses came in 78 sizes in 1914; within a decade, that number had fallen to 4 for 90 percent of output.

Wartime agencies, working through trade associations, slashed product variety across some 250 lines in 18 months. President Hoover revived and institutionalized the effort in the 1920s, creating the Division of Simplified Practice as a neutral broker for voluntary, industrywide standards.⁵ Early wins—paving bricks, mattresses, bedsprings—cut varieties by more than 90 percent. By the early 1930s, 135 Simplified Practice Recommendations were in place, growing to 173 by 1939 and 267 by 1971.⁶ Each one tightened the link between design and efficiency, reducing waste, cutting costs, and freeing up capital for innovation.

Compatibility standards powered the US leap in mass production and consumption, turning variety into scale and waste into efficiency. What looked like a technical exercise was in fact an economic policy of uncommon power, one that

quietly multiplied productivity across an entire economy.

When innovation is measured by patent applications per capita, the Republic of Korea may be the world's most innovative economy today.⁷ It is surely one of the most successful development stories in modern history.

Korea built its rise from postwar ruin to technological powerhouse on a foundation of quality standards. It embedded quality upgrading into its national strategy, shifting from adopting to shaping global standards, especially in information and communications technologies.⁸

To win in export markets in the 1960s, Korea built a national quality infrastructure: metrology, standardization, conformity assessment, and accreditation.⁹ The country's 1961 Metrology and Industrial Standardization Acts created Korean Industrial Standards; the Korean Standards Association (KSA) spread them. The country's 1962 Export Inspection Act tied compliance to export viability. Its 1961 KS mark certification and preference in government procurement for products carrying the certification drove firm adoption.

As its heavy and chemical industries grew, supported by Germany and the United States, Korea modernized metrology via the Korea Standards Research Institute (or KSRI, now the Korea Research Institute of Standards and Science, or KRISS). A 1980 constitutional amendment mandated a national standards system, backed by the country's ten-year industrial standardization plan and subsequent five-year plans.

As Korea relentlessly upgraded its economic structure between 1996 and 2014, the country fused standardization with innovation. Private bodies gained a bigger role in drafting standards. Korea ramped up its participation in international standards development organizations (the International Organization for Standardization,

or ISO, and the International Electrotechnical Commission, or IEC) and technological consortia (the 3rd Generation Partnership Project, or 3GPP, and the one Machine-to-Machine Partnership Project, or oneM2M) moving from a country that implements standards developed by others (that is, a “standard taker”) to one that participates in and even leads the development of standards (a “standard maker”).¹⁰

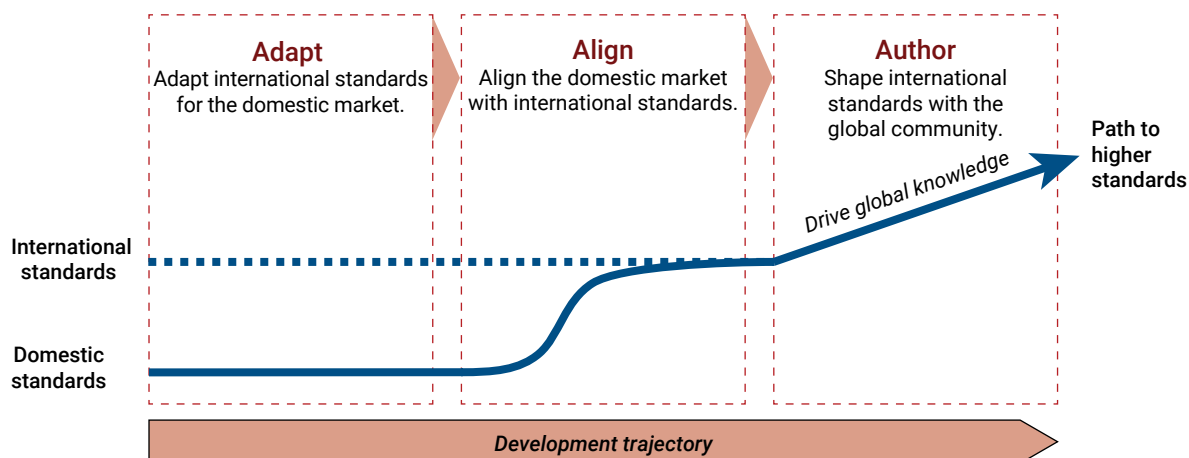
The lesson: Korea treated standards as quality-enhancing economic infrastructure. The state matched its vision with laws, institutions, and incentives (notably procurement advantages for products bearing KS mark certification), and its long-term plans and capability building sustained momentum. Korea's “stage-skipping” rapid economic advancement came from coordinated public-private investment, smart borrowing of foreign know-how, building of expertise in standardization, and making the latter a complement to industrial upgrading.¹¹

Adapt-align-author: How standards support development

Development is all about transitioning toward higher-quality goods, services, institutions, infrastructure, and quality of life. As the examples in the preceding sections have illustrated, standards play a catalytic role in this journey.

A fundamental question is, How should countries decide what standards to use, and how will those decisions change with economic development? At low levels of development, countries may need to *adapt* international standards to local conditions, especially if they are making them mandatory standards (refer to figure O.1). But global markets do not bend: Buyers expect full compliance with international consistency (including safety), compatibility, and quality standards—no compliance, no sales. For home markets, adaptation is

Figure O.1 Standards have a great impact on development



Source: WDR 2025 team.

possible but risky: Industry may capture the process, watering down standards, making them hard to reverse, and locking countries into low-quality norms and lower levels of development. Deviating from international standards should therefore be a last resort, used only when firms' capacity to meet those standards cannot yet be strengthened.

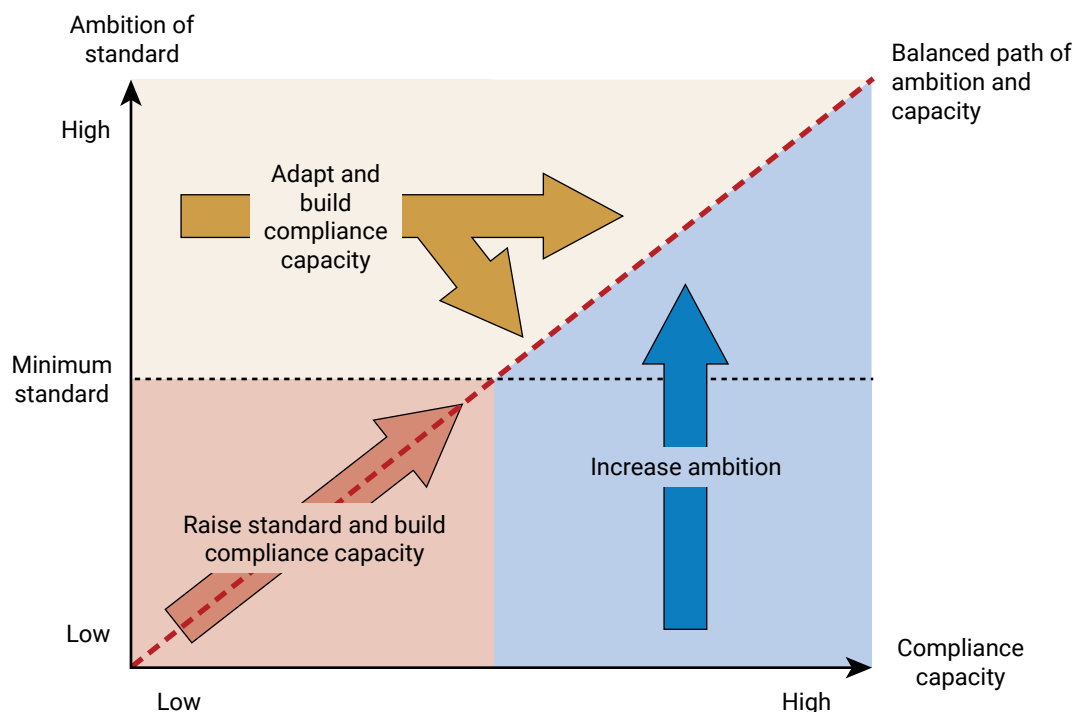
As developing countries adapt international standards to local conditions, they will need to balance the standards' ambition, in terms of their stringency and the breadth of areas they cover, with the capacity of firms in the countries to comply with those standards (refer to figure O.2).

When mandatory standards are set too low, society loses out in regard to quality of education and health care, food safety, and environmental protection. When these standards are set too high and burden producers with steep compliance costs, prices spike and shut out consumers, and society loses out again. For example, setting reporting requirements beyond what small firms can meet can push the firms out of business, as in the case, for example, of stringent rules for dairy safety that only large industrial producers can afford to comply with. Worse, ambitious regulations without enforcement muscle invite uneven application and potential corruption and can alter the trajectory of

a country's development forever. The central task, shown in figure O.2, is striking the right balance between ambition and ability.

As countries increase their capacity for compliance, they should *align* standards for the domestic market with international standards. This is beneficial because international standards reflect good international practices that countries can learn from. The WTO Agreement on Technical Barriers to Trade encourages alignment of national with international standards to ensure that measures that countries enact to achieve legitimate public objectives like health, safety, and environmental protection do not unnecessarily disrupt trade. Moreover, aligning national with international standards ensures that firms in a country do not need to produce one variant for the domestic market and another for export. In nontradable areas like education, health care, and public administration, standards must be more sensitive to context but have a clear pathway for improvement. In these areas, although international standards can serve as benchmarks, developing countries may need to develop their own standards. The process of standards development itself should encourage these countries to address their own priorities and capabilities within specific political and cultural contexts.

Figure 0.2 Countries should match their ambitions with their abilities



Source: WDR 2025 team.

As countries become wealthier, they should deliberately become more active in *authoring* international standards, either by developing new ones or by updating existing standards based on their experience and needs. Active participation in developing international standards is important even if a country has limited technical expertise in the areas the standards govern. It allows the country to share its challenges and priorities, thereby influencing what the standards should cover. Additionally, international standards development organizations serve as learning environments and help countries gain a deeper understanding of how standards are developed through interactions with participants from other nations and stakeholders. Of course, the level of a country's participation will depend on its priorities and expertise in particular sectors.

The trajectory of standards, from adaptation to alignment to authoring, is not linear or uniform across sectors. Countries can move between the choices of adaptation, alignment, or authoring in different areas at varying speeds. For example, Ethiopia is authoring standards for production of its local grain, teff, while adapting standards in other areas. India is taking up leadership in development of international standards for low-voltage electrification while adapting standards for fuel efficiency. The transition from adapting to aligning to authoring embodies the complex interplay among scientific and technological advancements, cultural traditions, social preferences, economic pragmatism, business interests, and political ambition and power. Understanding the transition process is crucial for policy makers, businesses, and civil society as they navigate the increasingly complex global landscape of standards.

Building capacity for compliance with standards

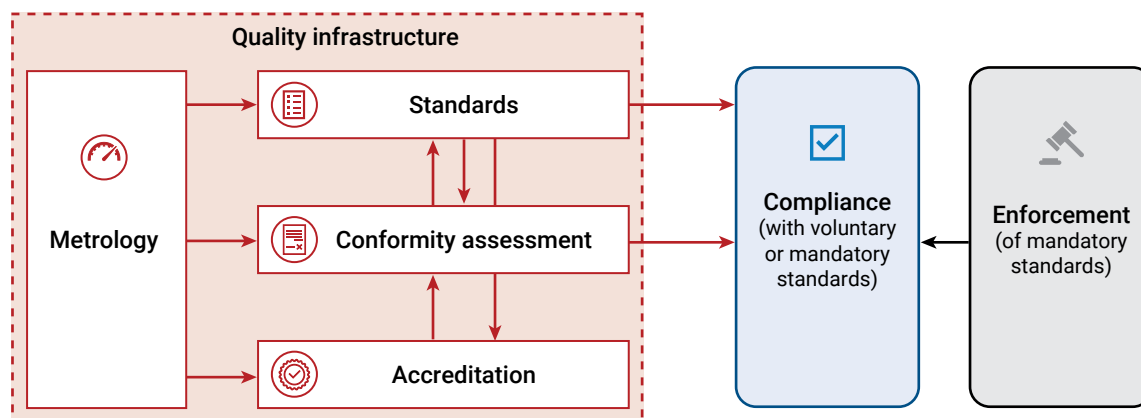
Building capacity for compliance with standards is not just about teaching firms to tick the right boxes, it is about wiring an entire system that makes quality the standard. That system of public and private institutions is called “quality infrastructure.” Although it is referred to as a type of infrastructure, it should not be confused with physical structures like roads or bridges. Instead, quality infrastructure serves as the backbone or foundation of quality and consists of four components that ensure standards are implemented correctly and consistently (refer to figure O.3):

- *Standardization*: Defining technical specifications and other things like testing methodology
- *Conformity*: Demonstrating that specified requirements of a product, process, system, person, or organization are fulfilled¹²
- *Accreditation*: “Checking the checkers” to ensure that conformity assessment bodies are technically competent
- *Metrology*: Ensuring accuracy and consistency in measurement through the science and application of measurement.¹³

Together, these components serve every sector and every standard, voluntary or mandatory. A buyer-approved laboratory inside a garment factory, health inspectors in hospitals, and market surveillance teams pulling unsafe toys off shelves: All exemplify the role of quality infrastructure. When a quality infrastructure system runs smoothly, firms can prove quality, regulators can enforce rules, and consumers can trust what they buy.

In wealthier economies, distinct institutions typically handle different functions such as developing standards, ensuring accurate measurements, and checking the competence of certifiers through accreditation. Because of limited resources, developing countries often merge these roles into a single organization. Such a consolidation, however, can create conflicts of interest. The most serious conflict arises when one body is responsible for both certifying products (conformity assessment) and assessing other certifiers (accreditation). This dual role compromises impartiality and erodes trust. An organization that certifies a product’s sustainability, for instance, should not also be the one to decide which other organizations are qualified to issue such certifications.

Figure O.3 Quality infrastructure ensures compliance with standards



Source: WDR 2025 team.

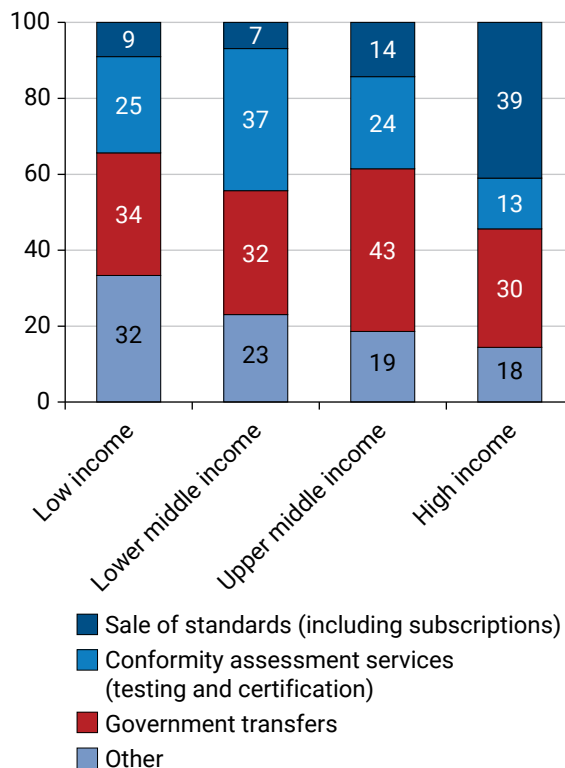
Another conflict arises from combining standards setting and conformity assessment. This practice is particularly common in developing countries, where national standards bodies often rely on revenue from conformity assessment. In 94 percent of low-income countries and 82 percent of lower-middle-income countries, national standards bodies are involved in conformity assessment. In the latter group of countries, conformity assessment services can account for nearly 40 percent of the revenue of national standards bodies (refer to figure O.4). Although ISO guidelines require a separation between the functions of setting standards and assessing conformity with them, limited resources in developing countries often make this separation difficult to implement.

As countries develop, their approach to building capacity to comply with voluntary and mandatory standards must evolve. Early on, countries need to build the *basics*, by investing in foundational quality infrastructure like metrology. The public sector typically takes a leading role at this stage in providing testing and certification services, because private markets are not yet deep enough. Governments also need to accord priority to mandatory standards on life-and-death activities like construction and medicine.

As countries climb the development ladder, they can *broaden* the objectives of their public quality infrastructure to cover more areas as they enable more private testing, inspection, and certification bodies, whose trustworthiness the government may oversee via accreditation. Eventually, countries' quality infrastructure covers public objectives more comprehensively. At this stage, countries should *balance* their approaches to developing quality infrastructure, with the government assuming the role of a "referee" while the private sector handles most matters related to compliance.

Figure O.4 Lower-income countries depend too much on revenues from services related to assessing conformity with standards

Share of total revenues of national standards body, 2025 (%)



Source: WDR 2025 team, based on World Bank and ISO 2025.

Note: The figure shows revenue sources of national standards bodies as of 2025. The survey sample includes 116 national standards bodies: 13 in low-income countries, 28 in lower-middle-income countries, 34 in upper-middle-income countries, and 41 in high-income countries. "Other" includes revenues from accreditation, metrology, partnerships or donor funding, and training and consulting services. Shares of components within bars may not sum exactly to 100 because of rounding.

When building quality infrastructure across these three stages, countries should sequence their investments according to market and societal needs and prevent institutional conflicts of interest. Although the division of roles between the public and private sector is a key concern,

developing countries can leverage their compliance capacity by working with civil society organizations like consumer groups or professional bodies.

Although companies establish most voluntary standards to ensure the quality and safety of

their inputs, products, and processes, this Report puts emphasis on voluntary standards developed by national and international standards organizations through consensus among different stakeholders, including industry, academia, government, consumers, and civil society (refer to box O.1).

Box O.1 Governments dominate national standards bodies in developing countries

Most countries have a national standards body that coordinates standards development and represents the country in international standards development organizations like the International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC), and the International Telecommunication Union (ITU). Many national standards bodies are autonomous governmental organizations created through the legislative process, such as those in Bangladesh and South Africa.^a In some countries like the United States, national standards bodies are nongovernmental organizations that the government recognizes as national standards bodies.^b A survey by ISO and the World Bank for this Report shows that whereas almost all national standards bodies in developing countries are government institutions, only 56 percent in advanced economies are. In many countries, national standards bodies take on a coordinating function among multiple national standards development organizations. For example, the Bureau of Indian Standards works with sectoral standards development organizations such as the Telecommunications Standards Development Society, India (TSDSI).

In addition to their different legal setups, national standards bodies have different models for financing that vary greatly between developing countries and advanced economies, with consequences for the roles they play. In high-income countries, national standards bodies generate nearly 40 percent of their revenues from selling standards, reflecting the private sector's greater demand for standards and greater capacity to pay for them. Conversely, in developing nations, these bodies get only about 10 percent of their revenues from the sale of standards. Notably, in developing countries, national standards bodies offer a wider range of services beyond standards development, such as testing, inspection, and certification, which account for nearly one-third of their revenues on average. Additionally, they are more likely to participate in regulatory functions: 75 percent of national standards bodies in developing countries are involved in setting technical regulations (mandatory standards), compared with just 35 percent in high-income countries.

These differences seem unremarkable, but they can fundamentally alter the dynamics of standards development. In many developing countries, national standards bodies play a

(Box continues next page)

Box O.1 Governments dominate national standards bodies in developing countries (*continued*)

central role in testing, inspecting, and certifying mandatory standards that, as government entities, they help develop, risking a shift from being service providers to being compliance auditors for voluntary standards demanded by the private sector. This also raises potential conflicts of interest.

Source: WDR 2025 team.

- a. The national standards body in Bangladesh operates as an autonomous government institution. For details, refer to Bangladesh Standards and Testing Institution (BSTI) (dashboard), BSTI, Ministry of Industries, <https://bsti.gov.bd/>. The South African national standards body was established in 1945 under the country's Standards Act. For details, refer to SABS [South African Bureau of Standards] (dashboard), SABS, Department of Trade, Industry and Competition, <https://www.sabs.co.za/>.
- b. The US standards body is a private nonprofit organization founded in 1918 that represents the United States in international standards development organizations, such as ISO and the IEC. For details, refer to ANSI [American National Standards Institute] (dashboard), ANSI, <https://www.ansi.org/>.

Who develops standards?

It makes sense to leave the drafting of voluntary standards to their primary users: private businesses. Automobile manufacturers, for instance, were indispensable to shaping ISO 26262, which governs the safety of electronic systems in road vehicles. Because standards rely on detailed technical know-how, the specialized expertise of industry is essential to their development.

Yet participation in developing standards is not purely a technical exercise. Steering a standard in one's own direction creates competitive advantage. Voluntary standards influence commercial behavior when firms reference them in contracts and drive demand when governments embed them in rules governing public procurement. Furthermore, voluntary standards can become compulsory once written into national law.

In some cases, products developed by a single dominant firm—examples include IBM's PC architecture, Microsoft Windows, and Adobe

PDFs—become *de facto* industry standards because the network effects of having many users on a single platform create high barriers to entry for competing systems. In many cases standards emerge from a market contest, not a neutral search for “the best” design or idea. Standard-setting bodies must therefore continually balance two objectives: drawing on the knowledge of stakeholders and avoiding regulatory capture by the largest or most politically connected firms.

That balancing act is getting harder. Products' technical complexity is increasing, and private sector expertise now far outpaces that within governments. The challenge is acute in many developing countries, where formal private sectors are small and often dominated by a handful of well-connected firms, some of which are state-owned enterprises.

Multinational corporations also work the system: By joining multiple national standards bodies (each of which enjoys one vote in intergovernmental forums), they can amplify their influence.

Reports suggest that some large technology companies are following this playbook to shape emerging standards for AI, even hiring local consultancies in countries where they have no physical presence. Because legislation such as the EU's Artificial Intelligence Act will rely on voluntary benchmarks, winning the standards race can confer a major edge.

In contrast to the private sector's dominance in establishing voluntary standards, governments set mandatory standards. Beyond achieving the right balance between ambition and capacity, as discussed earlier, a key issue for governments is time horizons. Benefits from higher levels of compliance often show up only in the medium term, with at least one election cycle elapsing between enactment and benefits. Building laboratories to test for heavy metal contamination in soil, for example, yields health gains that may be invisible—or politically irrelevant—when the next election arrives.

Ideally, the core principles of openness, balance, and consensus should drive standards development. But developing standards is also about power, incentives, and governance. In some cases, it reflects different societal preferences and cultural norms, as shown in strong disagreements in areas such as genetically modified crops and standards for meat and dairy. Getting it right requires transparent processes, broad stakeholder participation, and rigorous assessment of standards' economic and distributional effects.

More broadly, the research conducted for this *World Development Report* suggests the following principles:

- Demand should drive standards development, with standards enacted only in instances in which there is a strong market or societal need.
- In most economic sectors, the private sector should set voluntary standards.

- Governments should step in regarding the development of voluntary standards only when collective action fails or inclusion, fragmentation, and competition are problems—and even then, it should act only as convenor, rather than determining the technical content of voluntary standards.
- Mandatory standards should be reserved for essential public interests in areas such as health, safety, environmental protection, and preventing deceptive commercial practices.

Standards for growth, well-being, and stability

Standards can be leveraged for development in four ways. First, every developing country needs *economic growth*. Standards can be powerful drivers for diffusing good practices, increasing efficiency, and realizing economies of scale by connecting countries through trade and investment. Second, development is ultimately about improving individual *well-being*. Standards contribute directly here by helping to improve health and education, which, in turn, underpin economic growth. Third, standards are important tools for *risk management*—a necessity, given that unchecked economic growth can precipitate serious risks, from financial crises to the destruction of the environment. Lastly, all three of these areas require *government capacity*, which itself is buttressed by standards in areas ranging from budget and procurement processes to the recruitment and remuneration of government officials.

Economic growth: Standards increase efficiency and quality and enable scale

Geopolitical tensions, trade fragmentation, assertive industrial policies, and the long-term pressures of climate change increasingly constrain developing countries' growth through trade,

spillovers from foreign direct investment, and technology diffusion: the channels that carry the know-how embedded in standards. To respond, these countries need to start at home: They should create conditions that encourage firms to invest in upgrading to better standards in domestic markets. Industrial policies should be carefully calibrated so as not to shield firms from competition or alter their incentives in ways that could discourage rather than encourage them to upgrade quality. If industries are protected from the consequences associated with lack of quality, why would they invest in quality?

Aligning public and private incentives and ensuring competition are essential to enable the “infusion” and diffusion of know-how.¹⁴ Standards by themselves will not deliver technological upgrading, but inconsistent policies and regulations can certainly derail it.

Market realities also matter. Most firms are too small to justify spending money on the fixed costs of compliance with standards and obtaining certification that they have complied with them.

Developing countries should therefore follow a practical four-part strategy for upgrading quality in domestic production:

1. Give high priority to medium-size enterprises that are ready to adopt standards.
2. Support firm growth to create a virtuous circle of capability and compliance.
3. Strengthen links between large firms and smaller suppliers in supply chains to spread standards.
4. Invest in quality infrastructure and lower service costs to broaden access.

East Asia’s experience underscores common success factors in using standards to promote

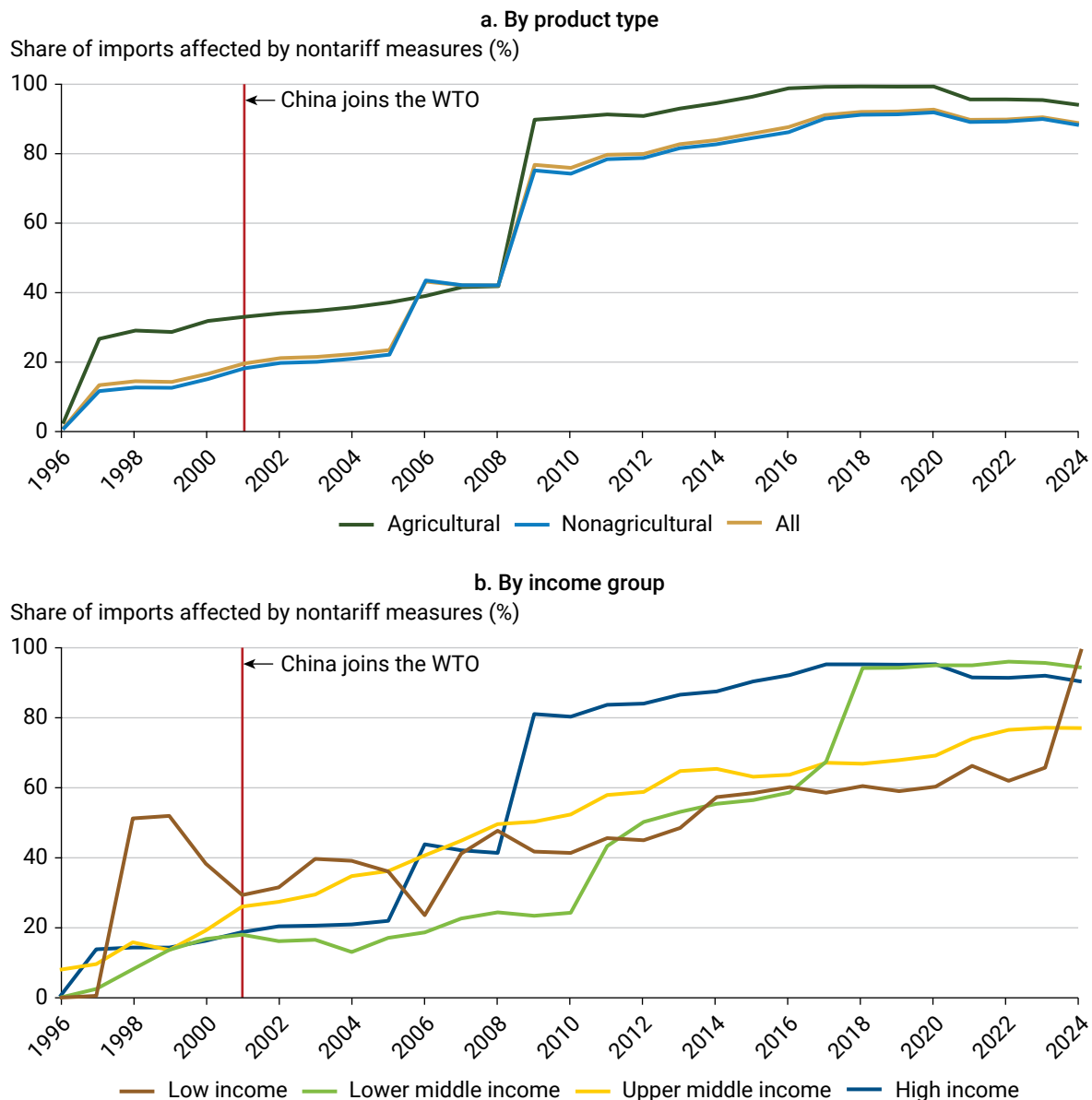
economic growth: an export orientation, a culture of quality, strong participation by the private sector, and sustained investment in quality infrastructure, both physical and human expertise—all tied to tapping external knowledge.

Coherence of a country’s policies involving regulations is as important. The recent surge in nontariff measures is not restricted to advanced economies; such measures are increasingly common among developing countries and can choke trade between countries, hurting consumers and preventing firms from scaling up (refer to figure O.5). Priorities in this area include regulatory alignment among countries, building capacity among a country’s firms, and facilitation of trade.

Governments should base technical regulations on international standards wherever possible and deepen cooperation through mutual recognition agreements: arrangements that allow trading partners to accept the results of one another’s testing, inspection, and certification. Such agreements prevent firms from having to prove compliance twice (once in the originating country, then again in the destination country), lowering costs and speeding up the entry of products into markets.

Engaging the private sector helps clarify the role of private standards, and digital portals and transparency tools can help firms anticipate and adapt to regulatory changes. Private standards have enabled outsourcing and improved sustainability practices, but their proliferation has created a “spaghetti bowl” of overlapping requirements that increase certification costs and fragment markets. Often spurred by stringent regulations in advanced economies (such as those surrounding food safety), private standards can inadvertently entrench the power of large global buyers and exclude smaller producers unable to shoulder the burden of complying with them.

Figure 0.5 Technical nontariff measures are now the main impediment to trade globally



Sources: WDR 2025 team calculations, based on data from TRAINS [Trade Analysis and Information System] (portal), United Nations Trade and Development, <https://trainsonline.unctad.org/home>; WITS: World Integrated Trade Solution (database), World Bank, <http://wits.worldbank.org/WITS/>.

Note: The figure plots the share of imports regulated by technical nontariff measures: sanitary and phytosanitary measures, technical barriers to trade, and preshipment inspections. The sample includes all countries surveyed for the TRAINS database since 2020 and all nontariff measures enacted since 1996. WTO = World Trade Organization.

To ensure that regulations protect consumers without morphing into protectionism, advanced economies should simplify technical regulations and make them more transparent. Doing so would lower compliance costs for producers in developing countries, an urgent task as tariffs and other trade barriers rise.

The benefits of well-designed standards extend beyond trade and competitiveness: Well-designed standards also shape the quality and inclusiveness of employment. As standards raise productivity and product quality, they also generate better jobs. By reducing uncertainty and facilitating trade and investment, they fuel firm growth and, with it, demand for labor. Upgrading to higher standards brings new technologies, better management, and new skills, creating learning and employment effects along the value chain. In services in which trust depends on certification, skills standards and professional accreditation help workers move across firms, sectors, and borders, aligning training systems with employer needs and making labor markets more inclusive. Yet a familiar challenge remains: Can countries raise standards for decent work without setting the bar so high that firms or workers retreat into informality?

Well-being: Standards for health and education

Developing countries can improve health and education by strengthening standards for measurement and input, supported by relevant components of quality infrastructure, to make outcomes in these two areas reliable and enable them to be compared. Although international standards in these two areas that embody best practice can serve as benchmarks, they need to be adapted to specific national contexts, given differing needs and resource constraints. In environments with limited resources, ambitious standards will not be achievable at scale. The more likely result is rationing of health and education services, benefiting the privileged.

Rather than by adopting international standards unchanged, countries achieve their desired outcomes in the area of human capital when they align their standards with enforcement capacity and update them as their capacity grows—that is, by adapting them to domestic needs and capabilities. National medicine lists are a good example. In compiling these lists, countries adapt the World Health Organization (WHO) Model Lists of Essential Medicines not only to their health needs but also to the compliance capacity of domestic firms. As countries' income per capita increases, the number of medicines from the WHO list on the countries' national essential medicines lists increases.¹⁵ Thus, lower-income countries adapt the list to a lower standard to minimize the potential gap in compliance among firms, then continue to adapt it to higher standards as those firms' capabilities progress.

Successful practices in Brazil, China, and South Africa show the effectiveness of the adapt-align-author sequencing in standards development discussed earlier in this overview, sensibly matching countries' ambitions to their abilities while ratcheting up both. A great example of progressing to higher standards through an adaptive approach to standard setting is the “barefoot doctors” scheme in China. In 1965, China shifted its health policy to focus on rural areas, reallocating resources to train and provide a paramedic, popularly referred to as a “barefoot doctor,” for each village. Instead of the standard medical school curriculum, training for barefoot doctors focused on basics like disease prevention, diagnosis and treatment of common symptoms, family planning and birth attendance, women's and children's diseases, and first aid. As China's system matured, the country gradually raised its standards, in 1984 requiring barefoot doctors to pass a new set of professional tests to become “village doctors.”¹⁶ WHO later praised the model for providing the greatest health benefits with the least amount of investment.¹⁷

In education, the achievements of the state of Ceará in Brazil illustrate the recommendation “adapt what you adopt as you implement.” Initial education reforms in Ceará (1997–2000) successfully increased school enrollment but not student learning. In response, the state launched a second phase based on clear standards for foundational learning, integrating this goal with updates to systemwide standards, including reforms to the curriculum focusing on basic literacy and numeracy, professional development for teachers aligned with new instructional methods, and regular state-level assessments to track student progress. Although local adaptation was promoted, meeting state benchmarks for literacy and numeracy became a requirement for accessing additional state funds. Within two decades, Ceará achieved nearly universal literacy by the end of grade 2.¹⁸

As developing countries attempt to leverage digital technologies to increase human capital in remote areas, they need to pay greater attention to the standards underpinning these technologies. Telemedicine potentially allows millions of people living in remote areas to access medical services. As an example, Telemedicine Africa operates a virtual telemedicine consultation center that makes specialists and general practitioners available to patients across Limpopo, South Africa’s poorest province, saving the rural population millions of dollars each year on travel to urban hospitals.¹⁹ Similarly, digital technologies are extending instructional support to millions of learners.²⁰

Elsewhere, Uruguay’s Ceibal program has helped position the country as a global leader in digital learning.²¹ Realizing the promise of initiatives like Ceibal and Telemedicine Africa, however, requires clear standards for digital infrastructure to ensure that all service providers, as well as patients and students, have secure access to devices, internet connectivity, and digital platforms.

Stability and safety: Financial and environmental risks for resilience

As noted earlier in the section, economic growth is essential for developing countries. But it brings with it risks that can undermine stability and resilience, from financial bubbles to the erosion of natural wealth to societal risks arising out of new technologies like AI. It is increasingly evident that without the guardrails that standards provide for managing risks robustly, risks can undermine the fruits of economic growth, turning it into something uneconomical.²²

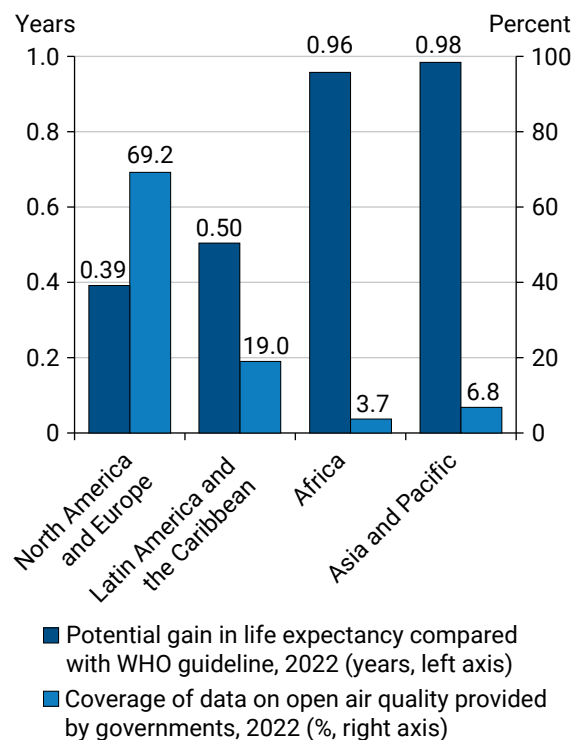
Weak or absent financial standards and lax enforcement of standards when they do exist have been the one constant in the recurrence of human folly in the form of financial crises for nearly a millennium, afflicting both high- and low-income countries.²³ Financial standards underpin a country’s financial and economic stability. But these standards need to be calibrated for risk, the way the standards embodied in the Basel Capital Accords are. As with standards in other areas, financial standards need to evolve as a country’s financial system develops and new technologies emerge. On the one hand, the anti-money laundering standards of the Financial Action Task Force (FATF) have curbed money laundering, but their lack of calibration to accommodate situations in individual countries has also made it much more difficult (and expensive) to send remittances to conflict-ridden countries.²⁴ For example, in Pacific Island countries, the withdrawal of correspondent banking relationships by international banks has sharply reduced access to cross-border financial services, constraining trade, tourism, and remittance flows. On the other hand, other FATF standards, such as those relating to customer due diligence measures, can be expanded to cover virtual assets such as cryptocurrencies, although their decentralized and transboundary nature will require new approaches for implementing and

enforcing them effectively. Experience with the Basel framework has shown that standards need to be transparent and adapted (specifically, using a tiered approach) to enable effective monitoring and supervision; similar principles should be applied to standards for the multitude of nascent virtual assets.

A mounting threat to countries' resilience comes from growing environmental stress. For low-income countries, the immediate priority is economic growth and poverty alleviation; environmental concerns understandably rank lower on their policy agendas. Given the well-known negative effects of pollution—to focus on the most potent among the environmental stresses countries are facing—on health, worker productivity,²⁵ and human capital²⁶ and so ultimately on long-term economic growth, middle-income countries have strong incentives to avoid the “develop first, pollute, and then clean up” pathway of today's developed countries.²⁷ Additionally, recent examples, such as China's quick rise to global leadership in electric vehicles and renewable energy, show that developing countries can leapfrog polluting technologies, especially in key sectors like energy and transportation.

No meaningful action can be taken to address environmental issues such as pollution, however, without accurate measurement standards. Most of the world's population lives in areas that lack reliable data on their exposure to pollution (refer to figure O.6). Only 3.7 percent of governments in Africa, 6.8 percent of those in Asia, and 19 percent of those in Latin America provide dependable data on air quality.²⁸ Similarly, more than 3 billion people worldwide are at risk of disease as a result of the unknown quality of the water in rivers, lakes, and groundwater, largely because of insufficient monitoring.²⁹ Data on soil contamination are even more scarce. Expanding and improving systems for monitoring the environment is therefore critical for identifying challenges and strengthening the enforcement of standards.

Figure O.6 Most of the world lives in places for which reliable data on pollution exposure are lacking



Source: Hasenkopf et al. 2023.

Note: The figure creates “potential gain in life expectancy compared with WHO guideline” as a measure of air pollution to account more effectively for differences in population exposure across locations. Specifically, it measures the potential gain in life expectancy, in years, if levels of particulate matter with a diameter of 2.5 micrometers or less were reduced to the WHO guideline of 5 micrograms per cubic meter. For example, high levels of particulate matter in uninhabited parts of the Sahara may have limited impacts on outcomes relating to human health and economies because there is no population to experience the negative effects, whereas they can have devastating impacts on highly populated areas. Refer to AQLI: Air Quality Life Index, EPIC Clean Air Program, Energy Policy Institute, University of Chicago, <https://aqli.epic.uchicago.edu/>. WHO = World Health Organization.

In addition to increasing capabilities for monitoring in order to provide more comprehensive data, developing countries need to strengthen the standards that form the foundation for building systems that monitor pollution, as well as those that ensure the quality, consistency, and

transparency of pollution data. The last of these, transparency, is important for raising awareness and thereby fostering action, not only by governments and polluters, but also by individuals, to push governments to take stronger measures to rein in pollution. It also empowers individuals to adopt adaptive behaviors to mitigate harm, such as avoiding pollution hot spots or using filters to clean their water.

Standards will be central to confronting the twin challenges of meeting the rising demand for energy and reducing local pollution and mitigating emissions. Measures to adapt to climate change, such as greater reliance on air conditioning to cope with extreme heat, will also boost electricity consumption. To curb the growth of demand for energy, developing countries need to use standards across the energy supply and usage chain, for areas ranging from generating power to transmission and distribution lines to the energy efficiency of buildings and household appliances.

Although environmental standards should be embedded within a broader coordinated framework to balance competing objectives, there is a clear tension between a “fit-to-context” approach and justifiable fears of a race to the bottom. Differences in standards across jurisdictions can—and do—lead to pollution leakage, in which polluting activities shift to jurisdictions with weaker standards regarding pollution, thereby undermining environmental goals. Coordinated international efforts, such as the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, that regulate flows of materials like plastics and prohibit trade with countries that are not parties to the convention can mitigate such leakage.

Making it happen: Standards to strengthen governments

To design standards effectively and ensure compliance, governments must put their

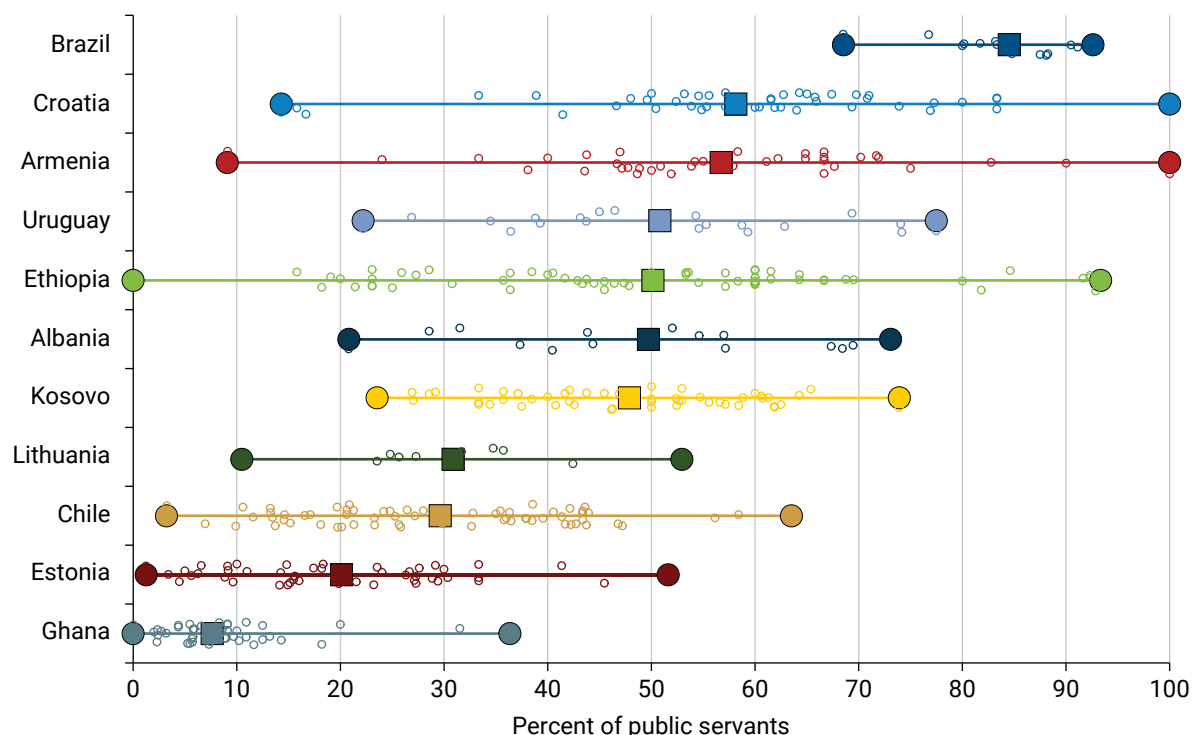
own houses in order. They can do so by using standards to strengthen their governance of public institutions responsible for implementing policies.

Standards-based governance ensures that three sets of standards, encompassing organizational functions common to all public institutions, are established according to a government’s ability to comply with them. The first set are *budget standards*, which ensure that payments are disbursed on time and consistently measured. The second set are *recruitment standards* that build competency by ensuring personnel are selected through objective assessments (such as written examinations; refer to figure O.7). The third are *procurement standards* that uphold the transparency and competitiveness of government tenders.

Standards-based governance ensures a consistent approach to the classification and measurement of government activities. For instance, budget standards such as the United Nations Classification of Functions of Government set a unified framework for classification and measurement within budgets. *Quality standards* should codify procedural requirements and guidelines for institutions and their personnel to apply in their organizational routines. For example, a procurement standard can specify that government tenders require competitive bidding (that is, an open tender).

Setting and implementing standards for governance comes with a cost, however. For instance, the administrative burden of complying with standards reallocates scarce institutional and personnel time from implementation to compliance. To mitigate operational costs and amplify benefits, governments need to assess the organizational impact of standards regularly and put standards into practice through an iterative approach driven by priorities. This requires collecting and analyzing survey and administrative data on organizational processes, as well as listening to the voices of

Figure 0.7 Governments have no standard criteria for recruiting talent



Source: WDR 2025 team calculations, based on data from Global Survey of Public Servants, Data Downloads, Bureaucracy Lab, Development Impact Group and Governance Global Practice, World Bank, <https://www.globalsurveyofpublicservants.org/data-downloads>.

Note: The figure reports the latest data available by country. Each small hollow circle in the figure represents an organization-level share of respondents in a particular country who were selected through a written examination, whereas the range of each horizontal line indicates the minimum and maximum shares (large bullets) observed in organizations in that country. The blocks represent national average shares at the organizational level.

institutions, public sector employees, and citizens using particular government services. Through this approach, governments should pragmatically put a priority on enacting and practicing standards that work better for the main stakeholders, rather than general “best practices.”

Despite the costs, however, governments that adapt governance standards to national needs and resources reap big dividends. For example, the government of Viet Nam adapted International Public Sector Accounting Standards as a tailored national framework, the Viet Nam Public Sector Accounting Standards.³⁰ Recognizing the

significant costs of implementing and the complexity of a full-scale overhaul of the government’s accounting system, Viet Nam rolled out the new accounting standards gradually over multiple years and targeted specific aspects, such as assets, using a modular approach. The Public Expenditure and Financial Accountability framework offers an evidence-based assessment that governments can use to understand public financial management; the assessment draws on policy reviews, data analysis, and engagement with government officials.³¹ This contextual information enables governments to take a more tailored approach to implementing standards in their governance.

Priorities for policy makers

Historically, given their weak technological capabilities, developing countries have been standard takers rather than participating actively in the development of international standards, in which they have been significantly underrepresented. Whereas low-income countries participate in just 7 percent of all active ISO technical committees, high-income countries participate in 84 percent of them.³² In other words, most international standards are developed with scarcely any representatives from developing countries at the table. Even more strikingly, developing countries also send far fewer delegates to meetings at which international standards are developed. On average, advanced economies send 525 delegates to ISO meetings per year. Low-income countries send only 9, lower-middle-income countries merely 14, and upper-middle-income countries just 65. It is no wonder that some international standards fail to address the needs of developing countries: These countries have not been effectively involved in their development.

But with massive technological changes underway, developing countries risk being locked into costly or ill-fitting technological trajectories and relegated to reduced policy autonomy if they remain passive adopters of standards created by advanced economies and multinational corporations. These countries must become more active participants in shaping standards relevant to the countries' priorities, including standards for interoperability and compatibility standards in emerging technologies. Such engagement is not just defensive but strategic: It allows developing countries to ensure standards are tailored to local realities, such as connectivity challenges, privacy needs, risk management, and language diversity, while building the capabilities necessary to compete in fast-evolving global value chains.

Priorities for low- and middle-income countries (that other countries may also want to consider)

For standards to be a springboard for development, policy makers in developing countries should follow the adapt-align-author model discussed earlier in this overview. They will need to start by tailoring standards to local realities (the adapt phase), move toward convergence with global standards as capacity grows (the align phase), and ultimately help write them (the author phase). Done well, the adapt-align-author sequence turns standards into market access, investment, and increases in living standards.

Table O.1 summarizes the priorities for developing countries.

Use standards as springboards

Upgrading quality without defaulting to mandatory standards will need to be the starting point in developing countries. Governments will need to embed standards in economic policy so that certification opens doors: to public contracts, export promotion, schemes for supplier development, and cheaper finance. When buyers and financial institutions reward the use of standards, entrepreneurs will aim for the badge on their own. For instance, Japan's diffusion of total quality management owed more to peer learning and procurement signals than to edicts. Further, India's shift from incandescent bulbs to lighting that employs light-emitting diodes succeeded because voluntary standards aligned incentives across the supply chain, with selective certification to help gain consumer trust.

Next, governments in developing countries will need to adapt quality standards to bring them in line with the compliance capacity of stakeholders. Setting the bar too high merely drives firms into the shadows. It is better to publish tiered

Table O.1 Main policy recommendations regarding standards for development

RECOMMENDATIONS FOR LOW- AND MIDDLE-INCOME COUNTRIES (THAT OTHER COUNTRIES MAY ALSO WANT TO CONSIDER)		
Use standards as a springboard for development, not as a straitjacket.	Learn to use the full toolbox of standards for policy, not just the hammer.	Use quality infrastructure to realize the full potential of standards.
Create the conditions needed for firms to upgrade quality; don't enforce such upgrading with mandatory standards. Improve fundamentals (macroeconomic environment, rule of law) in the country to create demand for standards. Integrate standards into broader industrial policies. Adapt quality standards in line with the capacity of stakeholders to comply with them. Overly ambitious standards that cannot be met create risks. But if standards need to be adapted to the local context, do so systematically to avoid creating hurdles for that country and others. A tiered approach involving standards with varying degrees of strictness may help with systematic adaptation of standards. Show up and speak up in international standards forums and share findings at home. Attend international meetings of organizations such as ISO and the IEC to influence international standards, and use the process as an opportunity for learning. Virtual participation, often now possible, helps reduce travel costs.	Use standards as a flexible tool in public policy. Combine voluntary standards and regulation to pursue innovation-friendly policy approaches. Require all sectoral regulators and other government bodies to use quality infrastructure^a consistently. Using uniform approaches to compliance across the government and sharing facilities like testing laboratories save public resources and avoid creating nontariff barriers to trade.	Sequence the development of quality infrastructure^a according to market demand and country preferences. Infrastructure (such as laboratories) can be expensive and should grow together with countries' demands in order to optimize use of quality infrastructure resources. Develop capacity for compliance as a public-private partnership. It is often more cost-effective for the government to oversee compliance with standards than to carry out all compliance checks in government facilities. Focus on the availability of quality infrastructure, not the location. Not all quality institutions need to be physically located in each country. Share costly laboratory infrastructure with regional partners. Leverage digital tools for better quality infrastructure. Low- and middle-income countries can benefit from leveraging digital technologies to make quality infrastructure more accessible and cost-effective.
RECOMMENDATIONS FOR THE GLOBAL COMMUNITY		
Develop international standards that better serve low- and middle-income countries.	Ensure that well-intended standards do not become barriers to development.	Tackle global challenges.
Support low- and middle-income countries in the process of developing international standards—or risk low uptake. Inclusive processes for developing standards should include voices from low- and middle-income countries. Support is needed to make international standards truly international. Promote tiered standards to match different capacities. From the design stage, standards should integrate varying capacity levels of countries.	Deepen international regulatory cooperation. Regulation grows more complex over time, creating the risk that standards become barriers to trade. Early cooperation on regulations helps prevent this. Tidy up the “spaghetti bowl” of standards. Even if standards are voluntary, fragmentation (multiple standards for the same product or service) has become a problem in some areas. Consolidating by building trust and mutual recognition is key. Amass more data and evidence. Standards are an underappreciated and underresearched topic. More data and evidence are important to inform regulatory impact assessments and guide policy makers.	Set and comply with standards now—or face crises later. The risks of unchecked technological progress like artificial intelligence and environmental degradation grow exponentially, outweighing the benefits. Standards are essential to align technological development with societal preferences.

Source: WDR 2025 team.

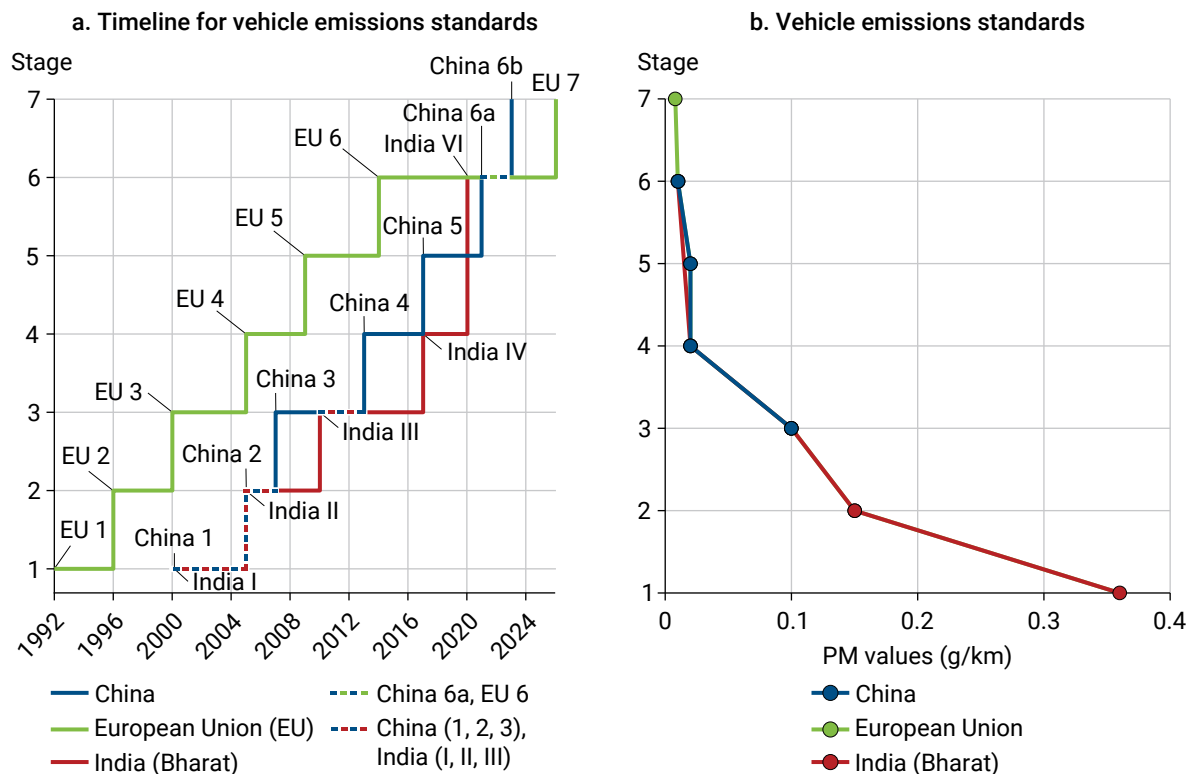
Note: IEC = International Electrotechnical Commission; ISO = International Organization for Standardization.

a. “Quality infrastructure” refers to a system of public and private organizations and policies that provide services such as testing, inspection, certification, metrology, accreditation, and standardization.

requirements, pursue performance-based criteria for evaluating compliance, and allow generous transition periods that map an escalator from today's abilities to tomorrow's ambitions. For instance, in countries like Kenya, there have been efforts to provide simplified requirements for GLOBALG.A.P. that let smallholders use good agricultural practices that actually stick, while

keeping in sight the target of producing commodities of sufficient quality for export.³³ Large economies have long since mastered the art of sequencing: Think of how China, India, and the EU ratcheted up rules governing vehicle emissions over time, letting industry invest and regulators sharpen their teeth (refer to figure O.8). The message: Calibrate, then climb.

Figure O.8 Standards governing vehicle emissions and air pollution in China, India, and the European Union followed a tiered approach to stringency



Sources: China: Emission Standards, China: Heavy-Duty Engines (dashboard), DieselNet, <https://dieselnet.com/standards/cn/hd.php>; ICCT 2017. European Union: Emission Standards, EU: Heavy-Duty Truck and Bus Engines (dashboard), DieselNet, <https://dieselnet.com/standards/eu/hd.php>. India (Bharat): Emission Standards, India: Heavy-Duty Truck and Bus Engines (dashboard), DieselNet, <https://dieselnet.com/standards/in/hd.php>; data as of September 7, 2017, from Vehicular Exhaust (web page), Central Pollution Control Board, Ministry of Environment, Forest and Climate Change, India, <https://cpcb.nic.in/vehicular-exhaust/>.

Note: The emissions standards in the figure are those for heavy-duty vehicles (those with compression ignition engines) for steady-state testing. EU = European Union; g/km = grams per kilometer; PM = particulate matter.

Standards need to be adapted to local circumstances especially in the case of nontradable services like education, health, and public administration. Simply importing high standards can lead to *isomorphic mimicry*, in which countries set high standards without expecting to enforce them. Standards far above what local administrative systems can implement create “premature load bearing”: overly optimistic assumptions about progress and increasing capability that place excessive stress on systems and cause them to weaken or even collapse.³⁴

Developing countries should consider operating a dual regime to serve both exporters (by offering them assistance in meeting international standards) and domestic consumers (by adapting those standards for domestic markets). For exporting sectors, full compliance with (unadapted) international standards is critical for competing in export markets, as is expanding access to accredited testing and certification. Most domestic firms in developing countries, by contrast, are very small and serve consumers who are highly sensitive to prices and thus put a priority on affordability over quality. These firms need adapted, graduated requirements to avoid being excluded. Policies that help firms grow are likely the best way to enable them to cover the fixed costs of adopting standards. Korea’s early schemes for inspecting exports, used judiciously to protect brand reputation, and South Africa’s decisive ban on 2G phones to accelerate adoption of mobile internet show how dual tracks can be calibrated.

Developing countries will also need to show up and speak up in meetings in which international standards are developed—and bring the learning home. For countries that trade, the rules of the game are increasingly written not just in ISO, IEC, and ITU committee rooms, but in nongovernmental consortia for developing standards like the Internet Engineering Task Force (IETF, internet), 3GPP (mobile communications), Institute of Electrical and Electronics

Engineers (IEEE, robotics), and SAE International (aerospace).³⁵ Developing countries will need to pick the committees that matter for prominent sectors in their economies—say, those involved in developing standards for off-grid renewable energy systems, food safety, or digital technology—and fund expert participation in them. They will also need to mirror these committees in national organizations to help translate the deliberations of these committees into domestic guidance and curriculums.

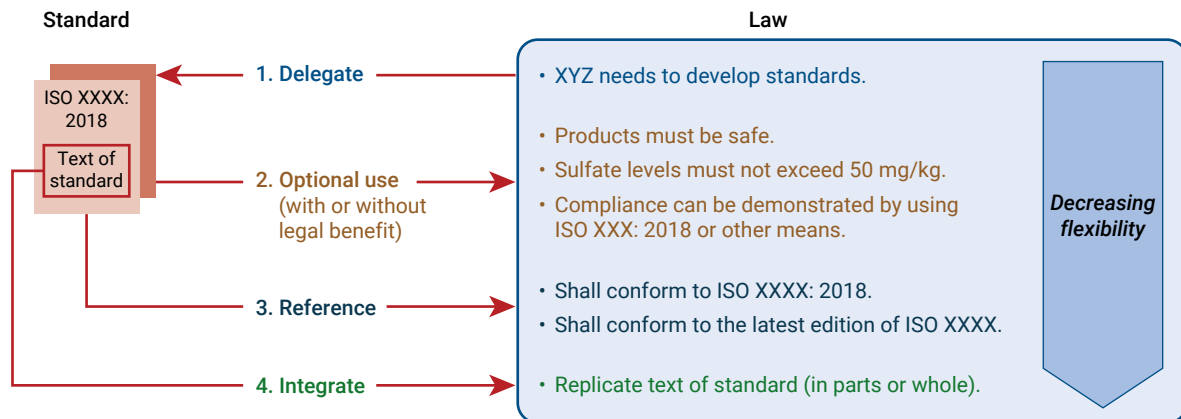
China’s reforms of its standards during the country’s post-1978 reform era, which shifted standards from a basis in bureaucratic fiat to a regime more driven by the market while leaning into international forums, show how active engagement shapes both domestic modernization and the global rule book. Influence travels with attendance, and so does know-how.

For standards to truly work as springboards for development, governments need to use mandatory standards sparingly, in instances in which risk is clear and enforcement credible. Essential public interests such as health, safety, and air or water quality are obvious examples. However, before mandating, countries need to be self-disciplined and ask: Is there a material risk or market failure, are benefits likely to exceed costs, and can the requirements be enforced? And importantly: Can voluntary standards and regulation be combined in a mixed approach that fosters innovation while achieving the objectives of public policy?

Use the full toolbox of standards, not just the hammer

Policy makers in developing countries will need to combine regulation with voluntary standards, because regulation cannot and should not specify every technical detail involved in compliance. Doing so would create compliance burdens, overwhelm government capacity and technical expertise, and make regulations too rigid to allow for innovation.

Figure O.9 Standards can be used in regulation in a variety of ways



Source: WDR 2025 team.

Note: ISO = International Organization for Standardization; mg/kg = milligrams per kilogram.

Laws should be written for outcomes that society cares about: product safety, privacy, and energy efficiency, for example. Standards should define technical details regarding how to achieve these outcomes (refer to figure O.9). This enables countries to keep policy current as technology changes and allows fast-track updates to referenced standards without excessive legislative churn.

The EU has long practiced this art: Firms in EU member countries can meet “essential requirements” using harmonized standards or evidence of equivalence. The EU’s regime regarding AI takes the same tack, making risk management mandatory for high-risk systems while leaving technical specifics to voluntary standards. For developing countries, this approach trims administrative burdens and keeps domestic rules aligned with those for global markets, but it requires increases in government capacity for things such as market oversight and enforcement.

The use of quality infrastructure consistently by all regulators will cut costs. Policies committing sectoral regulators to accept results from accredited laboratories and inspection and certification bodies are of particular importance. Agencies can share costly facilities—general testing laboratories and metrology equipment, for example—through

service-level agreements rather than duplicating capacity. This averts the creation of a spaghetti bowl of duplicative checks that drive up compliance costs and act like a hidden nontariff barrier.

Private standards and third-party assurance of conformity should be leveraged where they help meet public goals. Governments should recognize (indeed, encourage) private initiatives for quality assurance, subject to transparency and oversight, and let accredited third-party assessment of conformity extend the reach of thin inspectorates. The United Kingdom’s “earned recognition” approach—reducing inspection burdens for operators achieving certain certifications—demonstrates how public authorities can focus scarce resources on actors that present higher levels of risk while maintaining adequate levels of protection. The key is to anchor recognition in accreditation and publish performance data so that competition and trust reinforce one another.

Although governments with sufficient capacity can enforce compliance with safety standards, in many cases, developing countries do not have such robust enforcement capacity. When this is the case, private instruments like insurance might be feasible alternatives, as demonstrated by the history of standards regarding boiler safety.³⁶

The toolbox of standards can be applied to fast-moving digital technologies in such a way that only high-risk applications of these technologies face mandatory standards, whereas lower-risk uses rely on voluntary standards, documentation, and postmarket surveillance. Developing countries can adopt relevant standards for a specific technology and build pathways for conformity—testing protocols, audit criteria, templates for technical documentation—so that innovators know how to comply with the standards. Regulatory sandboxes—in which regulatory requirements are relaxed to enable learning regarding policies—tied to programs of work in areas of standardization should be developed to ensure that lessons from pilot programs flow back into clearer guidance and better standards.

The enormous potential of digital technologies for transforming development rests on digital public infrastructure, the shared and extensive digital systems and platforms that enable essential services to be delivered on a large scale.³⁷ It is important that the core layers of digital public infrastructure be built on open standards (that is, standards that are generally accessible to all potential adopters without restrictions on use) as opposed to closed standards (that is, standards under the control of a single firm or consortium, which may impose licensing fees or constraints on their use) to avoid locking countries into a single vendor or development trajectory. A number of governments, including those in Brazil, India, and South Africa, have adopted policies requiring open standards for digital public infrastructure.³⁸

At the same time, governments need to recognize that in certain technology domains, the most advanced standards may involve some patented technology. In these domains, a hybrid approach based on principles is the most pragmatic: Use open standards wherever possible, particularly in regard to interfaces, but consider adopting proprietary technology if it serves the public interest

and does not undermine the overall openness of a system.

Build compliance capacity with quality infrastructure

Quality infrastructure needs to be matched with demand for it, not desire for it. Policy makers should start with the essentials: a capable national standards body; basic metrology; and practical access to testing, inspection, certification, and accreditation (on a regional basis, if need be). Specialized laboratories can be added when markets justify them, with equipment for cross-sector use the highest priority. Models for recovering costs and e-metrics for service quality should be developed from the inception of quality infrastructure in a country, so that institutions are rewarded for delivery, not just buildings. Regional mutual recognition arrangements and centers of excellence can give firms credible test results without every country buying the same expensive machines and then finding they lack the human capital to operate them.

Next, compliance capacity should be developed as a public-private partnership and evolve as markets mature. When private providers are thin on the ground, the state may need to fill gaps, carefully separating the roles of regulator and service provider to avoid conflicts. For instance, Codex offers guidance on overseeing such systems in food safety.

The focus should be on the availability of services, not the postal codes where they are located. What firms need is timely, credible results, whether from a laboratory downtown or one across the border in the next country. Policy makers should lean on international and regional arrangements for accreditation, so that buyers accept test reports where products are sold regardless of where they are made, and access needs to be negotiated with regional laboratories for pricey, specialized tests. Logistics in shipping and customs clearance need

to be streamlined so that turnaround times are predictable. Africa's push for harmonized technical regulatory frameworks points to the gains from regional thinking along these lines. Building regional quality infrastructure will anchor it in more robust foundations. And as the EU's embrace of USB-C plugs has shown, alignment and recognition of standards often matter more than duplicating infrastructure at home.

Finally, countries should broaden their enforcement tool kits beyond inspectors. Insurance and tort law can complement state enforcement of safety, and universities and professional societies can help keep standards current and relevant. Consumer protection groups can act as public watchdogs, running comparative tests that keep producers honest and consumers informed. In settings in which capacity is thin, such pluralism is not a luxury: It is how credibility scales faster than the civil service can.

How the global community can help

Develop international standards that better serve developing countries

The first responsibility for developed countries is to open up and actively support the participation of developing countries in developing international standards. As discussed earlier in this overview, representation in international standards development organizations is structurally imbalanced: High-income economies and China sit on far more technical committees and send many more delegates to the meetings of these organizations, so the standards coming out of these committees often miss the realities in lower-capacity settings. This is understandable at one level, given the deeper pools of expertise in more developed countries. Advanced economies should provide funding, mentorship, and technical assistance to ensure experts from developing countries are at the table, both to improve the quality and

legitimacy of standards and to increase uptake of them. This is an act not of charity, but of pragmatism: Standards that are cocreated are more likely to be implemented consistently across markets, reducing frictions and enhancing global interoperability.

A second, design-centered role for developed countries is to promote tiered or modular standards that match the different capacity levels of countries and firms. By embedding graduated stringency in the standards they develop, international standards development organizations can enable gradual adoption and upgrading without disrupting trade. Designs that follow such a development model recognize heterogeneous regulatory and firm capabilities and create clear pathways for convergence with international standards over time.

Deepen international cooperation regarding mandatory standards

A key area for global focus is deepening international cooperation so that well-intended mandatory standards built into regulation in advanced economies do not hinder development elsewhere. As regulation becomes more complex—across climate, deforestation-free supply chains, digital markets, and product safety—the risk of conflicting requirements from one country to the next increases. Early coordination on common terminology, baseline principles, and mutual recognition of compliance mechanisms can prevent standards from turning into de facto trade barriers. Building trust is central here, as mutual recognition depends on confidence in other countries' systems for assessing conformity.

The global community also needs to move faster to agree upon and implement credible standards that mitigate global technological risks. In areas like AI, biotechnology, and digital platforms, innovation outpaces governance, shifting externalities from new technologies onto societies

and ecosystems. Unilateral action is insufficient to address global technological risks and can fuel a race to the bottom; collective agreement on guardrails is required to align technological development with societal preferences and to avoid crises that are far costlier to manage after they have already occurred than when they are merely risks.

Standards remain underappreciated and under-researched, partly because they take many forms and act alongside other policies. The global community, including international organizations, standards development bodies, and academia, should invest in better data regarding standards: firm-level surveys that capture uptake across sectors and firm types, richer metrics regarding quality infrastructure, and accessible administrative data sets. The stronger evidence base that results from these additional data will help refine tiered designs for standards and evaluate what models of cooperation prevent fragmentation most effectively.

Although developed countries should do more to share the table and redesign the tools, the global community needs to strengthen the overall framework—cooperating early, governing emerging risks credibly, and building the evidence needed to make standards a true instrument of rapid economic development.

The paradoxical landscape of global standards

The global standards landscape is full of paradoxes. On the one hand, standards are proliferating—especially across environment, social, and governance domains—spanning measures as well as international rankings, ratings, and indexes.³⁹ Although many standards in these domains are formally voluntary, they have become de facto mandatory, and compliance with them imposes heavy demands on developing countries given their current capacities.

On the other hand, emerging, transformative technologies have few guardrails in the form of international standards. Despite their potentially grave implications for human safety and well-being, intense geopolitical rivalries have precluded prompt establishment of the necessary safeguards in these areas. When a bag of chips has about as many international standards as AI, which can upend the lives of billions, it is a sober reminder that the global community is “pitying the plumage but forgetting the dying bird.”⁴⁰

Amid the strong gusts of the winds of global disorder and societal distrust, standards offer a safe harbor, anchoring order and trust. Without them the task of development becomes much more arduous.

Epilogue: Standards in development economics

World Development Report 2025 has been written by a team of development economists. In concluding this overview, the team looked within standards in the development economics profession.

A striking finding in recent research is the severe underrepresentation of developing countries in development economics, with the severity increasing for journals with higher ratings in academic quality or prestige: the ones that really matter for recognition within the field. According to one study, “Fields such as international or development economics where global diversification may have been expected have not experienced much increase in developing country authorship. These results are consistent with a general increase in the relative supply of research in the rest of the world. But they also indicate authors from developing countries remain excluded from the profession’s top-rated journals.”⁴¹

Is this because these journals have high standards for publication of studies and researchers from developing countries are unable to clear the bar?

If so, this may reflect a lack of talent and expertise or point to resource constraints. For instance, if the journals' standards favor a certain type of methodology that requires a great deal of resources, such as randomized controlled trials, then the substantial costs of conducting research that employs such methodology might be a formidable entry barrier for researchers working on economic development who are based in developing countries.

However, in science, technology, engineering, and mathematics, in contrast to economics, the share of articles from developing countries in leading journals has been steadily increasing, with the surge led primarily by China, but also India and several other countries.⁴² High standards in academic publications alone would not explain these contradictory trends. A more likely explanation is that compared with publication in scientific fields, publication in top social science journals is a more discretionary process in which the tastes of the editors and those reviewing potential articles matters more. In other words, it is less about meeting standards than about the ambiguity of the standards themselves. Standards, as defined by this *World Development Report*, need to be precise. Enormous efforts are made in the process for developing standards to achieve this goal.

The absence of precision in standards can have exclusionary consequences. Because publication in top journals is the entry ticket to highly sought-after clubs in the field of development

economics, the absence in these journals of articles by researchers based in developing countries means those researchers are absent from these clubs as well. Take the Bureau for Research and Economic Analysis of Development (BREAD), which is dedicated to encouraging research and scholarship in development economics. Despite its goal, less than 2 percent of its affiliated fellows are based outside Europe and the United States. Less than 5 percent of the academic faculty members affiliated with the Abdul Latif Jameel Poverty Action Lab (J-PAL), the most influential global center for research employing randomized controlled trials, were based in developing countries, even though all the data used in their work are gathered there, with no representation from institutions in East Asia, the most successful region in regard to economic development. Just 6 percent of the 98 editorial board members of the *Journal of Development Economics* (whose title clearly states its objectives) are based in developing countries (and none in Africa).

This matters for development, as the views and voices of development scholars from emerging market and developing economies are not shaping global debates on development policy and perhaps even important questions specific to circumstances in their own countries. The development challenge is most pressing in Africa, making the exclusion of Africa-based voices even more glaring.

Notes

1. Bernhofen et al. (2016).
2. *Economist* (2013).
3. Kapur and Subramanian (2025).
4. Alder (1995).
5. Feiker (1922); Hoover (1922); Priest (1926).
6. Dunlavy (2025).
7. World Bank (2024b).
8. Choi and de Vries (2013); Lee and Kim (2025).
9. Choi and Choi (2019).
10. Refer to IEC: International Electrotechnical Commission (dashboard), <https://iec.ch/homepage>; oneM2M [one Machine to Machine]: The IOT Standard (dashboard), oneM2M Partners, <https://www.onem2m.org/>;

3GPP [3rd Generation Partnership Project] (dashboard), 3GPP Mobile Competence Center, European Telecommunications Standards Institute, <https://www.3gpp.org/>. oneM2M is a global partnership initiative among eight of the world's leading standards development organizations for developing specifications that ensure the most efficient deployment of machine-to-machine communication systems and the Internet of Things.

11. Lee and Lim (2001).
12. As defined in ISO and IEC (2020).
13. For the definition, refer to BIPM (2021, 7).

14. World Bank (2024b).
15. Based on data from Global Essential Medicines Database (data set), https://figshare.com/articles/dataset/GlobalEssentialMedicinesDatabase_xlsx/7814246?file=14541080; Persaud et al. (2019).
16. Fu (2025); Yiwon (2017).
17. Fu (2025).
18. Loureiro et al. (2020).
19. Tinsley and Agapitova (2018).
20. Muralidharan et al. (2019).
21. Luna-Bazaldua et al. (2025).
22. Costanza et al. (1990).
23. Reinhart and Rogoff (2009).
24. Refer to World Bank (2023) for information about a World Bank survey of documentation requirements among financial authorities around the world.
25. Chang et al. (2019).
26. Isen et al. (2017).
27. Damania et al. (2025).
28. Hasenkopf et al. (2023).
29. UNEP (2021).
30. World Bank (2024a).
31. Many assessments using the Public Expenditure and Financial Accountability framework are publicly available. For more information, refer to PEFA [Public Expenditure and Financial Accountability], Assessments, World Bank, <https://www.pefa.org/assessments>.
32. The participation rates of lower-middle-income and upper-middle-income countries are 15 percent and 46 percent, respectively (World Bank and ISO 2025).
33. Park and Gachukia (2021).
34. Pritchett et al. (2012).
35. Refer to IEEE (dashboard), <https://www.ieee.org/>; IETF (dashboard), <https://www.ietf.org/about/introduction/>; SAE International (dashboard), <https://www.sae.org/>; 3GPP (dashboard), 3GPP Mobile Competence Center, European Telecommunications Standards Institute, <https://www.3gpp.org/>. SAE International is an international standards development organization for the automotive and other industries.
36. Fressoaz (2025).
37. Sankritik and Shetty (2025); World Bank (2016).
38. Sankritik and Shetty (2025).
39. Cooley and Snyder (2015).
40. Shelley (1817/1880).
41. Aigner et al. (2025).
42. NSB (2023).

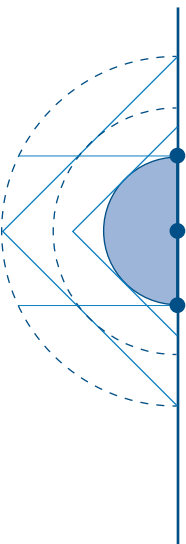
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PART 1

The Measure of Progress: How Standards Have Shaped Order, Trust, and Innovation

Part 1 offers an overview of how standards have supported humanity's pursuit of order, trust, and innovation by mitigating risk, establishing consistent practices, and upholding quality and safety.

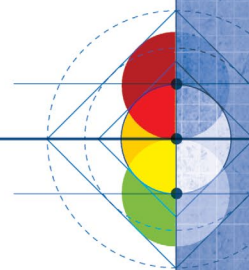
Chapter 1 examines the history of standards, from ancient systems of measurement to modern digital protocols, demonstrating how standards have served not only as technical tools, but also as means of coordination, authority, and exchange, supporting the governance of empires, the expansion of trade networks, and the advancement of science and industry. Developments in these areas have significantly contributed to nation building, market integration, and international cooperation, acting as catalysts for economic transformation.

Spotlight 1 illustrates how standards drove the East Asian development miracle in the second half of the twentieth century. The region's impressive success relied on three connected factors: strong state capacity to orchestrate systems of standards; export-driven strategies for growth to encourage upgrading of standards of quality; and the alignment of standards in smaller companies with those of leading firms, both international and domestic, for knowledge transfer.

Overall, part 1 examines both the pragmatic and the political factors underlying the expanding universe of standards. These include multiple trade-offs in the

development, adoption, and adaptation of standards to local contexts, the political forces that shape standards in situations in which large commercial and national interests are at stake, and the gaps, in the case of mandatory standards, between adoption and compliance. Part 1 sets the scene for the discussion in part 2 of the various types, forms, and functions of standards—and the crucial role of compliance.

1 A History of Standards



Main messages

- The evolution of standards reflects humanity's pursuit of order, trust, and innovation through harmonization of practices and mitigation of risks.
- *Measurement standards*, embedded in common understanding of units—as backed by metrology, the scientific study of measurement—have played a key role in projecting authority, building states, and strengthening markets.
- *Quality standards* have been essential in managing the risks that often come with new technologies and providing the assurance that ensures widespread adoption. Yet these types of standards have often been initially resisted until costs to public welfare become politically expensive.
- *Compatibility standards* have underpinned the diffusion and adoption of technologies, including those ushered in by each successive Industrial Revolution.
- Standards play an important role in managing risks arising from new technologies as well as in a wider understanding of negative externalities resulting from the expanding ecological footprint of industrialization and growing levels of consumption. Such standards matter for the quality of life: the deeper fundamental goal of development.
- Variations in social values, risk tolerance, market forces, and regulatory capacity affect the type and scope of standards.
- Standards often entail trade-offs. In the area of developing standards, these include inclusion of stakeholders versus speed and expertise versus capture. During the process of adopting standards, trade-offs exist between cost and quality, scale and diversity, and innovation and technology lock-in.

Introduction

Nearly 4,000 years ago, a dissatisfied customer in the Mesopotamian city-state of Ur penned the first recorded complaint in human history.¹ The complaint, written on a clay tablet with cuneiform script—a flourishing example of a standardized medium used for formal communication across parts of the region—charges a copper trader, Ea-nāšir, with several breaches of commercial expectations: the delivery of substandard copper, significant delays in transportation, and the mistreatment of his servant.² The dispute arose from a difference in measurement systems used to weigh copper at source and destination;³ the allegation of the servant's mistreatment further suggests expectations of basic normative labor standards.⁴ The complaint—and the copper consignment it describes—traveled through a network of messengers and caravans, illustrating the standardized infrastructure that supported communication and long-distance trade. Transactions relied on a standard silver-based monetary system for payments, supported by standardized administrative procedures: Scribes recorded accounts on clay tablets, sealed them in protective envelopes with cylinder seals, and archived them systematically.⁵

This story captures just how intertwined standards have been in human history, forming a codified ecosystem in terms of linguistics, commerce, measurement (metrology),⁶ money, and labor, that has mediated trust, coordination, and value since ancient times.

This chapter paints a broad historical canvas highlighting the three typologies of standards that are the focus of this Report: measurement standards, quality standards, and compatibility standards. Although measurement standards emerged in the premodern era, each of these types of standards grew over the course of the Industrial Revolutions that have marked the modern era, beginning with the First Industrial Revolution—the “age of steam”—beginning in the mid-eighteenth century.

Demand for standards skyrocketed during the late nineteenth century with the Second Industrial Revolution. The new “machine age,” defined by mass production, complex technologies with network externalities in transport and telecommunications, urbanization, and global integration, spurred needs for compatibility and quality standards underpinning safety. The dawn of the Third Industrial Revolution in the second half of the twentieth century—the “information age”—turbocharged the need for compatibility standards, which were vital for the internet revolution. It also marked a structural shift in economies from manufacturing to services, the many components of which would again need their own standards. At the same time, the environmental fallout from two centuries of technological changes and economic growth made the need for environmental standards clear.

Measurement standards

Early standards focused on basic measurement and aimed at establishing political control and facilitating commerce. “Man learned how to measure centuries before he learned to write, and it was through measuring that he learned to count. In the list of talents which sets man apart from other animals, his ability to measure ranks among the highest,” John Perry noted in *The Story of Standards*.⁷ Measurement was thus not only a practical skill, but a significant cognitive advancement that enabled humans to conceptualize. Initially, “man was his own measure”: Distances were gauged using the breadth of a finger, the span of a palm, or the length of an arm. These measurements, though imprecise and variable across individuals, sufficed when tasks were solitary and needs immediate.⁸

However, cooperative labor exposed the limits of measures based on the human body. When two workers used their own feet or arms to measure, their outputs would often be inconsistent.

To resolve this, measurements were often based on the dimensions of a leader, then encoded into physical proxies—such as measuring rods—for wider replication. In monumental constructions such as the pyramids, this logic was institutionalized with a single master standard embodied in a permanent object to ensure uniformity across dispersed labor groups.

In ancient Egypt (c. 2700 BCE), the royal cubit (*mahe*), a rod of 523 to 525 millimeters subdivided into seven palms and 28 digits, emerged as the primary standard. Precision was achieved through cubit rods made of wood or stone, used in constructing the Great Pyramid of Giza.⁹ The *khet* (a 100-cubit rope) standardized land surveys and tax assessments. The Roda nilometer, calibrated to the cubit, transformed Nile flood levels into measurable data, supporting agricultural planning and famine prevention.¹⁰ Standards developed in parallel in the Indus Valley, where the standardized “Indus foot” supported a modular regime for construction that centered on bricks with consistent proportions of 1:2:4.¹¹ Mesoamerican civilizations similarly relied on calibrated measures,¹² and in the Roman system of engineering, measurement underpinned large-scale water management.¹³

Beyond linear measures, standards measuring weight and volume formed the basis for trade, taxation, resource management, and administration. As seen in the Ea-nāšir complaint (c. 1750 BCE), disputes over weights could undermine trust in decentralized trade systems. In Sumer, where barley grains initially served as units of weight, merchants exploited natural variation by selecting larger grains to skew measurements.¹⁴ To counter this, durable stone weights and balance scales appeared independently in Egypt, the Indus Valley, and Mesopotamia about 3000 BCE.¹⁵ By the second millennium BCE, long-distance merchants had established weight standards that had diffused across Europe, creating what may be considered the first common Eurasian market more than 3,000 years ago.¹⁶ More than 2,000 weights,

the use of which spanned 5,000 kilometers and 2,000 years, consistently fell within a narrow range of 8 to 10.5 grams, from Britain to Mesopotamia. Merchant interaction and self-regulation, rather than political decree, best explain the diffusion.¹⁷

Conversely, some ancient states institutionalized measurement through codified governance, deploying administrative oversight to ensure reliability and maintenance. In India, the *Arthashastra* (thought to have been written sometime between 321 and 296 BCE) mandated a Superintendent of Weights and Measures to oversee standard tools, penalizing traders with a 25 percent tax on the value of any goods they sold that failed to comply with the standards.¹⁸ The legal regime established during China’s Qin dynasty (fourth century BCE) enforced uniformity via state-cast bronze *sheng* (pints) and *jin* (weights), inscribed with edicts, a policy expanded to assert central authority following unification of the empire (221 BCE).¹⁹

By the medieval period, basic measurement standards had emerged as an important tool of governance: Monarchs recognized that a stable and thriving economy could enhance royal revenues while extending rulers’ jurisdictional control.²⁰ Enforcement, however, proved difficult, hindered by limited administrative reach and resistance from local authorities and populations. Private franchises controlled markets, and violations of royal standards carried little stigma, undermining enforcement.²¹

Nonetheless, these standards served a vital symbolic function. The measurement tools they employed served as a legitimating mechanism for authority, linking the material and the metaphysical through the codification of standards. Although metrology reduced transaction costs, it was also rooted in promoting political goals—projecting state power and enabling state building—a role it maintained in later eras.

Two additional measurement standards discussed later in the Report also have antecedents in the

premodern period. Early standards for human capital, in the form of building skills, emerged in Europe in the second millennium, with the measurement of skills and products internalized within guilds. These bodies enforced the duration of apprenticeships and production quality, building competencies that ensured the compatibility of crafts across many parts of Europe for nearly eight centuries until guilds were abolished in the nineteenth century.²² Guilds were “private order” institutions that generalized trust and built social capital, allowing them to address various forms of market failure. The apprenticeship model coped with imperfections in markets for skilled training, and quality certification by guilds addressed information asymmetries between producers and consumers of goods. But guilds also regulated entry into their occupations and strove to keep prices high by limiting output, suppressing competition, and blocking innovation, serving as an early cautionary tale regarding the need for open standards in some instances.²³ Eventually, the artisanal skills they represented succumbed to the power of the First Industrial Revolution.

Another contemporary challenge for development, building stronger governance through better standards for recruitment, also has long historical antecedents. China’s examination system for civil service, operating over a millennium, pioneered how to measure competence for a “meritocratic” bureaucracy.²⁴ Yet family background significantly influenced success on the arduous examinations because of superior access among certain classes to social and cultural capital,²⁵ a pattern also observed in other contexts like France.²⁶

The First Industrial Revolution and the beginning of modern metrology

The First Industrial Revolution—what some have termed the steam age—began in Great Britain in the second half of the eighteenth century, driven

by coal, iron, and textiles. Standards began to have greater importance during this revolution in three distinct ways: in the development of new technologies, the diffusion of those technologies, and the management of risk from those technologies. Metrology (embodied in the metric system) and safety standards (through regulation of steam boilers) illustrate how standards began to seep into the modern era.

Metrology had barely advanced over the prior millennium. A sixteenth-century European treatise advised deriving a measuring rod from the footsteps of 16 men “as they leave church.”²⁷ The feudal system fragmented political authority and, with it, metrology, which had become an embodiment of power. Each authority (king, lord, town, monastery) defined units under the principle “a king, a law, a weight, a measure.” All this changed with the advent of the metric system.

The metric system: The confluence of political and measurement revolutions

The birthplace of the metric system was revolutionary France. Metrological chaos reigned in France through the 1700s, with about 250,000 localized weights and measures. Even a single measure, a pound of weight, was different for different commodities such as wheat, barley, and flour. With feudal lords controlling standards to extract fees, this huge variety in measures impeded trade and taxation among regions, undermining the monarchy’s political authority, and likely impeded technological development as well.²⁸

Demands for uniform weights and measures ranked among the top grievances of the bourgeois and working class, reflecting frustration with feudal arbitrariness and administrative inefficiency.²⁹ The revolutionary government of the 1790s framed metrological reform as both a scientific and an ideological project and tasked the

French Academy of Sciences with devising a system rooted in nature and reason, rejecting anthropocentric units like the *pied du Roi* (King's foot) in favor of universal, immutable standards.³⁰ Political and metrological revolutions were intertwined: The drive for standardization reflected broader ideals of rationality and equality. Universality became the core promise of the metric system: "for all people, for all time."

The metric system's certification process mirrored revolutionary state building. The Academy of Sciences, now an arm of the state, deployed expeditionary teams to measure the Earth's meridian and produce platinum prototypes for the meter and kilogram, embedding scientific authority into governance.³¹ By 1795, the system was codified into law, with a decimal structure that symbolized a clear departure from the past. Conversion tables, pamphlets, and physical standards were distributed to municipalities; education in the metric system was made compulsory; and the state issued standards, hired inspectors, and imposed penalties for failure to conform with the standards.³² The fact that uniformity in weights and measures would reduce diversity and weaken regional identities was seen as essential to forging a unified nation.³³

Despite the promise of metrification, its implementation was a fraught process. The revolutionary government framed it as a tool for dismantling feudal hierarchies and creating legally equal citizens, but the populace often saw its implementation as coercive. Artisans and peasants, reliant on familiar local units, maintained dual systems, sometimes marking old measures on new tools.³⁴ Shopkeepers exploited the transition by rounding up prices during conversions, and bureaucrats and surveyors quietly persisted with traditional units, undermining the system's credibility.

Napoleon's 1812 compromise, allowing traditional measures alongside metric ones, underscored

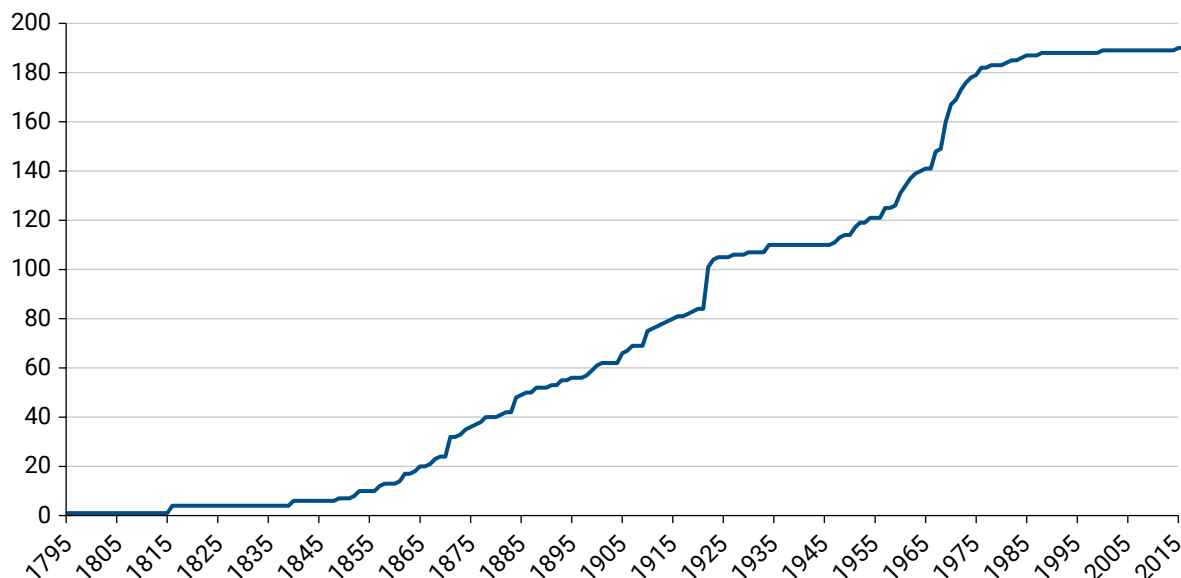
the limits of top-down standardization and the essential role of trade-offs in the development and implementation of standards. Though the metric system became legally required in contracts, taxation, and education, everyday commerce remained in a hybrid space.³⁵ This duality underscored a central paradox: The metric system, conceived as a tool of emancipation, relied on authoritarian enforcement that alienated the very citizens it purported to empower. Only through decades of state pressure, generational change, and the 1840 reinstatement of mandatory use of the metric system did it gain full traction in France.

Initially, the metric system spread across Europe largely as a result of Napoleonic conquest. Although universality was its stated aim, it advanced "in the wake of French bayonets,"³⁶ just as British standards spread with its empire. The metric system's adoption was as much about symbolism and nation building as utility: from Italy's Risorgimento, to Germany's unification, to nineteenth-century Latin America (Argentina, Chile, Mexico) and postcolonial states in the twentieth century.³⁷

Two new drivers for the metric system emerged in the later part of the nineteenth century: the expansion of science and technology and a spurt in cross-border movements of goods and information, marking the advent of the first age of globalization. The 1863 Paris Postal Conference led 15 nations to adopt metric weights for postal services, affecting 95 percent of global correspondence.³⁸ The dual purposes of national cohesion and international interoperability culminated in the 1875 Treaty of the Metre. Signed by 17 nations (including the United States but not Great Britain), it created the International Bureau of Weights and Measures (BIPM), which distributed certified prototypes of the meter and kilogram to member states.³⁹ As in France, global adoption of the metric system was slow, spanning more than a century (refer to figure 1.1). There were some

Figure 1.1 It took more than a century for the metric system to spread around the world

Cumulative number of countries adopting metric system



Source: Vera 2011, 494–97.

Note: The most recent adopter of the metric system, Samoa, joined in 2015.

notable exceptions, however. Despite early support from Thomas Jefferson and Great Britain's 1864 permissive law, neither Great Britain nor the United States fully adopted the system.

The introduction of the *Système International d'Unités* in 1960, which incorporated new measurements encompassing electrical, thermal, and luminous units, codified the metric system as the cornerstone of the world's metrological standards. But these standards were not static and have evolved with scientific advances.

India provides an example from a developing country of how common metrological standards provided a path toward national economic

integration in a highly diverse society (refer to box 1.1).

Increasing precision in measurement has characterized each Industrial Revolution. Cumulative leaps in measurement precision have opened the door to new industries, from mechanical tolerances of one millimeter in the eighteenth century (enabling production of steam engines and screws) to industrial tolerances of thousandths of an inch in the nineteenth (mass production) to micron tolerances in the twentieth (electronics) to atomic-scale tolerances today (quantum technologies). Indeed, it has been argued that civilization's technological advances are directly tied to escalating achievements in precision.⁴⁰

Box 1.1 How India used standards for state and nation building

Whereas nation building traditionally has been built around a common language, India's constitution, adopted in 1950, accorded official recognition to 14 languages (which later increased to 22). In this context, building a common set of metrological standards provided an alternative instrument for fostering national integration.

Despite colonial efforts toward standardization starting in 1833, including the 1870 Indian Weights and Measures Act, weights and measures in India remained fragmented, and a hybrid system of imperial and local units persisted. In 1934 the Indian Science Congress Association urged the colonial government to standardize weights and measures and adopt the metric system. Indian industry and scientific associations began putting pressure on the government for metrological reform. One of the first acts of the new government after India achieved independence from Great Britain in 1947 was to set up the Indian Standards Institution (ISI) to operate the country's certification marks scheme and facilitate consumer protection. Concurrently, the government set up the National Physical Laboratory of India to become the country's laboratory for calibrating measurement standards.

When India's first National Sample Survey went into the field in 1950, its results revealed a striking lack of standardization of weights and measures in rural areas: 143 different systems for measuring weight, 150 different systems for measuring volume, and 180 systems for measuring land area. These findings renewed support for switching to the metric system, with a new framing stressing that "Indianizing" the metric system was culturally more appropriate than unifying metrology on the basis of British imperial units, with their colonial baggage. India formally adopted metric units in 1956, implemented them legally in 1958, and made them mandatory by 1962.

The transition to the metric system demanded immense amounts of planning: new technical standards, public education campaigns, multilingual materials, and revisions to school curriculums. Indian Railways, the country's largest industrial employer, had to revise more than 35,000 standard drawings, but a shortage of draftsmen slowed the process. The limited capacity for manufacturing metric instruments stretched the transition across a decade.

Although metrology was one instrument, nation building also required a common set of standards for physical connectivity across a vast country, a role for which Indian Railways was ideally suited. But although railways connected the country physically, they employed three incompatible gauges (the width between rails): broad, meter, and narrow. This fragmentation led to inefficiencies, from maintaining different sets of rolling stocks to rerouting people and goods to ensure continuous journeys. Integration of railway gauges began in the early 1950s, with broad gauge selected as the standard, but advanced slowly. By the early 1990s, half the country's railway network still did not use broad gauge. In 1992, Project Unigauge was launched to convert all tracks to broad gauge. The process required new infrastructure and took another three decades. By 2022, a unified broad-gauge system of railways connected nearly the entire country. This single gauge made connectivity seamless and eliminated the need to have duplicate rolling stock to accommodate the different gauges.

(Box continues next page)

Box 1.1 How India used standards for state and nation building (*continued*)

India became the first Commonwealth country to switch to the metric system in 1956. However, despite this early start, the focus on standards declined during India's protectionist decades. Without market competition or export pressures, manufacturers had little incentive to meet higher standards. Moreover, the dominance of the public sector further reduced pressures to improve quality, which was not a priority in India's Five-Year Plans. Only after the country's 1991 liberalization, which ushered in a more open trade regime and increasing foreign direct investment, did standards slowly regain prominence in India's development strategy. Periodic conclaves on national standards began to be organized in 2014, leading to the formulation of the Indian National Strategy for Standardization in 2018.^a

Source: Kapur and Subramanian 2025.

a. Kaul (2025).

Quality standards

Like those for measurement standards, the antecedents of quality standards date back millennia. The Code of Hammurabi (c. 1750 BCE) in ancient Mesopotamia included concerns about building standards, along with 282 laws that specified punishments for a wide variety of infractions, including harm caused by a poorly constructed home or building. It covered prices of construction and contractor liability and established the concept of civil damages, whereby defective work requires compensation, a concept that persists to this day.

The advent of the First Industrial Revolution made the importance of quality standards more evident. Initially rooted in standards for industrial safety, quality standards spread to other domains. Unsafe practices in increasingly concentrated urban areas, mounting pollution hazards from industrialization, and hazardous practices in lengthening food supply chains all brought safety—and the quality standards underpinning safety—to the fore. Before the First Industrial Revolution, safety requirements were determined locally and, in the case of Western Europe, by professional guilds. But the novel and widespread technologies unleashed

by the Industrial Revolution posed new hazards. The sources, degree, and manifestations of the risks would change as new technologies emerged, but the basic questions around how to manage these risks and provide quality assurance would be perennial, from boilers in the nineteenth century to artificial intelligence in the twenty-first. The cases that follow hold a number of lessons that later chapters discuss further.

Regulating exploding boilers

Driving the First Industrial Revolution was a new source of harnessed energy: steam, generated (largely) by coal-powered boilers. However, these boilers posed significant risks to safety. The major industrial powers—France, Germany, Great Britain, and the United States—chose different ways to put safety standards in place to limit the risk that steam boilers would explode.⁴¹ The variation in the methods they selected illustrates that compared with other types of standards, safety standards, with respect both to the levels and to the manner of regulation, are more specific to context, reflecting variations in social values, risk tolerance, and regulatory capacity.

As the pioneering nation of the First Industrial Revolution, Great Britain had thousands of boilers in use by the early nineteenth century. However, despite numerous accidents involving boilers, it repeatedly rejected legislation that would have mandated safety standards. Imposing such standards retroactively would have been costly, since a large number of boilers were already operating, and enacting standards for new boilers while grandfathering older equipment would have created unfair competition. British industrialists opposed government interference, citing property rights and favoring self-regulation, arguing that safety and profit were aligned: Avoiding explosions was in entrepreneurs' best interest. Moreover, they distrusted scientists, believing engineers and capitalists had greater practical knowledge. Despite a string of accidents and parliamentary inquiries, steamboat boilers were not regulated until 1852, and industrial boilers remained unregulated until 1902.

France imported high-pressure steam engines from Great Britain after the Napoleonic Wars. But the French government imposed safety standards on boilers early, even though there were only about 200 steam engines in use in the country and there had been few accidents. The relative underdevelopment of steam technology meant that the French state faced fewer entrenched interests from both capital and labor than did Great Britain. The French Revolution had already disrupted older guild structures, and the new technology lay outside existing trades. The government, confident in science, believed it could impose a nationwide standard grounded in mathematical principles formulated by the Academy of Sciences. A central commission oversaw regulation, inspecting boilers annually and certifying them with official stamps.

Comparing the British and French approaches to regulating risk

The differing British and French approaches highlight fundamental questions about ensuring safety and the role of governance in ensuring

compliance with safety measures. France pursued safety through standards for product design brought to bear before manufacture, whereas Great Britain leaned on mechanisms put into play after equipment entered into service, namely, insurance and maintenance. In response to several dozen explosions of steam boilers occurring each year and mounting public pressure, Great Britain passed the Factory Act of 1844 (which imposed safeguards on the moving parts of machinery) and the Ordinance on Marine Steam Boilers in 1852. Entrepreneurs realized that they either had to solve the problem of the explosions themselves or risk having the government intervene. French-style standardization was ruled out on the grounds that it would increase the cost of boilers and subject industrialists to further government intrusion into their factories. Initially, the idea of insurance was resisted on the grounds that with the backup of insurance, boiler owners would become complacent about safety (moral hazard). But over time, the insurance model prevailed. The technical emphasis also diverged between the two countries: French engineers concentrated on structural specifications such as boiler thickness and valve diameter. British insurers, in contrast, made maintenance practices and boiler age the priorities, using these as the bases for setting insurance premiums.

By 1865, approximately 10,000 boilers in Great Britain were insured. Two decades later, that figure had grown to about 50,000, half of the national total. Insurance had as its purpose prevention of explosions, not compensation. British insurers focused on assigning liability to entrepreneurs to give them incentives to behave responsibly. French mining engineers, by contrast, often assigned blame to workers, sidestepping their own failures in design or oversight.

The contrast highlighted fundamental questions about who sets standards and how they are enforced. In France, annual government inspections were the norm; in Great Britain, insurance

companies conducted up to five inspections per year. This made the British system more effective in principle. Yet as noted earlier, as of the 1880s, half of all boilers in Great Britain remained uninsured and thus uninspected. In the 1860s, the explosion rate in both countries hovered around 6 per 10,000 boilers annually. However, for insured British boilers, the rate dropped to 2 per 10,000, meaning the insured boilers were safer than their French counterparts, but the uninsured ones were more hazardous.

The rigidity of French standards of safety may have constrained technological diffusion. Steam engines proliferated more rapidly in Great Britain. By the 1860s, France had about 25,000 boilers compared with 80,000 in Great Britain. By the 1880s, the figures were 60,000 and 120,000, respectively. However, it is hard to separate the role of standards from other economic factors, given the advantages British firms had as a result of cheaper raw materials and wider use of machine tools.

Eventually, the French safety regime also shifted from government toward industry associations and insurers. Political activism, particularly in the form of labor movements, played a key role in advancing workplace safety. By the mid-nineteenth century, workers began to demand better working conditions, including workplace safety. Ultimately, safety was not just a technical matter but a political one as well, shaped by the balance of power among entrepreneurs, labor, and regulators.

The story differs in other emerging industrial powers of the time. Germany adopted a more centralized approach, and earlier than either France or Great Britain. Prussia enacted legislation on boiler safety in 1831 and detailed general requirements in its 1845 Industrial Code. As a result, it had the lowest explosion rates for boilers in Europe. In contrast, the United States had the highest rate among industrial countries, followed by France and Great Britain. In fact, as many

Table 1.1 Risks from steam boilers varied widely across countries in the late 1800s because of very different approaches to safety

Per 10,000 steam boilers, 1882–92

COUNTRY	NUMBER OF EXPLOSIONS	NUMBER OF PEOPLE KILLED
United States ^a	20	29
United Kingdom	4.9	2.4
France	4.8	4.7
Germany	2.2	1.4

Sources: Crum 1910, 17–18; Hunter 1985; MTPTC 1988; Thurston 1907, 717.

a. The widespread use of steam boilers in remote sawmills, employing low-quality machinery with minimal oversight regarding safety, contributed to the greater frequency of explosions of steam boilers in the United States.

boilers exploded in a single month in the United States as did in a year in Germany, despite similar numbers of steam engines (refer to table 1.1).

Most early American explosions of steam boilers occurred on steamships. As in the United Kingdom, steamboat owners and boiler manufacturers had the attitude that no respectable manufacturer would risk its reputation in constructing a defective boiler; constant examination of boilers would cause serious inconvenience without any guarantee that such examination would ensure public safety; and the sheer range of different boiler and engine designs made it next to impossible to agree on methods of examination. Enlightened self-interest of an entrepreneur would suffice to guarantee the public's safety. These arguments weakened legislative efforts, but as fatalities mounted, stronger federal legislation passed in 1852. However, the law covered only marine boilers, leaving out factory and locomotive boilers. It took two serious explosions in shoe factories in Massachusetts in 1905–06 that killed dozens for the state to enact

the first code for stationary boilers in 1907. Other states followed suit until there were so many different codes that manufacturers requested a body of professional engineers, the American Society of Mechanical Engineers (ASME), to address the issue. The result was the first Boiler and Pressure Vessel Code, published in 1915, a single volume encompassing 114 pages. By 2001, the code had grown to 28 volumes with more than 16,000 pages, and it grew further, to 33 volumes and more than 19,000 pages, between then and 2025.

This short history of safety standards for boilers offers several lessons that later chapters explore further. First, the achievement of safety depends as much on regulations and institutions as on social demand, whether from workers for a safer industrial environment, or from consumers for a safer product.

Second, the method of regulating safety standards depends on context. Even as Great Britain chose the private insurance route and blocked all attempts to introduce legislation requiring inspection of steam boilers on land by an official agency, it introduced such legislation in its largest colony, India, finding the British model “impractical” for India based on evidence showing “unanimously the popularity of official inspection and the confidence resulting from the fact that it is done by a Government agency.”⁴² That confidence would lead to boiler inspections’ becoming the epitome of the “inspector raj” in independent India.

Third, there is a tendency to underinsure (limiting an insurance company’s liability), because firms find more value in obtaining insurers’ inspection service than they do in holding the insurance. According to one estimate, for every dollar they collect in premiums, insurance companies spend more than 22 cents on inspection services, whereas they pay 50 cents to policyholders for losses.⁴³

Fourth, performance standards can induce innovation, as safety norms for boilers resulted in greater efforts to study ways of improving boiler

efficiency and design. But standards need to evolve with new technologies, or they can hinder innovation.

Finally, the tendency for standards to proliferate appears inexorable. But whereas the need for planting new trees of standards for each new need seems obvious, the cumulative implications for the larger forest of standards are less clear.

The growing importance of safety standards: Fires, foulness, and food

Fires

The Second Industrial Revolution also drove a broader structural transformation marked by rapid, unregulated urbanization. A predominantly rural society had become overwhelmingly urban. Overcrowding, wretched housing for the working class, and substandard infrastructure (especially water and sewage systems) left cities highly vulnerable to catastrophic fires, prompting demand for standards of fire safety.

The groundwork for regulation in the area of fire safety was laid in the Middle Ages in Great Britain. The Great Fire of London in 1666 marked a turning point. The destruction it wrought, exacerbated by timber construction, narrow streets, and rudimentary methods for fighting fires, led to the Rebuilding of London Act the next year. The act mandated brick or stone construction, party walls, wider streets, height restrictions, and—critically—the appointment of building inspectors, or “surveyors,” with enforcement authority.⁴⁴ The regulatory framework the act provided became the prototype for building codes worldwide and established the fundamental principle that public safety could justifiably limit private building practices.

Two centuries later in the United States, the Great Chicago Fire of 1871—and subsequent catastrophic fires—killed thousands of people, rendered many more homeless, and destroyed countless buildings and neighborhoods. The human, physical, and

financial costs of these deadly fires drove demand for standards in urban planning, building standards, codes governing fire safety, and standards for firefighting equipment. These included new standards mandating tile roofs and the use of internal steel structures; requirements for outward-opening fire exits, unlocked doors, fireproof stairwells, and clear signage; and occupancy limits. Experts—often working between government, insurance, and industry—began codifying fire safety. The Great Baltimore Fire of 1904 needlessly spread because the numerous fire companies that had traveled to help fight the fire had equipment that was incompatible with the local fire hydrants and could not hook up to them. The disaster prompted the National Fire Protection Association (NFPA) to publish standardized codes for equipment in 1905. Adoption, however, was slow. A decade later, only 287 of 8,000 US cities had adopted the code's standards, highlighting the challenges of voluntary compliance, even after catastrophes.⁴⁵

Sprinkler systems were an early innovation in fire safety but lacked consistency. In the Boston area alone, nine different standards existed for sizes and spacing of sprinkler pipes. Insurance companies, bearing much of the losses related to fires, helped form the NFPA and promoted the first standards for sprinkler installation. The electrification of homes and factories added new fire hazards. Multiple overlapping standards for electrical construction created confusion and risk, prompting the creation of the National Electrical Code in 1897. Around the same time, Underwriters Laboratories (UL), a private initiative, was founded in Chicago to test and certify product safety. A century later, UL certification would appear on billions of consumer products worldwide.⁴⁶

Two workplace disasters a century apart, New York's Triangle Shirtwaist Factory fire (1911) and the Tazreen Fashions factory fire in Bangladesh (2012), exposed similar failures in protocols for exit access and safety. In both cases managers

had locked most exits to prevent theft and unauthorized breaks, trapping workers, mostly young women, inside the burning buildings. At the time of the Triangle Shirtwaist Factory fire, annual per capita income in the United States was US\$333 (about US\$10,000 in 2012), whereas in Bangladesh at the time of the Tazreen Fashions fire, it was less than US\$1,000. Whereas the former was a turning point in the histories of both labor and building safety as a result of domestic pressure, in the case of the latter, the shift came as a result of pressure from foreign firms importing the country's products. These tragedies created an awareness that workers deserved protection regardless of economic status.

Standards that affect public safety require building public trust, a process that requires patience and incorporating lessons of tragic failures. Yet the push for safety to reduce fire risks has always run up against risky behavior driven by financial motives, especially reducing costs by scrimping on safety codes for buildings and on firefighting equipment, overcrowding, and so on, on the one hand, and weak mechanisms for ensuring compliance with requirements, on the other. As the built environment expanded, so did building codes to strengthen public health and improve safety. That would invariably add to costs, highlighting the perennial tension between reducing risks and escalating costs.

Foulness

Although the Second Industrial Revolution is often associated with railways and steel, it also gave rise to one of the era's most consequential new sectors: the chemical industry. Laboratories increasingly synthesized a wide range of organic chemicals—used in pharmaceuticals, dyes, explosives, fertilizers, insecticides, pesticides, paints, plastics, synthetic rubber, fibers—rather than deriving them from natural sources. The fusion of scientific research and industrial manufacturing positioned the chemical sector at the center of industrialization.

As with boilers in the First Industrial Revolution, these new technologies created a pressing need for safety standards, in this case to manage the pervasive negative externality of pollution.

By the latter half of the nineteenth century, pollution had become a visible and widespread concern across Europe. Rapid urbanization concentrated populations in dense cities, compounding the environmental impact of coal burning, industrial waste, and inadequate treatment of sewage. Indeed, the larger the city, the greater the risk to life, with hazard ratios for mortality increasing with city size.⁴⁷ Initially, sewage pollution was a greater scourge than industrial releases in Great Britain. To delay or prevent new regulations aimed at controlling pollution, the British chemical industry offered arguments similar to those given earlier by boiler manufacturers: Controls would endanger national prosperity, would not significantly improve the quality of air and water, or would be premature until the technical situation was better understood—rationalizations that continue to resonate today. Despite these efforts, worsening river pollution, such as that produced from soda plants, finally resulted in the Alkali Act of 1863.

Similar patterns emerged elsewhere. In the Netherlands, concern initially focused on sulfuric acid and sugar residues from dye production and soon expanded to pollution from plants generating alkali and sulfuric acid as wastes. As in Great Britain, regulators turned to chemists for technical support. In Germany, the major concern was liquid emissions into lakes, rivers, and streams, such as the arsenic produced by the production of dyes. Industrialists there went a step further, claiming rivers were “natural sewage canals,” a rationale that framed pollution as an efficient, not a harmful, by-product of industrial progress.⁴⁸

These developments marked the start of a new type of safety standards, prompted not only by concerns about human health, but also by wider

understanding of negative externalities resulting from the expanding ecological footprint of industrial production and growing levels of consumption. Quality standards mattered for the quality of life, the deeper fundamental goal of development. Chapter 6 examines the resulting rise of environmental standards.

Food

Standards for food safety began to emerge in the medieval period. In medieval Islamic societies, the *Muhtasib* (market inspector) played a pivotal role in enforcing norms relating to safety and quality. Beyond policing fair trade, the *Muhtasib* regulated food production, barred the sick from working in food-related trades, and supervised sanitation in urban settings, highlighting an early institutional framework for public health.⁴⁹

The Industrial Revolutions and rapid urbanization meant that people increasingly purchased the food they consumed rather than growing it themselves. Together with growing international trade in foodstuffs, public concern about food safety mounted, prompting many European countries to pass food laws. A number of parallel attempts were undertaken to establish common techniques for assessing food samples so that results could be compared and interpreted. A notable milestone came in 1891 when Austria initiated the *Codex Alimentarius Austriacus*, publishing its first standards in 1911.

In the United States, reform came from the bottom up. Public outrage over food adulteration and unsanitary conditions in factories erupted after the publication of Upton Sinclair’s semi-fictionalized exposé, *The Jungle*, in 1906. Whereas earlier attempts at reform had stalled as a result of lobbying by the meat industry, Sinclair’s searing descriptions led to plummeting meat sales and foreign bans on imports of meat from the United States. An additional examination by independent inspectors appointed by the government was

equally damning (and also meant that the meat industry could not dismiss Sinclair's book as mere fiction). Together, these resulted in the Pure Food and Drug Act and the Federal Meat Inspection Act (both passed in 1906), the first comprehensive federal laws regarding food safety in the United States. These laws laid the groundwork for future regulations, culminating in the 1938 Federal Food, Drug, and Cosmetic Act.⁵⁰

In Europe, the Codex Alimentarius Austriacus metamorphosed into the Codex Alimentarius Europaeus, which developed standardized rules for testing food samples to eliminate trade barriers within the region. It subsequently joined forces with the Food and Agriculture Organization and the World Health Organization (WHO) to ensure common global standards for food safety to prevent barriers to food trade. Since 1963, the Codex Commission of these two organizations has been issuing its Codex Alimentarius standards to guide governments in establishing regulations pertaining to food safety. Growing government sensitivity to concerns surrounding food safety prompted the incorporation of sanitary and phytosanitary measures into the framework of the World Trade Organization. Yet as some countries adopt increasingly stringent standards for food safety, it remains unclear to what degree these measures primarily reflect scientific evidence, domestic consumer preferences, or a veiled form of protectionism.

Compatibility standards

The foundational compatibility standard: The communication tools of script and language

Script standardization has evolved from a tool of resource management and state control to a technical protocol for global interoperability.⁵¹ Early societies found standardization of script and language critical for communication, recordkeeping,

and institutional interactions. It would also be an early forerunner of the power of network externalities. The development of cuneiform in Mesopotamia (c. 3100 BCE) exemplifies this pattern, evolving from pictographs to a standardized system encoding complex texts. Thousands of surviving clay tablets reveal its primary economic function: tracking goods, labor, and transactions to support centralized governance and long-distance trade.⁵² Similarly, Egypt's Middle Kingdom (c. 2000 BCE) institutionalized hieratic script—a cursive derivative of hieroglyphs—to streamline taxation, legal documentation, and resource allocation, reflecting state-driven standardization to promote administrative efficiency.⁵³ These systems developed symbiotically: Writing enabled management of resources on a large scale, and state demands shaped script uniformity.⁵⁴ The Phoenician alphabet (c. 1000 BCE) further revolutionized compatibility by introducing a simplified, phonetically consistent script that laid the groundwork for later alphabets, including those for Greek and Latin.

Communication compatibility did not always require written language. The Inca Empire (1450–1534 CE), lacking a writing system, employed *quipu*—a standardized knotted-cord system—to manage census data, taxation, and resource distribution across 12 million subjects. Trained personnel (*quipukamayusqs*) ensured consistent interpretation.⁵⁵

Script standardization accelerated during the medieval era in Europe, driven by technological innovation and geopolitical imperatives. The invention of the printing press by Johannes Gutenberg (c. 1440) necessitated uniform letterforms, entrenching Roman and Gothic scripts across Europe. Market expansion solidified the Latin alphabet as a de facto standard, reinforcing its dominance in administrative and scholarly contexts.⁵⁶ By the twentieth century, script modernization became a tool for cultural and economic alignment: In 1928, Turkey adopted a Latin-based

alphabet under Atatürk, replacing the previous Arabic script, to boost literacy, streamline bureaucracy, and integrate with the industrializing West, demonstrating the effects of choosing a specific standard.⁵⁷

The network effects of standardization in languages came at a cost to languages spoken by linguistic minorities, underlying the inherent tension between compatibility standards and diversity. About 43 percent of the more than 7,000 languages in the world are endangered and likely to die off by the end of this century, the United Nations Educational, Scientific and Cultural Organization (UNESCO) estimates. The power of standardization has led to larger numbers of people speaking fewer languages as glottophagy—a dominant language’s consuming smaller ones—has become more common. More than half of the world’s population speaks just 23 languages. This matters critically, as language and cultural diversity appear to correlate with regional biodiversity: Loss of one may endanger the other.

The need for new standardized scripts driven by novel technologies emerged during the Second and Third Industrial Revolutions. The telegraph’s true value could be realized only when it could bridge geographic and linguistic divides, which required a standardized script: Morse code. The dawn of the computer age necessitated the American Standard Code for Information Interchange, better known as ASCII. This character-encoding system, released in 1963, digitized the Latin alphabet, numerals, and symbols, enabling seamless data exchange across early computer networks. Its Anglo-centric limitations spurred Unicode (1991), standardizing more than 149,000 characters across global scripts (Cyrillic to Han ideographs) to ensure cross-linguistic digital compatibility. Barcodes—including quick-response or QR codes—similarly provide universal standardized “scripts” in the form of standardized, machine-readable formats that enable data to be captured efficiently and ensure interoperability across systems.

The Second Industrial Revolution: The age of standards and the emergence of complex networks and systems and standardization organizations

The Second Industrial Revolution, which unfolded between the final third of the nineteenth century and the beginning of the First World War, marked the onset of the “age of standards.” The deployment of large technical networks such as electricity and railways, mass production based on a system of interchangeable parts, and pressures to protect workers and consumers (such as those in the field of food adulteration) fueled a powerful movement led by engineering associations, hygienists, major corporations, and governments. Beginning with the creation of the German Reichsanstalt in 1887, countries began establishing national standardization offices. The first international organization for standardization, the International Electrotechnical Commission (IEC), established in 1906, signaled the increasing international prominence of standards at the dawn of the twentieth century.

The deepening connection between scientific progress and technological development in part defined this era. As David Noble (1977, 76) observed, “scientific standardization paved the way for industrial standardization.” Scientific inquiry demanded standardized vocabularies and measurement systems, leading to classification schemes such as the periodic table and the Linnaean taxonomy. Breakthroughs in chemistry and burgeoning new chemical industries, from dyestuffs to refining, led to the Geneva Rules for chemical nomenclature in 1892. Over several decades (and as a result of many international conferences), these efforts led to the emergence of the International Union of Pure and Applied Chemistry (IUPAC), which coordinated the international standardization of nomenclature, terminology, symbols, and quantities in chemistry. Electropedia, produced by the IEC and first

published in 1938, presented international standards in electrotechnology, the world's most comprehensive database of terminology, containing more than 22,000 terms in two dozen languages.

Later, the United Nations system began managing some classification schemes. For instance, its Globally Harmonized System of Classification and Labelling of Chemicals standardized hazard communications, while the International Classification of Diseases (maintained and updated by WHO) enabled public health systems worldwide to categorize and share epidemiological data using a common language for diagnostics. WHO's Anatomical Therapeutic Chemical classification system and the International Nonproprietary Names system for pharmaceuticals similarly supported the global harmonization of drug nomenclature.

A distinctive hallmark of the Second Industrial Revolution was the onset of mass manufacturing. Modern manufacturing would be unthinkable without interchangeable parts, which make it possible for complex products to be assembled from mass-produced individual components. No complex product epitomized this era as much as the automobile. Although powered by a general-purpose technology, the internal combustion engine, it required a chassis, wheels, tires, brakes, brake linings, spark plugs, a carburetor, a radiator, a differential, a steering wheel, headlights, and fuel distributors (for gasoline or diesel fuel), each of which had to be built to very specific standards to enable assembly of a safe, reliable product.

The emergence of complex technologies with large network externalities (like rail, telephones, and electricity), as well as of the core infrastructures of cities (water, sewage, and gas systems), was the other defining feature of this era. These technologies required networks of closely interconnected, compatible inventions, which had to be integrated seamlessly to be effective. Whereas earlier technologies consisted of separate components that could be optimized individually,

the increasingly complex technologies of this era “required a great deal of coordination that free markets did not always find easy to supply,” requiring governments or other mechanisms to standardize railroad gauges, electricity voltages, rules of the road, and so on.⁵⁸ Coordination of technological systems required “technical standards,” also known as “compatibility” or “interface” standards,⁵⁹ to ensure compatibility and interoperability among a system's components.

Technologies of this era not only birthed new products but also integrated global markets through innovations in transport and communication. Telegraphy, telephony, and wireless radio revolutionized global connectivity. Each evolved through networks of compatibility standards that enhanced reliability, interoperability, and cost-efficiency. But these very features would also sow the seeds for entrenching market power.

Telegrams, telephones, and trains: Shoring up hard infrastructure with the soft infrastructure of standards

The standardization of telegraphy illustrates the interplay of technological innovation, imperial ambition and control, and institutional development. Great Britain's reliance on telegraphy as a “quintessential technology of empire” drove significant advancements in cable technology and electrical measurement.⁶⁰ British physicists, in collaboration with telegraph operators, conducted pioneering research on signal propagation through underwater cables, addressing the practical challenges of imperial communication. Despite competing measures, such as Werner von Siemens's German standard, the ohm became a global de facto standard measure of electrical resistance because of Great Britain's dominance in the telegraph industry and its extensive submarine cable network, referred to as the “nerves of empire.”⁶¹ The effort to standardize the measure of electrical resistance laid the groundwork for

broader international cooperation, as subsequent electrical congresses in Paris (1881), Frankfurt (1891), and Chicago (1893) sought to harmonize electrical units and practices. These meetings culminated in the formation of the IEC in 1906, institutionalizing multilateral efforts to develop standards for a new technology. A century and a half later, the physical arteries of a successor technology, the internet—a million and a half kilometers of fiber-optic cables—crisscrossed the world's oceans, built to standards specified by the IEC and the International Telecommunication Union (ITU), two of the oldest international standards development organizations.⁶²

In the United States, telegraph development followed a market-led path, shaped by competition and the federal government's decision not to acquire Samuel Morse's patents, leaving the industry to develop through private investment. This resulted in rapid growth of telegraphy but fragmented infrastructure for it. Competing firms built overlapping systems with incompatible practices until Western Union consolidated the sector through a series of mergers and acquisitions ending in 1866.⁶³ It imposed internal standards for operations and cemented American Morse code domestically, even as International Morse code, adopted by the International Telegraph Union in 1865, spread globally, reflecting the difficulties of reconciling national and international standardization.

Telephones were also standardized through a mix of entrepreneurial initiative, monopolistic consolidation, and eventual regulatory oversight. In the 1880s, telephone technology was in its infancy, with no formal standards; decentralized entrepreneurs operated early networks, licensed under Bell Telephone patents, and built isolated systems with little interoperability.⁶⁴ As with the telegraph, industry consolidation resulted in a single private actor driving standardization of telephony: the American Bell Telephone Company (later the American Telephone and Telegraph Company, widely known as AT&T, and even later, Verizon). Bell leveraged

standardization to consolidate manufacturing and engineering across regions, creating hierarchical control that bolstered competitive advantage.⁶⁵ To mitigate resistance from local operating companies, it adopted a collaborative approach through the National Telephone Exchange Association (NTEA), through which engineers from Bell and independent companies shared operational insights to develop voluntary technical specifications adaptable to local conditions.⁶⁶ This cooperative yet strategic process laid the groundwork for interoperability while preserving Bell's influence.

The expiration of Bell's patents in the area of telephony in 1894 spurred competition, but AT&T responded with its "one system, one policy, universal service" strategy, framing monopoly control as essential for national integration. But under the guise of public benefit, positioning AT&T as a "benevolent monopoly," this rhetoric masked a strategic bid to eliminate competition.⁶⁷ By the 1910s, AT&T had absorbed most of its competitors, exerting technical and commercial control through its subsidiaries. In the 1920s, AT&T shifted tactics, engaging with national standards bodies like the American Standards Association. Although initially wary of ceding control, it recognized the strategic value of consensus committees for resolving systemic challenges, such as specifications for wooden telephone poles and radio interference, that no single firm could solve alone, while retaining dominance in critical areas like network architecture.⁶⁸

However, in 1956, the Federal Communications Commission forced settlements in antitrust cases that mandated patent licensing and restricted AT&T to regulated services.⁶⁹ By the 1960s, rulings by the commission had dismantled AT&T's control over customer equipment, mandating standards for new technologies like modems and fostering competition in data communications. Policies based on these rulings decentralized innovation, shifting authority to industry committees and rival firms, creating demand for interoperability driven by market forces.

Another industry, railroads, exemplified the need for compatibility standards. Even a modest railway comprised hundreds of interdependent parts: couplers, brakes, rails, signals, crossties, and rolling stock. In the late nineteenth century, railroads embraced the systematic gains that professional engineers promised them by standardizing each component—from rail strength to paint colors to unit measures like “ton-miles” for cargo—to increase productivity, “precisely because they restricted the realm of technical possibilities and pursued one grand objective with single-minded purpose . . . laying down clear ground rules about operations and shunning innovations that threatened to disrupt those rules.”⁷⁰

The shift from iron to steel rails in the late nineteenth century marked a leap in productivity, enabling heavier locomotives and larger freight loads while reducing maintenance costs. Early steel rails often failed under stress as a result of inconsistent metallurgy. In response, scientists and engineers formed the American Society for Testing and Materials (ASTM) to create standardized methods for testing. Its first standard, ASTM A1, specified requirements for the quality of steel rails. These requirements significantly reduced rail failures and supported the safe operation of heavier,

faster trains. By 1910, steel rails alone accounted for the largest productivity gains in the US railroad sector, saving an estimated US\$479 million annually.⁷¹ Today, ASTM is an international organization with 13,000 plus standards, ranging from measurements for aircraft braking (from its Committee on Vehicle-Pavement Systems) to standards for biodegradable plastic (from its Committee on Plastics) and standards for infrastructure that are essential to the world’s built environment (from its Committee on Soil and Rock).

Railways also emerged as the quintessential example of the importance of interoperability standards, stemming from a seemingly simple technical problem: differences in railway gauges, the width between rails (refer to box 1.2). The standardization of railway gauges and steel rails thus reveals a recurring pattern in the history of compatibility standards: economic imperatives driving institutional coordination, which in turn fosters technological innovation and market integration. It also demonstrates how an industry frustrated by the unpredictability of the market-based system for patents circumvented that system by creating trade associations and engineering societies to facilitate the industrywide exchange of technical standards.

Box 1.2 The transaction costs of incompatible railway gauges

The railway “gold rush” of the nineteenth century produced a global patchwork of more than two dozen rail gauges shaped by local needs and engineering preferences. By the 1860s, the United States alone had nine distinct regions with different rail gauges; eastern Canada added a tenth. The expansion of interregional trade made the economic costs of these incompatibilities untenable. Perishable goods, in particular, suffered from delays at gauge breaks.^a By the 1880s, competitive pressures and network consolidation pushed US railroads toward convergence around the standard gauge of four feet, eight-and-a-half inches, already prevalent in the industrial Northeast and Midwest. In a concerted effort in 1886, southern railroads converted 13,000 miles of track to standard gauge in just two days, dramatically ratcheting up the shift. This physically integrated the South into the national rail system. However, although the change spurred a shift in freight volume from steamships to

(Box continues next page)

Box 1.2 The transaction costs of incompatible railway gauges (*continued*)

rail, it did not lower prices, likely because the same collusion that enabled the gauge change also dulled its competitive effects.^b

Although standard gauge has since become dominant within many countries, cross-border incompatibilities persist. In Eastern Europe, Ukraine and the Baltic states are increasingly developing standard-gauge (1,435 millimeters) rail connections alongside their existing broad-gauge (1,520 millimeters) infrastructure to enhance interoperability with the European Union rail system. Across the vast Eurasian landmass, freight trains from China must currently switch gauges at the Kazakh and Mongolian borders. These trains must then switch gauges again in Poland.

Decisions about gauge conversion are often framed around capital costs or engineering feasibility. Yet the deeper economic rationale lies in coordination failures, fragmented supply chains, and long-term transaction costs. Break-of-gauge points delay transit, raise handling costs, and require complex infrastructure like transfer stations. Moreover, declining global demand for legacy-gauge equipment drives up maintenance costs and creates dependency on a shrinking group of specialized suppliers, introducing risks of delay.

As countries consider whether to align their rail systems with regional standards, they must view the economics of gauge conversion not only in terms of up-front costs, but also through the lens of transaction costs, resilience of supply chains, and long-term integration.

Source: Binyam Reja and Matthias Plavec, Transport Global Unit, Infrastructure Vice Presidency, World Bank.

a. Puffert (2000).

b. Gross (2020).

The advent of mass manufacturing: Compatibility standards as coordination mechanisms

The coordinating role of standards has deep historical roots, evolving from early state oversight to market mechanisms to sophisticated regulation by industry. In ancient China, state-led efforts standardized axle lengths for wheeled vehicles, ensuring smoother travel on rutted roads, a practical solution to a widespread infrastructural challenge.⁷² China also pioneered interchangeable parts in military applications such as crossbow triggers, predating similar Western developments by centuries.

The Industrial Revolutions catalyzed a paradigm shift toward technical standardization driven by the imperatives of mass production and mechanized efficiency. Interchangeable parts in modern manufacturing can be traced back to late-eighteenth-century French armories. The idea crossed the Atlantic in the early 1800s, as US armories adopted jigs, gauges, and rigorous protocols for inspection to produce standardized muskets, laying the groundwork for what became known as the “American system of manufacturing.” Yet achieving seamless interchangeability remained elusive. Even after the Civil War, firms like Singer still relied on hand-fitting and serializing parts, illustrating how slowly artisanal practices retreated.⁷³

True interchangeability required not only precision machine tools, but also institutional support for codifying processes. Innovations in these areas spread globally, but high costs kept interchangeability out of reach for many industries until the late nineteenth century. The turning point came with Henry Ford's synthesis of armory practices, pressed steel parts, and moving assembly lines in the 1910s. Ford's system required absolute interchangeability, achieved through specialized machine tools and strict standardization, fusing precision and scale.⁷⁴ Yet broader industrial coordination lagged. The Society of Automotive Engineers (SAE), founded in 1905, emerged to address proliferating variations in parts—such as more than 1,100 types of lock washers and tubing—by establishing industrywide standards. Its efforts at such standardization enabled smaller manufacturers to compete through economies of scale, though giants like Ford and General Motors initially made proprietary systems a priority over collaboration. This trajectory underscores the tension between market-led standardization, driven by efficiency and competition, and the systemic coordination required to mitigate the costs of fragmentation. The latter has sometimes required the “fostering hand” of the state, as seen in the “simplification” drives engineered by Herbert Hoover in the United States in the 1920s (discussed in box 1.3).

Standardization enabled mass production by codifying best practices for repeatable processes, lowering costs, and enabling learning-by-doing effects captured in Wright's Law (first observed in aircraft production in the 1930s): As cumulative production increases, unit costs decline. However, maintaining consistent quality as production increases becomes more difficult, making standards essential. They structure worker training, support process innovation, and facilitate knowledge transfer.

The production of penicillin offers a compelling case. Though discovered by Alexander Fleming in 1928, the antibiotic remained a laboratory curiosity for more than a decade. But World War II created an urgent demand for an effective antibacterial treatment, leading governments, scientists, and industry to find ways to produce penicillin on an industrial scale. Standard procedures were developed to screen, identify, and select high-yielding strains of the fungus that produces penicillin. A global effort—including notable work by US Department of Agriculture (USDA) laboratories in Peoria, Illinois—standardized how strains were tested and preserved, ensuring consistent performance in different setups for the fermentation process involved. Scaling up production across multiple facilities (especially for wartime production) required standardizing conditions for fermentation (temperature, pH, aeration, agitation), protocols for sterilization, compositions of nutrient media for growing cultures, and procedures for inoculation. After early batches of the drug were found to vary widely in potency and purity, standards for testing bioactivity and purity were set to ensure patient safety and make dosing consistent and predictable. Finally, bioreactor design was standardized with regard to dimensions, materials, and operating features, which ensured that process parameters developed in one facility could be replicated elsewhere.⁷⁵

Standardization also began to transform commodity markets in the late nineteenth century, as exemplified by the Chicago Board of Trade's system for grading grain. By creating uniform benchmarks for quality, the board transformed grain into a fungible commodity. This decoupled ownership from physical stock, enabled trading in grain futures, and mirrored emerging practices in industry.⁷⁶

Box 1.3 Standardization as simplification—and as an instrument of industrial policy

The rise of the United States as the global leader in manufacturing by the mid-twentieth century is often attributed to entrepreneurs like Henry Ford, whose model of mass production of automobiles set benchmarks worldwide. However, supplementing this visible hand of entrepreneurs was the fostering hand of government through its “simplification” programs, which began as a way to persuade manufacturers to move to standard sizes, thereby pushing manufacturers toward mass production.

Standard sizes—for example, of beds, printer paper, and electrical outlets—are a familiar feature of modern production and consumption that are often taken for granted. What makes a nation’s standard sizes “standard” is that dozens, if not hundreds, of firms manufacture everyday products in the same, limited set of sizes or shapes.

In the early twentieth century, standard sizes in the United States were confined almost entirely within individual firms. Even the Ford Motor Company, initially a small-scale assembler of automobiles, adhered to the prevailing strategy, until it took the radical step of abruptly cutting its product line to a single model and ramping up production. Instead of catering to consumer demand, it “worked out a car and at a price which would meet the largest average need. In effect, [it] standardized the customer.”^a

The fragmentation that prevailed at the time was in part the outgrowth of a bewildering number of state and national laws. A 1912 compendium on laws governing weights and measures totaled 564 pages, and codes governing food regulation and buildings differed from the national through the state to the municipal level.^b At the beginning of the 1920s, US manufacturers made mattresses and beds, for example, in 78 sizes; within a decade, 90 percent of the industry’s output conformed to 4 standard sizes. This remarkable convergence raises two questions: How did it happen? What were the consequences?

The effort originated during World War I, when the US government sought to conserve critical resources—labor, materials, and transportation—by persuading civilian manufacturers to reduce the variety of goods they produced. Working through trade associations, the government helped industries reach consensus on conservation measures.^c Initially, it encouraged compliance through social pressure and public pledges, reinforcing it later by giving firms priority in the allocation of resources. Within 18 months, product variety shrank across about 250 business lines.

When the war ended, the government dismantled the office that had coordinated simplification. But momentum revived in 1921 when the Federated American Engineering Societies,

(Box continues next page)

Box 1.3 Standardization as simplification—and as an instrument of industrial policy (*continued*)

led by Herbert Hoover, issued *Waste in Industry*. This report argued that raising the national standard of living hinged on enhancing “national productivity,” which required eliminating waste in industry.^d When Hoover became Secretary of Commerce, he created the Division of Simplified Practice within the National Bureau of Standards to act as an “unbiased third party,” helping industries reach voluntary “simplification” agreements to reduce product variety and promote mass production.^e

The first simplification efforts, focused on paving bricks, mattresses, and bedsprings, reduced varieties of these goods by more than 90 percent. By the early 1930s, 135 Simplified Practice Recommendations were in effect. Though adoption slowed during the Great Depression, the number of these recommendations rose to 173 by 1939 and to 267 by 1971.

National-level agreements do not arise spontaneously; they must be constructed.^f Simplification succeeded because it followed a voluntary, data-driven approach. Without legal powers of enforcement, the government relied on social incentives and procedural legitimacy to maximize consensus as a means of enhancing adherence. The endeavor succeeded because of efforts mounted on three fronts. The first was winning consumer acceptance through advertising campaigns that resulted in firms’ “catering to the tastes and needs of the average buyer, leaving those who fall outside their field of specialization to the special-order manufacturer.”^g The second was leveraging the power of government procurement, ensuring that only products that met the federal specifications in Simplified Practice Recommendations could be sold to the federal government, the nation’s largest consumer. The third was building alliances between the National Bureau of Standards and other federal agencies as well as private associations with high credibility in the private sector: the US Chamber of Commerce and the American Engineering Standards Committee (AESC, now the American National Standards Institute, ANSI).

Overall, standardization, in the guise of simplification coordinated by the federal government, played an important role in the rise of mass production and consumption in the United States, shaping American manufacturing for decades. One observer described it as “an industrial policy of first-rate importance and one which can scarcely be ignored.”^h With the return of industrial policy today, the role of standards should not be underestimated, either.

Source: Dunlavy 2025.

a. Couzens (1921, 263–64).

b. Gephart (1919, 265); Whitehorne (1923, 40).

c. Werking (1978).

d. FAES (1921, ix); Hoover (1921, 77).

e. Feiker (1922); Hoover (1922); Priest (1926).

f. Offe and Wiesenthal (1980); Olson (1965).

g. Bangs (1930, 234).

h. Chisholm (1922).

The evolution of standards following World War II

The international system changed markedly following World War II. For the purposes of this Report, four developments radically changed the world of standards. First, a range of new international organizations, including the Bretton Woods institutions (the International Monetary Fund and the World Bank), the International Labour Organization (ILO), and WHO were established to manage the international order following the war. Although intergovernmental organizations for developing standards had emerged in the nineteenth century, notably the International Telegraph Union (1865, subsequently ITU) and the Universal Postal Union (1874), standards development remained largely within national standards bodies. The establishment of the International Organization for Standardization (ISO) in 1947 complemented the founding of the IEC, a pioneer in the field, in 1906. Other international organizations also became involved in the development of standards in their domains, such as health (WHO) and labor (ILO), through conventions.

A second development was the emergence of many new states following waves of decolonization between 1945 and 1960 (three dozen new states in Africa and Asia alone), followed by another 92 new states thereafter. These newly independent countries had nation building as a central objective. Standards were an important instrument for achieving this, as illustrated by the case study on India discussed in box 1.1, although not all new states pursued a national strategy for standardization.

Third, global economic integration deepened as a result of increasing cross-border movement of goods (especially manufactured goods), people (migration), and money (financial flows). Development of standards lubricated these booming flows, providing the “soft infrastructure” underpinning the flows.

The fourth development was technological: the Third Industrial Revolution, a digital transformation powered by semiconductors and information technology. This revolution ushered in an era of rapid innovation in digital products and services, underpinned by the development of seamless compatibility standards and protocols for communication (refer to chapter 4). It further accelerated globalization, especially after the 1990s, this time in digital services. But as with all transformative technologies, it also brought with it new risks. Managing them would require new standards.

Although each of these trends independently shaped the world of standards, their interactive effects resulted in a more overarching trend: a world of greater complexity that could be managed only through more standards.

Compatibility standards for cross-border flows of people and goods

The primary document for international travel, the passport, regulates international movement while literally putting a stamp on nationality. Before World War I, international travel usually did not require a passport, though practices varied by country. This changed after the Great War, as nationalism surged. The League of Nations convened a series of passport conferences in the 1920s with the aim of abolishing requirements for passports. Although it soon abandoned that goal, its efforts in this area produced the first international standards for passports, with the British passport becoming the model for national designs.²⁷

As air traffic increased, so did the need for harmonized formats for passports to expedite passenger processing. The United Nations’ creation of the International Civil Aviation Organization (ICAO) in 1944 marked a turning point. One of the organization’s mandates was to standardize travel documents, particularly to facilitate air travel.

In 1968, ICAO convened a small group of experts to develop a machine-readable zone on passports,

focusing on document security and proof of citizenship. However, the initial format failed to accommodate African, Arabic, and Asian names, the use of scripts other than Roman, and diacritics such as accent marks. Eventually, the first edition of the standard for the zone was published in 1980 and was accepted as an ISO standard, smoothing the rapid growth of international air traffic, from 0.2 billion passengers in 1980 to 1.9 billion by 2019.⁷⁸

Subsequently, efforts mounted to standardize the format of visas affixed to passport pages, which finally occurred in 1992.⁷⁹ Later, the standard for the layout of passport data was modified to accommodate the European Union's Schengen visa. As concerns regarding international security mounted, new biometric standards were included, starting with facial recognition; fingerprint and iris recognition were later added as additional supporting technologies. After the 9/11 terrorist attacks in 2001, the United States required countries in its Visa Waiver Program to issue biometric passports aligned with ICAO's new electronic machine-readable travel document (eMRTD) standard. Standards for documentation for international travel further evolved with e-Passports, which incorporate a contactless radio-frequency identification chip (using near-field communication protocols) that securely stores digitally signed personal and biometric data in line with ICAO specifications. Although the eMRTD standard would likely have been widely adopted over time regardless, changing perceptions of risk precipitated political pressures on countries to adopt it more rapidly.

Indeed, the ICAO 9303 MRTD/eMRTD standard proved so successful that it became a de facto standard for national ID cards in many jurisdictions, including most member countries of the European Union and European Economic Area, as well as Albania, Algeria, Brazil, the Kyrgyz Republic, Pakistan, Panama, Saudi Arabia, Ukraine, and Uruguay, among others, where these documents can be read using the same equipment

as passports. The biometric chip included on these ID cards has proven very useful as the digital economy has grown, because it allows a form of digital ID authentication using biometric data.

A different process of developing compatible standards led to the massive growth of global trade in goods (which has increased about 45-fold in the last 75 years). Foremost was the land-sea shipping of dry goods general (or "break-bulk") cargo using standardized containers (refer to box 1.4).

The massive increases in air passenger traffic and seaborne goods traffic catalyzed by standardizing the passport and containers in turn created an urgent need for a new set of safety standards for each. Standards put into place by ICAO and the International Air Transport Association (IATA) drastically reduced the risk of a fatality in commercial air travel from 1 per every 350,000 passenger boardings in 1968–77 to 1 per every 13.7 million boardings globally in 2018–22. Over this half century, air travel fatalities dropped about 7 percent annually and by a factor of two every decade.⁸⁰

The history of marine safety, it has been said, "is soaked in water and written in blood."⁸¹ As with the development of most other safety standards, major disasters have largely driven the process in the case of marine safety. The sinking of the "unsinkable" *Titanic* in 1912 was the defining moment in modern maritime safety, leading to the adoption of the International Convention for the Safety of Life at Sea in 1914. One ship in every 100 was lost in 1910. A century later, this rate had declined to about 1 ship in every 670,⁸² the result of a host of safety standards put into place by an evolving system of marine insurance and technical standards established by Lloyd's Register of Shipping and later expanded by the Inter-Governmental Maritime Consultative Organization as an arm of the United Nations in 1948 (the latter in turn became the International Maritime Organization, or IMO, in 1959).

Box 1.4 A box on a box

The standardized intermodal shipping container represents one of modern economic history's most transformative yet understated innovations. This seemingly simple steel box, leveraging standardization and intermodality, eliminated critical bottlenecks in shipping goods using a combination of land and sea transport; unlocked unprecedented economies of scale; and revolutionized the cost, speed, and geographic span of global transport of freight.

Until the mid-twentieth century, the technology for unloading general cargo through break-bulk shipping had barely changed for centuries. A labor-intensive process involved manually handling individual items in barrels, sacks, and crates, which were transferred piecemeal between land and ship. Despite minor improvements like pallets, cargo handling remained inefficient, making the risk of loss or damage high and causing port congestion and delays, with ships spending two-thirds of their productive time idle in port, loading or unloading.

Italian visionary Silvio Crespi, founding director of the Bureau International des Containers et du Transport Intermodal [International Bureau of Containers and Intermodal Transport], conceptualized the modern container as early as 1928, describing it as “the mobile box of the carriage.” It would be detachable from wheels and platform, enabling “international house-to-house transport via multiple modes of transport” in which “reloading is kept to a minimum, and the goods within the container are not touched at all.”^a But realizing this vision would require systemic change.

The breakthrough came from outside shipping. Concerned about highway congestion, US trucking entrepreneur Malcom McLean envisioned integrating trucking and shipping door to door. His pivotal insight was that success in this type of integration required complementary innovations across the entire chain: ships, cranes, ports, trucks, trains, and storage. He shipped the first intermodal containers on a converted tanker in 1956.

Initially, containerization expanded domestically within the United States. Loading costs plummeted from US\$5.83 per ton for break bulk to a mere US\$0.16 per ton for containers: a 36-fold reduction. The time savings, which were also dramatic, meant that ships spent vastly less time idle in port, aligning with McLean's principle that “a ship earns money only when she's at sea.”

But early adoption faced significant hurdles. Container sizes varied widely, creating incompatibility. Manufacturers, haulers, forwarders, agents, railways, and stevedoring companies operated in isolation, using diverse handling practices and equipment, hindering interoperability. The US Federal Maritime Board initially drove standardization, mandating in 1961 that ships for commercial transport be built to specific dimensions in order to receive

(Box continues next page)

Box 1.4 A box on a box (*continued*)

construction subsidies. But international diffusion of standards accelerated only following McLean's decision to license key patents royalty free to the International Organization for Standardization (ISO), which went on to create standards for almost every aspect of containers (in 1965)—from their dimensions, to how they can be stacked, to the twist locks that securely fasten them to ships' decks or to trucks, to their strength requirements and lifting standards—making a universal system feasible. Although adoption was rapid, usage was more gradual, partly because of the sizable fixed costs of investment.^b

Dockworkers resisted the implementation of containerization, rightly viewing it as a threat to their livelihoods, as did port authorities navigating the trade-offs between significant up-front costs and uncertain returns. Initially, smaller ports that undertook the necessary investments edged out then-dominant ports. Soon, containerization sharply reduced the costs of handling cargo, insurance premiums, and inventory capital tied up in transit. Transit time between Australia and Europe, for instance, dropped from 70 to 34 days, halving the associated capital cost of inventory. The reduction in ship turnaround times unlocked large economies of scale. Vessel capacity quadrupled between the 1960s and the 1980s, only to increase even further in the decades that followed. Sealed containers drastically reduced the pilferage, damage, and theft common in break-bulk shipping, reducing insurance costs greatly. By 1983, nearly 90 percent of countries had container ports, underscoring the rapid and pervasive adoption of containerized shipping.

The private sector developed the shipping container, but the container had its global impact only after ISO developed a standard format for it. The standardization of the physical container itself, however, was not enough. A complementary standardization was needed in the procedures and information flows that accompany containerized trade. The United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT) played a key role in developing procedural standards and standards for data exchange that enabled efficient container use across borders and transport modes.

Containerization delivered “a permanent boost” to bilateral trade, with a cumulative increase of 1,240 percent in trade among developed countries after 15 years, far exceeding the impacts of trade policy.^c Arguably, it “boosted globalisation more than all trade agreements in the past 50 years put together.”^d

Source: WDR 2025 team.

a. Klose (2015, 47).

b. Egyedi (2000); Rua (2014).

c. Bernhofen et al. (2016).

d. *Economist* (2013).

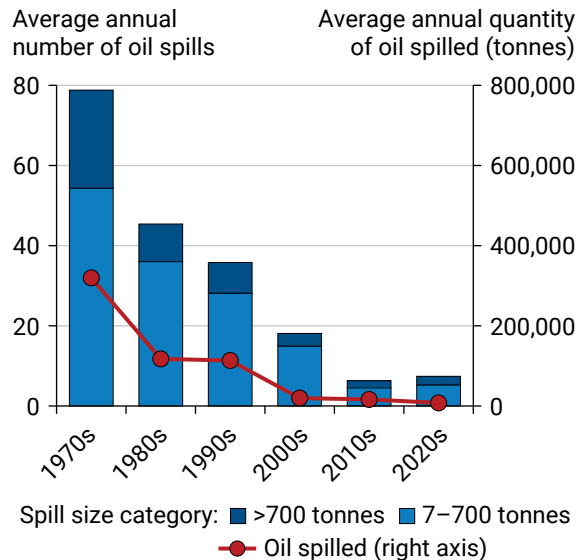
Although ship disasters for the most part meant loss of lives and financial costs, one type of ship disaster also had substantial negative externalities as a result of the environmental damage that resulted: oil spills from oil tankers. As global demand for oil grew in the post–World War II era, so did the number and size of oil tankers—and the number of environmental disasters from oil spills. The *Torrey Canyon* oil spill off the French and Cornish coasts in 1967 resulted in the landmark International Convention for the Prevention of Pollution from Ships. Although this convention was adopted in 1973, it became effective only in 1983, 16 years after the disaster. A series of other major disasters involving oil tankers, including the *Amoco Cadiz* in 1978 (off the Brittany coast in France) and *Exxon Valdez* in 1989 (off the coast of Alaska), increased pressure to raise standards for shipping oil, encompassing construction (double hulls), crew certification and staffing, contingency planning, and the development of plans for responding to disasters. US regulators made the ceiling for compensation in cases of accidents so high that the tanker industry mobilized, resulting in a 90 percent decline in oil spills over the past half century (refer to figure 1.2).

Interoperability standards as protocols in the digital age

Information and communications technologies have been the core technological drivers of the Third Industrial Revolution. They have been built on multiple layers of countless standards for computer hardware and software and for the internet and wireless networks. As innovation has accelerated, standards have proliferated across competing firms, consortia, and nations, becoming increasingly salient in geopolitical technology-centered competition. Macro-level standards for infrastructure (such as fiber-optic specifications from ITU and space-data interfaces from the Consultative Committee for Space Data Systems, or CCSDS) have complemented micro-level protocols (such

Figure 1.2 Standardization, in the form of improved oil tanker design and protocols, and regulation have sharply decreased the size and number of oil spills since 1970

Global spills from oil tankers, by decade



Source: Oil Tanker Spill Statistics 2024 (web page), International Tanker Owners Pollution Federation, <https://www.itopf.org/knowledge-resources/data-statistics/oil-tanker-spill-statistics-2024/>.

Note: The bars show the average number of spills annually in each decade (left axis) broken down by spill size category. The plotted red line shows the average annual quantity spilled (right axis).

as those for LANs, Bluetooth, USB, and wireless communications) shaped by the Institute of Electrical and Electronics Engineers (IEEE) and private consortia.

From the 1950s to the 1980s, proprietary products in the area of networking developed by dominant firms like Digital and IBM dominated computing. However, beginning in the 1970s, nonproprietary standards such as TCP/IP emerged from a Cold War-era blend of academic and defense research in noncommercial settings. Ethernet's triumph as the standard for LANs resulted not from its technical superiority to its competitor

(IBM's token ring), but because its promoters made it an open standard, allowing any firm to build products compatible with Ethernet. This created a broad technological community that contributed to ongoing development, testing, and knowledge sharing, which steadily improved Ethernet and lowered its cost.⁸³

However, open standards alone do not guarantee success. In the mid-1980s, the Open Systems Interconnection (OSI) model seemed poised to become the dominant global standard in network communications. Backed by major firms like Digital, Honeywell, and IBM, it was supported by governments across Asia, Europe, and North America and became an ISO standard in 1984. Although the US government had sponsored the internet protocols, it embraced the conclusions of a 1985 National Research Council report that recommended moving toward OSI. Indeed, the Department of Commerce mandated in 1988 that all computers purchased by US government agencies employ the OSI standard.⁸⁴

Despite the mandate, that did not happen. OSI succumbed to a fatal flaw that, ironically, stemmed from its commitment to openness. The formal rules of international standardization allowed any interested party to participate in the standards development process, resulting in clashing visions and disruptive tactics.⁸⁵ The emphasis on inclusiveness came at the expense of speed, a fatal liability in regard to rapidly evolving technologies.

By contrast, internet protocols were widely implemented during the 1980s and early 1990s because of their low cost and flexibility.⁸⁶ Interestingly for such a transformative technology, the process of creating standards for internet protocols was managed in a remarkably open, decentralized manner. Tim Berners-Lee invented the web at CERN (the European Organization for Nuclear Research) in 1989 (coining the term “World Wide Web”), and a few years later, in 1994, the World Wide Web Consortium (W3C) was established

at the Massachusetts Institute of Technology (MIT, in collaboration with CERN) at the urging of many firms investing large resources in the web. Subsequently, the consortium added three other institutions (in China, Japan, and Europe) as cohosts that jointly partnered in a “hosted model,” and in 2023, it transitioned into a new public-interest nonprofit organization, maintaining its core mission to develop open web standards (such as HTML, Extensible HTML [XHTML], Cascading Style Sheets [CSS], and XML). Although ITU developed key standards related to public key infrastructures, organizations such as the Internet Engineering Task Force, the European Telecommunications Standards Institute, ISO, and the IEC have all developed standards related to public key infrastructures for different contexts (refer to spotlight 5).

Despite the success of open systems, strong global network effects continued to act as incentives for proprietary standards. Microsoft's DOS and Windows, Apple's control over iOS application programming interfaces and its App Store, and Google's Android ecosystem enabled the firms that created them to dominate developers and users alike—and to extract massive rents. Still, firms have often joined standardization efforts—despite commercial rivalries—because such efforts have offered shared technological road maps, especially when firms have had complementary capabilities. Industry-driven consortia have produced many now-ubiquitous standards for interoperability such as Wi-Fi, Bluetooth, and HTML.

Standards have become even more important in areas in which there is a convergence of complex technologies, such as in the cases of 5G telecommunications networks and the Internet of Things. In the absence of a clear platform leader in a particular ecosystem, standards are key for shaping and coordinating innovation. Firms participate because participation enables them to shape technology trajectories, collaborate on joint development, and gain access to strategic information.

Currently, Werner von Siemens's assertion in the late nineteenth century that "who owns the standards, owns the market" appears to have new adherents, because technological standards have emerged as a key geopolitical battleground among the major powers. Multilateral standards development organizations, such as ITU and the World Intellectual Property Organization (WIPO) have themselves become part of a "battle of standards," especially in emerging technologies for 5G and 6G, with developing countries largely on the sidelines. If standards represented a unifying world in the twentieth century, today a fragmenting world could well result in fragmented standards putting developing countries in a quandary: How should they navigate a world of fragmented standards if competing standards emerge?

Conclusion

From ancient systems of measurement to contemporary digital protocols, the evolution of standards reflects humanity's pursuit of order, trust, and innovation through harmonized practices and risk mitigation. These attributes have been crucial for reducing the transaction costs and information asymmetries that

weaken markets. Standards have long served as codified ecosystems that have been vital for the diffusion and adoption of new technologies and for enhancing public welfare.

An important lesson from history is that standards involve trade-offs. In the process of developing standards, these include inclusion versus speed or expertise versus capture. When standards are being adopted, trade-offs exist between cost and quality, scale and diversity, and innovation and technology lock-in. On the other hand, there are complementarities between development and adoption. Deeper involvement in the development of a standard enhances the likelihood that an organization will implement the standard. The next chapter explores these trade-offs.

The history of the three successive Industrial Revolutions also teaches the critical importance of standards for managing the risks that arise from new technologies. With the dawn of the Fourth Industrial Revolution and the growing maelstrom from a combination of an incredibly transformative technology (artificial intelligence), turbocharged entrepreneurs, and intensifying geopolitical rivalries, the need for standards to manage these risks has never been greater.

Notes

1. The chapter is necessarily selective, and the three broad types of standards serve as a heuristic to organize a very broad field. It is not exhaustive, and multiple categories often operate within the same place and historical periods. For a more comprehensive classification, refer to de Vries (1998).
2. Oppenheim (1954).
3. Leemans (1960).
4. Englund (1991).
5. Middeke-Conlin (2020).
6. Metrology is the scientific study of measurement, establishing a common understanding of units and traceability.
7. Perry (1955), 5.
8. Perry (1955); Willard (2008).
9. Stone (2014).
10. Vincent (2022).
11. Rottländer (1985).
12. Clark (2010).
13. Landels (2000).
14. Perry (1955).
15. Ialongo et al. (2021); Rahmstorf (2014).
16. Mederos and Lamberg-Karlovsky (2001).
17. Ialongo et al. (2021).
18. Shamasastri (1915); Sihag (2004).
19. Li (2017); Loewe (2004); Major and Cook (2017).
20. Rosenthal (1964).
21. de Vries (2025); Rosenthal (1964).
22. Epstein (1991).
23. Ogilvie (2019).
24. Ho (1962).
25. Elman (2013).
26. Bourdieu and Passeron (1977).
27. Jacob Köbel (1536), "Geometrei von Künstlichen Messen und absehen," cited in Cochrane (1966, 48).
28. Alder (1995).
29. Vincent (2022).
30. Vincent (2022).

31. Alder (2002).
32. Alder (2002); Vincent (2022).
33. Wise (1995).
34. Scott (2020).
35. Scott (2020).
36. Kula (2014).
37. Vincent (2022).
38. John (2015).
39. Quinn (2011); Vincent (2022).
40. Winchester (2018).
41. The discussion on France and Great Britain draws on Fresso (2025), a background paper prepared for this Report. The discussion on the United States draws on Burke (1966).
42. Boiler Laws Committee (1921), 2–3.
43. UIE (2017).
44. Coffman et al. (2022).
45. Seck and Evans (2004).
46. Knowles (2011).
47. Cain and Hong (2009).
48. Homburg et al. (1998).
49. Buckley (1992); Tengku Zawawi et al. (2021).
50. Barkan (1985); Hutt and Hutt (1984).
51. Although de Vries (1998) considers scripts and alphabets to be “basic standards,” in the threefold classification set out in this Report, they are included under compatibility standards.
52. Schmandt-Besserat (2009).
53. Allen (2013).
54. Vincent (2022).
55. NIST (2025); Urton (2010).
56. Eisenstein (1980).
57. Lewis (1999).
58. Mokyr (2000).
59. David and Greenstein (1990).
60. Hunt (1997).
61. Hunt (1997); Russell (2005).
62. Saran (2014).
63. Du Boff (1980); Thompson (1947).
64. Russell (2014).
65. Smith (1985).
66. Garnet (1985); Russell (2014).
67. Russell (2014).
68. Russell (2014).
69. Russell (2014).
70. Usselman (2002, 142).
71. Fishlow (1966); Usselman (2002).
72. Major and Cook (2017).
73. Hounshell (1984).
74. Hounshell (1984).
75. Bud (2007).
76. Cronon (1992).
77. Lloyd (2003).
78. Refer to “World Air Passenger Traffic Evolution, 1980–2020” (chart), International Energy Agency (sourced from the International Civil Aviation Organization), <https://www.iea.org/data-and-statistics/charts/world-air-passenger-traffic-evolution-1980-2020>.
79. Chatwin (2011).
80. Barnett and Reig Torra (2024).
81. Keefe (2014).
82. AGCS (2012).
83. von Burg (2002).
84. Russell (2013).
85. Russell (2013).
86. Abbate (1999).

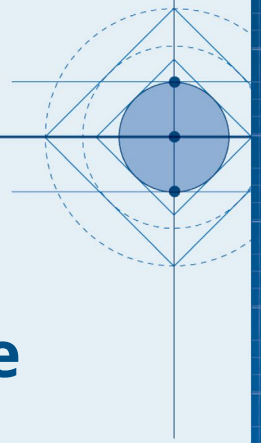
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SPOTLIGHT 1

The Role of Standards in the East Asian Miracle: Core Infrastructure for Global Competitiveness

The East Asian economic miracle, characterized by rapid, sustained growth and dramatic industrial upgrading across Japan; the Republic of Korea; Taiwan, China; and later China, has been the subject of extensive scholarly inquiry. Prevailing explanations emphasize the role of the developmental state in guiding capital allocation,¹ high saving and investment rates,² state-directed export-oriented strategies for industrialization,³ and effective development of human capital.⁴

An underappreciated factor underpinning the transformative success that these countries achieved was the systematic promotion of manufacturing standards and systems for quality control. From Japan's postwar quality revolution, orchestrated through the Japanese Standards Association (JSA) and the widespread adoption of total quality management, to Korea's Industrial Standardization Act of 1961 and China's 2015 standardization reforms, East Asian states have leveraged the development and implementation of standards strategically. Standards, quality control, and quality infrastructure are not deployed solely for purposes of regulatory compliance, but as deliberate tools in industrial policy to upgrade technological capabilities, build formidable reputations in global markets, and drastically reduce transaction costs associated with information asymmetry and excessive product variability. In this light, standards have not been ancillary to

development; they have been core infrastructure for global competitiveness.

Japan: From “shoddy imports” to paragon of global quality

Japan's ascent as a global leader in manufacturing is inseparable from the metamorphosis in its quality standards. Before World War II, Japanese consumer exports were frequently synonymous with low quality and unreliability, a damaging reputation rooted in mass-produced, inexpensive goods.⁵ Although pockets of exceptional craftsmanship existed, particularly in traditional artisanal sectors, and the country invested significantly in military hardware, the consumer goods sector more broadly lagged significantly in consistent quality. The postwar imperative for economic reconstruction and export-led growth demanded a radical break from this past. Crucially, Japanese industrial leadership proved exceptionally receptive to external expertise at a pivotal moment. When American experts on quality W. Edwards Deming and Joseph M. Juran lectured in Japan in the early 1950s under the auspices of the Union of Japanese Scientists and Engineers (JUSE), their audiences included the chief executives of Japan's largest industrial conglomerates. This was in stark contrast to their experiences in the United States, where their audiences typically comprised engineers and managers of quality

control, rarely top management.⁶ This top-level engagement by the leadership of firms, driven by an urgent need to access lucrative markets for exports (especially the United States) and overcome the country's reputation for producing shoddy goods, signaled a commitment to institutionalizing quality as a core strategy for increasing competitiveness.

At the time, prevailing conceptions of quality control, articulated in Juran's *Quality Control Handbook* (1951), primarily focused on the detection and prevention of defects, viewing quality control as an exercise for containing costs. Juran distinguished between avoidable costs (scrap, rework, warranty claims) and unavoidable costs (preventive measures like inspection and testing). In 1956, Armand Feigenbaum took Juran's ideas a step further by proposing total quality control.⁷ This approach advocated cross-functional involvement (marketing, engineering, purchasing, and manufacturing) in quality efforts. Although this was a step in the right direction, Feigenbaum did not really consider the ways in which quality was first of all a strategic question for any business; how, for instance, quality might govern the development of a design and the choice of features or options. However, Japanese practitioners, guided by Deming and Juran and facilitated by institutions like the JSA and the Ministry of International Trade and Industry (MITI), recognized that quality needed to be redefined strategically. Starting with Deming's emphasis on reducing process variation through statistical methods and management's responsibility for fostering a culture of continuous improvement, Japanese firms transformed total quality control into total quality management, which put a priority on customer satisfaction, companywide participation, and the integration of quality objectives into the core process of strategic planning led by senior executives.⁸

Japanese firms built a quality revolution around total quality management. With senior executives assuming direct responsibility for quality management, companies invested heavily in training

engineers and managers in sophisticated statistical techniques for process control, empowering front-line workers through quality-control circles to identify and solve problems.⁹ Critically, Japanese firms moved away from relying solely on end-of-line inspection to catch defects. Instead, they emphasized designing quality into products and processes from the beginning and building strong networks of suppliers. Recognizing that the final quality of products depended on the consistent excellence of components, leading manufacturers like Toyota worked closely with their suppliers, sharing knowledge regarding total quality management and enforcing strict standards for quality, which helped raise capabilities across the entire supply chain.¹⁰ The JSA played a vital role in disseminating best practices and harmonizing domestic standards with those of its international counterparts. A dual focus—establishing precise technical specifications for both inputs and end products (through Japanese Industrial Standards) and codifying specific processes for management (like procedures for total quality management through standards equivalent to the Japanese Industrial Standard Q 9000 series)—ensured that quality meant adherence to defined, measurable standards throughout the value chain.¹¹

The drive to access demanding export markets, particularly the United States, catalyzed adoption of standards and upgrading of quality. Foreign buyers (and competitors), acting as conduits of knowledge and enforcers of compliance, played a crucial role in pushing Japanese suppliers beyond initial domestic capabilities.¹² Furthermore, compliance with standards likely played a role in lowering variable costs of trade associated with rejection, returns, and reputational damage, facilitating deeper integration into global markets. Firm-level evidence from industries like automobiles and electronics shows that meeting these external standards spurred significant upgrading of technologies and gains in productivity, moving Japan up the quality ladder and building comparative advantages in high-value manufacturing.¹³

This relentless, systemic focus on integrated standards had transformative results. Japanese automobiles, emblematic of the country's reputation for poor quality in the 1950s, improved dramatically. By rigorously applying principles of total quality management, focusing on customer-defined dimensions of quality (reliability, durability, conformity, perceived value), and empowering their workforces and suppliers, Japanese automakers achieved unprecedented levels of consistency and reliability, surpassing their US counterparts in key metrics of quality by the late 1970s and early 1980s.¹⁴ Japan's journey demonstrated that quality, underpinned by robust standards and institutionalized management systems, was not merely a defensive cost but a potent strategic instrument in building global competitive advantage. The state, through MITI and the JSA, provided the framework and impetus, and industry leadership, driven by export imperatives and competitive pressure, internalized and executed the quality revolution, creating an ecosystem in which standards became the foundation of manufacturing excellence.

The Republic of Korea: Strategic standardization as an engine of industrial transformation

The Republic of Korea's extraordinary journey from postwar devastation to global technological powerhouse offers a compelling case study in the deliberate deployment of standards and quality infrastructure as core instruments of industrial policy and export competitiveness.¹⁵ Although Korea shared the East Asian model in having a developmental state, its approach to standardization was anchored in a systematic integration of standards into the national economic strategy and a pioneering role in stimulating education in the area of standardization. Ultimately the country transitioned from adopting to authoring international standards, particularly in the area of information and communications technologies.¹⁶

From the outset of its export-driven strategy for industrialization in the early 1960s, Korea recognized that penetrating international markets necessitated achieving international benchmarks for quality and safety. The state took measures to establish the foundational elements of its national quality infrastructure, encompassing metrology, standardization, conformity assessment, and accreditation.¹⁷ The 1961 Metrology Act and Industrial Standardization Act launched Korean Industrial Standards (KS), with the Korean Standards Association (now known simply by its acronym, KSA) managing dissemination. Crucially, the 1962 Export Inspection Act mandated preshipment checks, directly linking compliance with standards to export viability. The introduction of the KS mark certification system in 1961, coupled with preferential treatment in government procurement for KS-certified products, created powerful domestic incentives for KS adoption, embedding quality control into nascent export sectors like textiles and light manufacturing. Korea's accession to the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) in 1963 affirmed the country's commitment to international alignment.

During the country's growing stage (1973–95), Korea's strategic pivot toward heavy and chemical industries demanded a more sophisticated national quality infrastructure. The Korea Standards Research Institute (KSRI), later the Korea Research Institute of Standards and Science (KRISS), strengthened its metrological capabilities, aided by Germany and the United States. Importantly, a 1980 constitutional amendment obligated the state to establish a national standards system, elevating standardization to a national priority, reflected in the country's ten-year industrial standardization plan (1971–80) and subsequent five-year strategies. In the country's upgrading stage (1996–2014), standardization became integral to innovation and global competitiveness. Private sector organizations were empowered to

develop standards, increasing alignment within industries. Korea significantly increased its participation in international standards development organizations (like ISO and the IEC) and in emerging technologies in which Korean firms were becoming technological leaders (such as the 3rd Generation Partnership Project, or 3GPP, and the one Machine-to-Machine Partnership Project, or oneM2M), boosting the country from standards adopter to aspiring author.¹⁸ More recently, in its expanding stage (since 2015), Korea has decentralized its standardization authority, delegating responsibility for developing KS to relevant ministries, enhancing expertise, responsiveness, and collaboration among ministries while reducing duplication. Concurrently, Korea has intensified its drive to author global standards in frontier fields such as artificial intelligence, 5G and 6G wireless communications technology, and quantum, backed by the country's 2022 Measures for Promoting National Strategic Technologies.

Korea's ascent vividly illustrates how standards, strategically planned and institutionalized, can function as indispensable economic infrastructure. The state provided the initial vision, legal frameworks, institutions, and incentives (like the advantage given in government procurement to products certified with the KS mark), recognizing standards as fundamental to export credibility and industrial discipline. Long-term plans ensured continuity and alignment with national goals, and initiatives to build human capital and a standardization culture fostered sustainability. Rarely did firms alone drive Korea's successful cases of "stage-skipping" and "path-creating" catch-up.¹⁹ Rather, these cases relied on coordinated public-private investments, strategic access to foreign knowledge, and a policy environment that made standardization a complement to, rather than a substitute for, industrial upgrading.

Korea's global economic role transformed as a result: Standards began as keys unlocking export markets, became drivers of domestic efficiency and

quality enabling upgrading of industries, and ultimately evolved into strategic levers allowing Korea to shape the technological landscape itself. The country's deliberate, phased, and state-facilitated integration of standards into the core of its economic strategy was not ancillary to the Korean miracle; it was a critical enabler and accelerator, transforming the nation from an adopter of global standards into a formidable architect of them.

China: Strategic standardization for global leadership

China's stunning economic ascent, lifting hundreds of millions of people out of poverty and transforming the nation into a technological superpower, represents a distinct yet integral chapter within the narrative of the East Asian miracle.²⁰ Although state-led investment, export-oriented manufacturing, and development of human capital were essential to the country's economic success, the development community has overlooked China's strategic use of standards and quality infrastructure in industrial upgrading and global integration. China's path reflects a transition from passive adoption of foreign standards to active leadership in developing them, particularly in the areas of telecommunications, high-speed rail, and renewable energy.

China laid the foundations for its economic miracle during the post-1978 reform era. Recognizing that standards were vital for modernization, quality control, and access to global markets, China passed the Standardization Law in 1988. This period has been characterized by strategic alignment with international standards. China joined key international bodies (the IEC in 1957; ISO in 1978; and the World Intellectual Property Organization, or WIPO, in 1980), and by 2001, 38 percent of ISO/IEC standards had been converted into Chinese national standards, and 43.7 percent of China's national standards had been developed by adopting international standards.

China's accession to the World Trade Organization (WTO) in 2001 was a turning point and marked an acceleration in its economic transformation, shifting the country's strategy from alignment toward active participation in standards development and indigenous innovation. The establishment of the Standardization Administration of China (SAC) and the Certification and Accreditation Administration (CNCA) centralized functions that had previously been fragmented, providing stronger governance. SAC formalized procedures for adopting international standards, and CNCA drove conformity assessment, approving 182 certification bodies by 2007 and increasingly aligning China with the international systems for quality management (ISO 9001) and environmental management (ISO 14001) to bolster global legitimacy for the country's products.²¹ Strategic plans like the National Medium- and Long-Term Plan for Science and Technology Development (2006–20) explicitly tied standardization to indigenous innovation and institutionalized collaboration across sectors.

China's standardization strategy was closely integrated with government efforts to boost manufacturing by encouraging foreign firms to invest heavily—not only financially, but also in manufacturing expertise, as well as an array of complementary activities, through infrastructure, subsidies, and access to a large pool of inexpensive migrant labor. Systematic efforts in regard to education and research to support standardization underpinned these efforts.²²

By 2015, adoption of international standards in key consumer sectors in China exceeded 80 percent. Chinese standards for specific sectors, such as those for food safety and environmental regulation, boosted export performance in two ways. First, it reduced information asymmetries between Chinese firms and importers by signaling quality to foreign buyers, especially when harmonized with international standards.²³ Additionally, it lowered import barriers associated with noncompliance

with international standards (rejections, delays) and facilitated transfer of knowledge regarding international best practices. China's institutional clout also grew: Chinese experts held more than 10 leadership positions on ISO and IEC technical committees by 2015, and their contributions to international standards jumped from 13 (before 2000) to 182 that same year. Xiaogang Zhang's election as ISO president, again in 2015, further affirmed this rise.

The 2015 adoption of international standards, embodied in the Program for Deepening the Reform of Standardization Work and later the National Standardization Development Outline (targeting global leadership in the area of standardization by 2035), represented a strategic shift toward a market-driven, innovation-centric model for standards. The government consciously moved from direct control to setting baseline thresholds (often via mandatory national standards focused on health, safety, and security), while empowering enterprises, research institutions, and industry associations to lead standards development. Government-led standards provided a regulatory foundation, and market-driven standards became the engines of innovation and competition, mirroring international practices.

The resulting framework, balancing state direction with market dynamism, has positioned China as a global leader in development of standards in key emerging technologies. In telecommunications, for instance, it moved from developing stand-alone standards for third-generation wireless communications technologies to dominating 5G standards. By 2024, Chinese firms held 40.8 percent of standards-essential patents for 5G technologies declared to the European Telecommunications Standards Institute (ETSI) and contributed about 34 percent of technical proposals accepted by the 3GPP, with Chinese multinational technology company Huawei alone accounting for more than 20 percent of contributions and 16.9 percent of standards-essential patents. In the area of

high-speed rail, China evolved from a technology importer to standard setter, holding about 70 percent of global patents in the area of high-speed rail by the mid-2020s, chairing subcommittees of ISO Technical Committee 269 and driving all 13 International Union of Railways system-level international standards for high-speed rail.

Chinese standards underpin major international projects like the Jakarta-Bandung and Mombasa-Nairobi railways, demonstrating economic impact and serving as vectors for standards diffusion. In the realm of solar energy, China leads in both production and standard setting, holding 66 percent of global photovoltaic patents by 2023, driving work in IEC Technical Committee 82 on next-generation technologies, and exporting solar components embedded with Chinese standards. However, unlike what happened in regard to 5G wireless communication technologies, which are globally interoperable, in the case of charging infrastructure for electronic vehicles, China chose its own path, supporting domestic industry, even though it means incompatibility with foreign charging technology for such vehicles, which is based either on Japanese or European/US standards.

Standards diplomacy has been an important component of China's Belt and Road Initiative. Bilateral agreements between China and other countries regarding standardization grew from 81 (with 47 countries) in 2017 to 108 (with 65 countries) by 2023. Regional platforms such as the China-ASEAN [Association of Southeast Asian Nations] Standardization Cooperation Forum promoted alignment of these agreements with one another. Underpinning these efforts were massive increases in spending on research and development, with Chinese patent filings surging from 103 in 1995 to 70,153 in 2024 (25.6 percent of the global total). A strengthened regime regarding intellectual property (observable in a 450 percent

rise in litigation in the area of intellectual property between 2013 and 2023) and proenforcement rulings by China's Supreme People's Court enhanced trust in Chinese standards. All of these contributed to China's growing influence in bodies that develop international standards.

China's standards development has been based on *incremental adoption*, beginning with selectively adapting foreign standards that suited domestic conditions; *pilot testing*, with new technical standards introduced in limited pilots or select industries, tested in practice, and only later scaled nationwide; and *hybrid strategies* with dual systems allowing domestic standards to coexist with international ones before decisions were made as to which pathway would dominate. The country's swift ascendance from aligning with international standards to systematically shaping them in specific sectors has involved a two-legged approach: mandatory state standards to ensure baseline compliance and voluntary standards driven by the market to spur innovation and competitiveness in high-tech sectors. Although strategic direction on priorities is set centrally, there has been a deliberate shift from top-down control to delegated standard-setting authority.

Lessons for latecomers

The East Asian economic miracle was underpinned by the strategic deployment of standards, quality control, and quality infrastructure as core tools of industrial policy for technological upgrading, export competitiveness, and productivity growth. Japan's quality revolution, Korea's phased institutionalization of its national quality infrastructure, and China's shift from alignment with international standards to indigenous innovation and development of international standards each demonstrate distinct yet effective approaches that fit the countries' cultures and institutions.

Institutional setup critically shaped outcomes: Japan's initial emphasis focused on internal (company) standardization to build quality rather than participation in international standardization, and its polycentric model fostered deep capacity building but required strong interfirm trust; Korea's centralized hierarchy enabled rapid mobilization of resources but initially limited private initiative; China's two-legged approach balanced regulatory control with market dynamism but risked fragmentation. Delegated authority to private actors (such as business networks and industry consortia) proved essential for responsiveness to technical change. Strong state capacity was crucial in all three cases: Japan's MITI and JSA, Korea's KATS/KSA, and China's SAC provided coordinated vision, legal frameworks, and institutions to align standards with industrial policy.

Although the precise causal weight of each of the components of these institutional models varies, a common thread emerges: a feedback loop between trade and standards. The imperative to access demanding export markets and integrate into global value chains acted as a potent catalyst,

driving firms to adopt and upgrade standards through mechanisms like learning-by-exporting.²⁴ This adoption and upgrading, in turn, lowered trade costs, boosted productivity, facilitated diversification into higher-value exports, and built endogenous comparative advantages, further enhancing trade competitiveness.²⁵ Another common thread has been the emphasis on building expertise by incorporating standards in regular education courses.

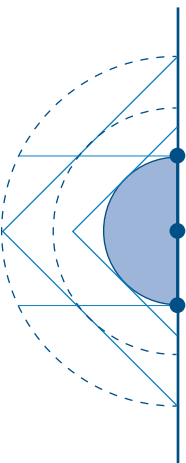
East Asia's success in the area of economic transformation rested on three interlocking conditions: strong state capacity to orchestrate standards ecosystems, export orientation to catalyze upgrading, and alignment with lead firms for knowledge transfer. Although many low-income developing countries would find these conditions difficult to reproduce, it must be remembered that six to seven decades ago, China, Japan, and Korea were in roughly similar straits. A more challenging international environment, however, means that latecomers need to engage more actively with standards development while fostering agile public-private partnerships.

Notes

1. Johnson (1982).
2. World Bank (1993).
3. Amsden (1989); Wade (1990).
4. Stiglitz (1996).
5. Vogel (1979).
6. Cole (1989); Juran (1995).
7. Feigenbaum (1956).
8. Nonaka (1998).
9. Ishikawa (1985).
10. Asanuma (1989); Cusumano (1985); Fruin (1992).
11. Nakamura (1993).
12. Lawrence and Weinstein (1999).
13. Henn et al. (2013); Hummels and Klenow (2005); Ito and Pucik (1993).
14. Liker (2004); Womack et al. (2007).
15. This section on Korea draws on Lee and Kim (2025), a background paper prepared for this Report.
16. Choi and de Vries (2013).
17. Choi and Choi (2019).
18. Lee and Kim (2025).
19. Lee and Lim (2001).
20. This section draws on Gong and Zhang (2025), a background paper prepared for this Report.
21. Kennedy (2006).
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PART 2

Navigating the Complex World of Standards and Using Them Effectively

Standards are essential for the functioning of markets and institutions. They come in many forms and serve many different purposes. Most standards are voluntary, developed by stakeholders who perceive a market or societal need for them. Standards can become mandatory, however, when they are enshrined in laws or agreed upon in legally binding contracts. They may differ in their geographic reach, varying, for instance, according to whether they have been developed at the national or international level. Depending on their function, standards establish consistent measurement, ensure compatibility, and enhance quality.

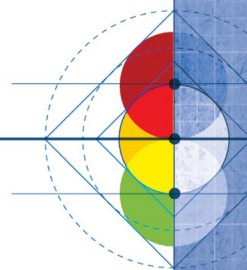
To build an understanding of how best to use standards for development, chapter 2 provides a clear definition of standards and distinguishes their various types, forms, and functions. It explains the rationale for standards in diffusing knowledge and information, enhancing coordination, encouraging competition, and addressing externalities. The chapter also discusses how various stakeholders—in the private sector, civil society, and government—contribute to the development of standards. Understanding the motivations of these stakeholders can help in assessing the opportunities, challenges, and trade-offs involved in the development and adoption of standards and in identifying instances in which too few or too many standards are likely to emerge.

A key question of this Report is: How should low- and middle-income countries use standards for development? Chapter 2 offers guidance on the different ways that both voluntary and mandatory standards can serve as tools of public policy, highlighting how standards differ from regulations and how they complement other instruments such as market-based policies. It also presents a conceptual framework showing how

low- and middle-income countries can move toward higher standards for quality, adapting international standards to local capacity when necessary, while gradually raising the ambition of their standards and their ability to meet those standards.

Both the implementation of voluntary standards and the enforcement of mandatory standards rely on a broader system of public and private institutions and policies. This system, known as quality infrastructure, includes metrology, conformity assessment (testing, inspection, and certification), accreditation, and standardization itself. A country's quality infrastructure functions across various policy areas, from accrediting universities in education to inspecting hospitals in health care. Chapter 3 explains how countries can increase their ability to comply with standards by developing effective quality infrastructure. It discusses how to strengthen institutions, sequence reforms, and allocate roles between the government and the private sector.

Spotlight 2 discusses the important role of international standards development organizations in promoting international coordination in developing standards, noting that low- and middle-income countries tend to be underrepresented in these organizations. Spotlight 3 focuses on national standards bodies and builds on a novel survey conducted by the International Organization for Standardization (ISO) and the World Bank. The spotlight emphasizes differences and similarities between low- and middle-income countries and high-income countries, such as the varying roles played by governments in these countries with respect to standards.



2

Using Standards as a Catalyst for Development

Main messages

- Standards are more important for low- and middle-income countries today than when high-income countries were at similar levels of development, especially because of increased technological sophistication and the pressures and opportunities of globalization.
- Standards are ineffective when they are not implemented. Therefore, countries need to adopt a balanced approach that aligns their ambition for higher standards with their capacity to comply with them.
- Aligning with international standards enables market access and learning, but low- and middle-income countries may not always find such alignment feasible. Countries should first *adapt* international standards as needed, then *align* with them over time, and eventually *author* them. This path is not necessarily linear and may differ by country and by sector.
- Low- and middle-income countries may face a *vicious circle of low quality* created by low demand for quality among domestic markets and society, weak institutions and low quality of production, and low compliance capacity. Standards can help break this circle.
- This Report considers a wide range of different types of standards, both voluntary and mandatory ones. It focuses on three types of standards based on their core function: *measurement standards*, *compatibility standards*, and *quality standards*.
- Most standards are *voluntary* and emerge because of private incentives to address market or societal needs or both. Sometimes, governments need to help convene development of voluntary standards.
- Standards may become *mandatory* if enshrined in law. Mandatory standards are particularly useful when uniform compliance is needed to meet a given target or when they simplify compliance and enforcement.
- Policy benefits from using the full spectrum of standards include using voluntary standards to drive innovation, leveraging them to support regulation, and applying mandatory standards in high-risk areas.

Introduction

This chapter first clearly defines the nature and different aspects of standards. It then builds on basic economic principles to explain the rationale behind standards and how to differentiate them from regulation. It also develops a conceptual framework to help policy makers understand how to use voluntary and mandatory standards, leveraging the strengths of each type of standard as catalysts for development. This chapter should be read alongside chapter 3, which focuses on how to build a country's public and private system for implementing and enforcing standards (that is, the country's quality infrastructure).

Understanding standards

Definition and typology of standards in the Report

Important standards surround us, defining the precise dimensions and tolerances of screw threads, the weight of a kilogram, how to build a fire-resistant wall, the minimum age for legal work, and how digital devices communicate with cell towers and one another, among many other things. Standards enable trade in goods and services, improve education and health care, help protect the environment, and support knowledge sharing.

Aiming to capture the different ways standards matter for development, this Report adopts a broad definition. It defines standards as *codified solutions meant for common and repeated use that are recognized by multiple stakeholders*.¹ This definition of standards centers on four key elements:

- *Codification*. Standards systematically document rules or specifications. Therefore, traditions or rules of thumb are not considered standards.²

- *Need*. Standards should be developed and implemented only when there is a clear need for them, such as addressing market failures or agreeing on, as the International Organization for Standardization (ISO) puts it, “the best way of doing something.” Standards provide a *solution* to such a need, and the solution can vary depending on the context. They are *normative* documents, as they provide not only information, but also specifications that are preferable over alternatives.
- *Common and repeated use*. Standards are designed for wide and repeated application, ensuring consistency or uniformity. For example, a manufacturer may use standards for its inputs to ensure that its suppliers consistently deliver the same level of quality.
- *Recognition*. Codified solutions become standards when other entities recognize them. Such recognition can occur either because entities consider the process used for developing a standard to be legitimate or because they accept a standard's authoritative status, whether voluntarily or not (for example, to access a market or to comply with a regulation). Although organizations may develop standards for their internal processes (such as the size of the hamburger bun in a fast-food chain), these internal standards are not the focus of this Report.

The Report's definition of standards broadly aligns with existing definitions but adapts them to accommodate the wide scope of the Report's analysis. In particular, the definition used by ISO and the International Electrotechnical Commission (IEC) characterizes standards as documents established by *consensus*, a principle that reflects the governance model of these organizations.³ Although this is an important principle at ISO and the IEC and among their member bodies, many other standards of high relevance to low- and middle-income countries, especially

those promulgated by industry associations, governments, or private initiatives, are not based on consensus.⁴

It is helpful to distinguish among the various types of standards discussed in the Report that fall under the broad definition just presented. Table 2.1 presents a typology. Importantly, compliance with standards may be either voluntary or mandatory. Although many are voluntary, standards become mandatory when enshrined into law. Voluntary standards can also be legally binding when they are included in contractual obligations. The Report highlights that both voluntary and mandatory standards play a critical role for development, and that policy makers must clearly distinguish between them, because they serve different functions and pose distinct policy challenges.

The Report’s use of the terms *voluntary standards* and *mandatory standards* departs slightly from common usage in the standards community and in organizations such as the World Trade Organization (WTO). In that expert context, *standards* are understood as voluntary instruments, whereas once their requirements are made legally binding, they are referred to as *technical regulations*.⁵ The distinction between these two terms underscores that not all technical regulations are based on, or make reference to, recognized standards, contrary to good international practice.

This Report nonetheless adopts the terminology of *voluntary* and *mandatory standards* for two reasons. First, it provides greater clarity for nonspecialist audiences. Second, it reflects the fact that standards are applied in many domains beyond trade policy—such as education, construction, and public administration—in which the term *technical regulation* is rarely used. Throughout the Report, *mandatory standard* may therefore be read as broadly synonymous with *technical regulation*, particularly in contexts relating to trade.

Table 2.1 Typology of standards

DIMENSIONS	OPTIONS
Legal status	• Voluntary • Mandatory
Stakeholders involved in standards development	• Government • Private sector • Civil society, academia, and professional associations • International organizations • Mixed
Exclusiveness	• Open • Proprietary
Geographic level	• International • Regional • National • Subnational • Organization
Target	• People • Processes • Organizations and systems • Products and services
Core function	• Measurement • Compatibility • Quality (for example, performance, safety)

Sources: WDR 2025 team, based on de Vries 1998; OECD and ITC 2024.

Note: The list of options included in the table is not exhaustive.

Standards can also be classified according to the types of stakeholders involved in developing them (for example, government, private sector, or civil society). Standards developed by the government are often referred to as *public standards*, whereas *private standards* are developed by private or multistakeholder entities and are typically voluntary.

Standards may be developed in consensus in formal standards development organizations or evolve as de facto standards. When developed in consensus, standards, particularly international standards, typically result from the pooling of knowledge from leading experts in agreement on what they consider “the best way of doing things.”⁶ In contrast, de facto standards are typically put in place by a single firm with market power. The Microsoft Word file format is an example of a standard developed by a single company, and so without formal consensus. On the other hand, the PDF file was a de facto standard, a proprietary technology developed by Adobe, which became a formal international standard, having been adopted by consensus at ISO (in the ISO 32000 series of standards).

A further distinction can be made between open and proprietary standards. *Open standards* are publicly accessible, and anyone can use them. Standards developed in consensus tend to be open but may still be behind a paywall. In contrast, *proprietary standards* are typically controlled by a company or consortium and may be protected by intellectual property rights such as patents or copyrights. Their use may require licensing agreements or fees or be accompanied by technical restrictions, giving the holder of the rights to them control over implementation and potentially limiting competition or interoperability. De facto standards are often proprietary (refer to the discussion in chapter 4 on standards for a better economy).

Standards can also be classified by their geographic scope (international, regional, national, or subnational) and by what they standardize (that is, their target). Standards may pertain to people (such as skills standards), processes (such as methods for testing products), organizations and systems (such as quality management systems), or products and services (such as standards for material strength).⁷

This Report focuses on three types of standards based on their core function: measurement, compatibility, and quality standards.⁸

- *Measurement standards* are agreed-upon methods for ensuring consistency, accuracy, and reliability in measurement. They are crucial across various fields for providing a common understanding of weights and measures or a common metric for assessing quality or progress, reducing errors, and enhancing consumer confidence in products and services. Measurement standards enable accurate comparisons of measurements across different locations and times, thus supporting global trade and technological advancement. Disability-adjusted life years and quality-adjusted life years are examples of measurement standards in health care.
- *Compatibility standards* are agreed-upon specifications that ensure interoperability and compatibility among different systems, devices, or components. They enable products or services to work together seamlessly even if developed by different manufacturers. Standard gauge for rails in railway systems and standardized freight containers are both examples of compatibility standards. Compatibility standards also help reduce product variety. For example, in the 1920s the US government pushed manufacturers to move to “standard sizes,” which helped enable mass production (refer to chapter 1).
- *Quality standards* specify properties a product, service, system, or process needs to have to achieve a defined level or state of quality (for example, performance, safety, reliability, sustainability).⁹ If measurement standards define a ruler, quality standards define a marker on the ruler. Examples of quality standards include standards for product safety, caps on fuel emissions, quality management systems, and professional skill qualifications. Quality standards are often an important prerequisite for a product to be sold in the market and for schools, hospitals, and businesses to operate.

In addition to these three core functions, further types of standards can be distinguished. For instance, some standards serve primarily to establish common terminology or definitions.¹⁰

Types of problems standards address

Standards can play a crucial role in improving coordination and facilitating the efficient functioning

of markets by addressing failures in coordination and market failures related to imperfect information, externalities, or market power. Depending on the nature of the policy challenge and the incentives of the stakeholders involved, voluntary standards may offer a more effective solution, or mandatory standards may, as table 2.2 illustrates. Policy makers must balance the complementary strengths of these two types of standards, drawing on voluntary standards when market demand

Table 2.2 How standards may reduce transaction costs and address market failures

ROLE OF STANDARDS		PURPOSE	TYPE OF STANDARD USUALLY APPLICABLE		OUTCOMES
			VOLUNTARY OR MANDATORY	MAIN FUNCTION	
	Diffusing information	Offer codified good practices	Mostly voluntary	Quality	• Knowledge transfer • Quality upgrading • Productivity
	Addressing coordination failures	Provide common specifications	Voluntary and mandatory	Compatibility, measurement	• Economies of scale • Compatibility • Lower transaction costs • Variety reduction
	Promoting competition	Provide common specifications	Voluntary and mandatory	Quality, compatibility	• Lower switching costs • Transparent information • Competition
	Reducing information asymmetries	Provide transparent, reliable, or consistent information	Mostly mandatory	Quality, compatibility, measurement	• Lower search and transaction costs • Higher trust and consumer protection
	Addressing negative externalities	Define thresholds, processes, or technologies to reduce harm to others	Mostly mandatory	Quality	• Environmental protection • Social sustainability • Economic fairness

Source: WDR 2025 team.

Note: Whereas this table illustrates typical patterns, real-world standards often serve multiple purposes simultaneously, for instance, blending measurement, compatibility, and quality functions.

drives innovation and adoption and enforcing mandatory standards when public interests like health, safety, or environmental protection require enforceable rules. Quality, compatibility, and measurement standards all play a role, but certain types tend to be more effective for specific problems, for example, compatibility standards for network effects.

Diffusing information. Quality standards embody information about good practices, especially when these standards are developed through consensus by leading experts. Quality standards are usually best kept voluntary. For example, an organization can follow the guidance and requirements in ISO 9001 to learn how to set up a quality management system that ensures consistent product quality, tracks defects, and incorporates customer feedback.¹¹ Standards help organizations avoid having to “reinvent the wheel.” Like a recipe, standards codify good practices, allowing the transfer of knowledge. As a result, standards significantly enhance quality and boost productivity. Low- and middle-income countries can benefit from the knowledge transfer that standards allow by adopting international standards or participating in expert discussions as international standards are developed.

Addressing coordination failures. Standards help address coordination failures. The US National Institute of Standards and Technology (NIST) calibrates a standard for time measurement using atomic clocks that time-stamp hundreds of billions of financial transactions every day, and the institute’s internet time service receives more than 40 billion hits daily to synchronize clocks on computers and network devices. From the rise of mass production to the development of global value chains and increased reliance on the internet, standards have become essential foundations of the economy. By offering common specifications, they enable economies of scale; support network industries like railways, telecommunications, and the digital economy; and increase market sizes (for example, through regional economic

integration such as that which characterizes the European Union). Shared specifications also help reduce the variety of products and components available, which can significantly boost efficiency, as when automotive manufacturers standardize parts like bolts or battery sizes across models, facilitating bulk purchasing, streamlining assembly, and making maintenance easier. Standardization of this kind can occur through market forces via voluntary standards or through government regulation. Compatibility standards also promote wider dissemination and ease of use of technology, allowing users to switch among compatible products. Additionally, product standardization is essential for enabling worker specialization within firms, leading to higher productivity and growth.¹²

Promoting competition. Standards can also promote fair competition by lowering barriers to market entry.¹³ For instance, compatibility standards in telecommunications or payments allow users on one network to connect with users on another, encouraging competition among service providers.¹⁴ By sharing information, standards help businesses compete by enabling consumers to make better-informed decisions. They can also create a level playing field. For example, safety standards that underpin conformity marks let smaller manufacturers compete by ensuring they meet the same safety requirements as established brands.¹⁵ Likewise, bioequivalence standards allow generic drug manufacturers to compete with brand-name medicines, offering consumers confidence that generics are equally effective.¹⁶ However, standards can also act as a barrier to entry, which is one of the risks discussed in the next subsection.

Reducing information asymmetries. Standards can convey vital information that helps build trust between people and organizations. When paired with credible certification (discussed in chapter 3), standards help fill information gaps by signaling product quality or specifications.¹⁷ For example, standards enable a buyer of gold to trust that the weight and purity of the gold match the

seller's claims.¹⁸ This boost in trustworthiness can reduce the costs associated with managing economic transactions in firms, bureaucracies, and broader economic systems, which is why both voluntary and mandatory standards can be effective, depending on the situation. For instance, with standards, a firm does not need to spend time and resources verifying quality and specifications with each purchase.¹⁹ Reducing such costs, often referred to as *transaction costs*, allows organizations to thrive and countries to develop.²⁰

Addressing negative externalities. Standards are crucial for addressing negative externalities, a significant market failure. Negative externalities happen when an economic actor does not bear the full costs of its actions, passing some of those costs on to others. Standards—usually mandatory ones—set rules, thresholds, or procedures to help prevent or lessen harm caused by negative externalities. For example, to cut air pollution, emissions standards limit the amount of harmful chemicals that factories can release into the environment. Standards for lending and capital adequacy establish minimum requirements financial institutions must meet in order to extend credit, reducing the risk of financial instability from excessive lending. Standards also support the enforcement of these rules, thresholds, or procedures. For instance, the World Health Organization (WHO) offers air pollution guidelines that countries can use when creating their own national standards. Regarding greenhouse gases, ISO 14064 provides guidance for measuring, monitoring, and reporting emissions and removals, helping entities mitigate their environmental impact.

Risks of standardization

Although standardization can be helpful, it can also create risks depending on the way standards are designed and used. Developing and implementing standards with requirements that are unrealistically high can be a case of “the best being the enemy of the good,” especially if the standards

increase costs for adoption and enforcement. Standards can also be exclusionary, particularly for small firms that lack the financial resources needed for their implementation and for certification that they have been met.

Mandatory standards, which as noted earlier are also called “technical regulations” in some domains, can be used as barriers to trade. As chapter 4 shows, the share of global trade subject to nontariff measures such as mandatory standards rose from about 15 percent in the 1990s to nearly 90 percent in the 2020s.²¹ High-income countries have historically relied more on such measures and often imposed stricter ones, but low- and middle-income countries are now applying them almost as extensively. Beyond their impact on international trade flows, mandatory standards and other nontariff measures also influence competition among domestic firms.

Dominant firms may promote their own technological standards to increase their own market power. For most of the twentieth century, this did not present a major obstacle to competition, thanks to the open and collaborative processes used to establish most standards, whether in national or international forums. However, this started to change during the Third Industrial Revolution (driven by information technology, or IT) and has continued into—or even worsened in—the ongoing Fourth Industrial Revolution, in which digital, physical, and biological systems come together. The network effects inherent in these new technologies create a winner-takes-all environment, encouraging the use of standard essential patents or other forms of intellectual property protections to earn rents.

Standards can lock firms and countries in a sub-optimal equilibrium if they prevent adjustments in a rapidly changing environment. For example, the QWERTY keyboard is a well-known example of technological lock-in. Originally designed to prevent typebars on a typewriter from jamming, it remains the standard layout for computer

keyboards today, although other designs may be more efficient. Similarly, the persistence of the Imperial measurement system illustrates the strong path dependency of standards that become deeply embedded in institutions, infrastructure, and everyday practices, making change costly.

Who develops standards and why

Because standards serve multiple purposes, stakeholders have various reasons to develop them. The demand for voluntary standards typically arises from practical market needs. Custom screw threads were acceptable when made in small quantities, but mass production of goods with screws naturally created the necessity for standard screw threads as a practical way to simplify processes. Constant train derailments in the late nineteenth century highlighted the need for mandatory standards ensuring consistent quality in steel rails (refer to box 1.2 in chapter 1).

The different motivations of stakeholders influence how and with whom they collaborate to develop standards. In network industries like IT, a small group of technology companies often has a strong commercial incentive to develop voluntary standards that address specific issues, such as communications and exchange protocols. In sectors undergoing rapid technological change, the speed of standards development becomes more important than wide stakeholder participation. As a result, firms frequently form private consortia for developing standards rather than relying on formal international standards development organizations like ISO or the IEC. This is one reason why many standards development organizations around the world are specific to particular sectors.

In some contexts, a standard may require the involvement of many different stakeholders, as in the case of international standards. ISO and IEC commitment to inclusive stakeholder engagement

and consensus is based on the understanding that, for a standard to be applicable internationally, its development process must be accessible to a diverse group of stakeholders. For this and other reasons, the WTO has established six principles for international standards development, among them openness and consensus.²² However, the goal of inclusivity often results in longer development times for standards and a risk that the purpose of a standard may become diluted as a result of the many participants involved (refer to spotlight 4 for details). Meanwhile, broad and balanced stakeholder involvement in international standardization remains a goal, as the representation of low- and middle-income countries and smaller firms is often inadequate.

Stakeholders' private incentives for participating in developing international or national standards vary. They may want to influence the process to shape markets in favor of their own technologies or to guide future regulations related to a particular standard. However, their incentives to participate in the development of a particular standard can be weak if the standard is not essential to their area of work, leading to a free-rider problem. For example, while a shared standard for data exchange may benefit an entire industry, no individual firm may be willing to invest its own time and resources to help develop it.

Unlike industrial standards, the development of which has only commercial incentives, *voluntary sustainability standards* evolve from a mix of commercial incentives and broader societal objectives. Such voluntary sustainability standards are often sector specific and developed outside established national or international standards development organizations by a group of industry players, though often with contributions from nongovernmental organizations, government institutions, and academics. For example, Unilever and the World Wide Fund for Nature (WWF) founded the Marine Stewardship Council (MSC) to address concerns about overfishing and lack of

sustainability standards in global fisheries. With sustainability regulation often providing only a floor for performance, voluntary sustainability standards offer a way for better-performing firms to differentiate themselves and appeal to a segment of customers willing to pay a premium to cover firms' adherence to a higher standard. These commercially driven standards increase the risk of multiple standards' coexisting (that is, fragmentation), which in turn contributes to the "spaghetti bowl" effect discussed in chapter 4.

Then there are standards that no individual stakeholder may have a strong commercial incentive to develop, such as those addressing negative externalities to protect the public's health and safety. In such areas, governments, international organizations, or nongovernmental organizations often must take a leading role. Examples include food safety standards developed under the umbrella of the Codex Alimentarius, published by the Food and Agriculture Organization of the United Nations (FAO) and WHO; labor standards developed by the International Labour Organization (ILO); and health standards maintained by WHO. The international reach of such standards means that stakeholders need to be significantly involved to ensure the standards' legitimacy and adoption.

Determining the right number of standards

Is there an optimal number of standards, and when do oversupply (fragmentation) or undersupply (lack) of standards become issues? The preceding discussion provides some insights into these questions. In technology-focused sectors like IT, network externalities create winner-takes-all incentives that favor the rapid development of standards. The need for speed explains why consortia or individual firms create most IT standards. However, fragmentation becomes a major concern when multiple standards coexist because the network effects of using a single standard do not materialize. For example, Blu-ray

and HD DVD standards coexisted early on until Blu-ray gained enough market share to become the dominant video format. Companies use private standards for sustainability, on the other hand, to differentiate their products and often go beyond what existing sustainability regulations require. The resulting fragmentation can create problems if consumers struggle to recognize a sustainability label among the many different ones. Meanwhile, a growing number of voluntary sustainability standards relate to business-to-business relationships, with little risk of confusing consumers.

Standards created by international standards development organizations such as ISO, the IEC, and the International Telecommunication Union (ITU) usually do not suffer from fragmentation because only one standard is developed for a specific need. Fragmentation becomes an issue when national standards differ from international standards or when there are multiple conformity marks. For example, the CE (Conformité Européenne) mark in the European Union, the CCC (China Compulsory Certificate) mark in China, the FCC (Federal Communications Commission) mark in the United States, and the ISI mark (standards mark of the Bureau of Indian Standards) in India are typically mandatory for electronic products. A product with a CE mark cannot be sold in China unless it also meets CCC requirements, which adds cost and delays in time to market. This happens because conformity marks are based on different technical standards and different procedures for assessing conformity, such as testing procedures, factory audits, documentation, and follow-up inspections.

Although fragmentation caused by an oversupply of standards is a problem, so is a lack of standards, especially in areas concerning safety. Private stakeholders may lack incentives to develop standards, making it necessary for governments or international organizations to intervene. Consumer groups can also play a role in

demanding standards.²³ For example, in the nineteenth century, workers most at risk of death from boiler explosions demanded safety standards for boilers.²⁴ Today, consumer groups push for food or automobile safety, but concerted efforts of this type require collective action and time. Similarly, after a disaster, demand for safety standards often increases, such as calls for stricter building codes after an earthquake or for stronger fire codes following a particularly deadly fire.

Although this Report emphasizes the benefits a country can reap from transitioning to more ambitious standards, political economy dynamics may obstruct progress in this area. In some cases, the absence of stringent mandatory standards does not reflect a lack of compliance capacity but rather the vested interests of powerful actors who benefit from regulatory gaps. Likewise, weak enforcement may not stem from institutional shortcomings alone: It can be a deliberate feature in systems marked by rent seeking and corruption. It should also be recognized that underdeveloped quality infrastructure systems pose significant challenges in many low- and middle-income countries (refer to chapter 3). A country's quality infrastructure system directly influences its capacity to use or adopt standards and to verify compliance with them, so many low- and middle-income countries cannot transition to more stringent standards, even if they recognize the significant benefits such standards could provide.

How to use standards for development

Standards as a public policy tool

When and how should governments use standards as policy tools? The answer to this question is complex, because public policy aims to achieve various objectives: from promoting economic development, to protecting the population's health and safety, to advancing national security, to

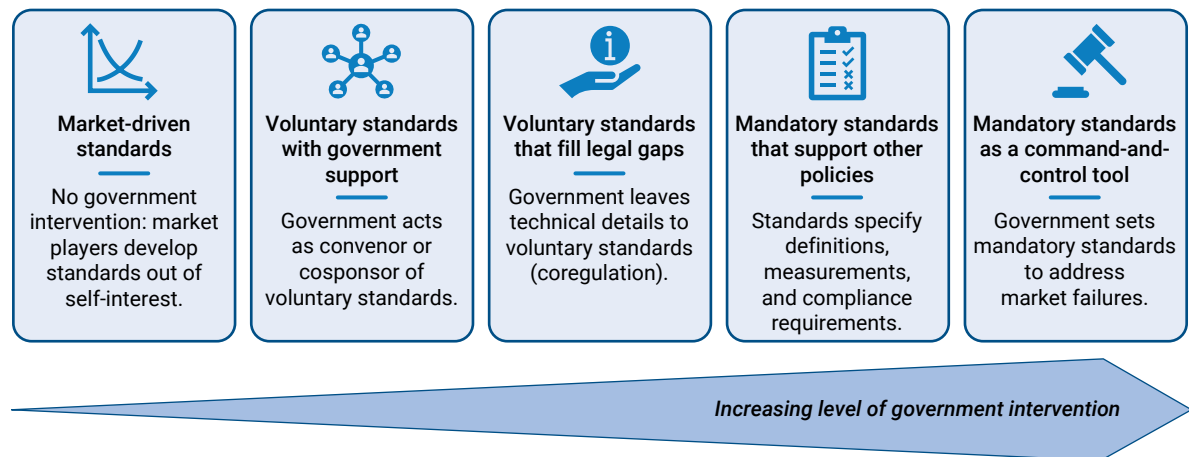
safeguarding the environment. Standards are not the only tool for achieving such objectives. Safer products, for instance, can result from tort and insurance premiums driven by costly payouts in the case of accidents. Carbon emissions can be limited using a price-based approach in which emissions are taxed. Population health can be enhanced through awareness campaigns about health risks.

If standards are the policy tool of choice, however, there are multiple ways to use them. This Report highlights that policy makers should leverage the strengths of both voluntary and mandatory standards; this subsection explains the key differences. On one end, governments might leave policy issues to voluntary standards if market demand drives their development and adoption. Government intervention may be necessary only to coordinate stakeholders or support the uptake of voluntary standards. On the other end, governments can require that products and services meet specific thresholds or design standards, such as emissions limits for vehicles or safety standards for electrical appliances. A combined approach might involve setting legal requirements in broad terms and allowing market players to use voluntary standards to address gaps. For example, the European Union's General Product Safety Regulation mainly requires that products be safe—and leaves many technical details to voluntary standards. Such an approach can be an effective and flexible form of coregulation with the private sector in which the government delegates some regulatory functions to voluntary standards.²⁵ Importantly, even if standards are not the primary tool for addressing a policy issue, they can still serve a supporting role. For instance, carbon pricing relies on clearly defining what emissions are covered, how they are measured, and how to verify them. Standards are crucial in these areas.

Five main ways to use standards as a policy tool

Figure 2.1 summarizes the five chief ways standards can be used as a policy tool: market-driven

Figure 2.1 There is a spectrum of ways to use standards as tools for public policy



Source: WDR 2025 team.

standards, voluntary standards with government support, voluntary standards that fill legal gaps, mandatory standards that support other policies, and mandatory standards as a command-and-control tool.

Market-driven standards

Governments may choose not to intervene in the market at all—and instead leave room for market-driven voluntary standards. The fact that most standards are voluntary and widely implemented demonstrates the power of private incentives and self-interest. Any supplier must meet the standards of firms, whether domestic or foreign, to which it sells its commodities, goods, or services. For example, a light bulb manufacturer needs to ensure it complies with the size standards of the sockets in which it expects its light bulbs to be used, showing how compatibility standards can create strong incentives across the supply chain. In many cases, there is no need for the government to be involved in voluntary standards. In fact, government involvement can be counterproductive if political or regulatory considerations influence technical specifications.

Voluntary standards with government support

Although voluntary standards can be beneficial, stakeholders may not participate in their development or be willing to pay for them. Private organizations may lack the ability to coordinate and agree on a common standard, leading to too many varieties of the same product and limiting the potential for mass production. In such cases, the government may step in to help develop industry standards, like the US government's standardization efforts in the 1920s (refer to box 1.3 in chapter 1). Developing standards requires attending many technical meetings, a cost not all firms can afford. It also involves overhead costs for coordinating stakeholders, sharing information, and distributing standards. In many high-income countries, national standards bodies fund standards development by selling standards to users and requesting a fee for participation in standards development. Such a revenue model not only sustains the process but also provides a market signal: The more often a standard is purchased and used, the greater the likelihood that it meets a real industry or societal need. Similarly,

many international standards development organizations like ISO rely on sales of standards to support their operations. However, in many low- and middle-income countries, the revenue from selling standards rarely covers the full costs of standards development. Whereas in high-income countries, national standards bodies on average generate 38 percent of their income from the sales of standards, sales make up only 2 percent of revenue of such bodies in low-income countries and 6 percent in lower-middle-income countries.²⁶ This is because national standards bodies in low- and middle-income countries are often government organizations with less of an orientation to and focus on sales. The government may therefore need to step in, not by specifying the content of a voluntary standard, but by encouraging its development. Similarly, governments might also want to encourage certain groups of stakeholders to use standards. For example, small and medium enterprises might need extra support for implementing standards because they lack the information or capacity to do so, even though it would be beneficial to them, for instance, in regard to international market access or quality upgrading.

Voluntary standards that fill legal gaps

Laws are often not very specific, because otherwise they could become outdated quickly or overly complex. In such cases, voluntary standards serve as important tools for filling technical gaps in legal provisions or for guiding compliance with laws. For example, governments may find it impractical to specify the thickness of cable insulation in a law promoting electrical safety. What if a new insulation material is discovered that provides the same insulation at half the thickness? Accordingly, it is good regulatory practice to leave such technical details to voluntary standards. Governments can issue these standards, or they may ask standards development organizations to develop them. If a voluntary standard relating to a particular regulation already exists when the regulation is codified, the government can simply

reference that standard in the regulation (refer to chapter 8). This approach saves time and relies on standards already familiar to industry. A similar approach applies in public procurement, in which firms can bid in tenders (public offers), but the government may require compliance with certain standards, serving as a powerful way to promote standards.

Mandatory standards that support other policies

Standards can support policy instruments by providing definitions and specifying measurements, verification, and requirements for compliance. For example, if a government offers financial incentives for energy-efficient appliances, it may rely on a standard to define which appliances qualify as energy efficient, how energy efficiency is measured, and how compliance is verified through testing or certification. Similarly, an emissions-trading system allows the market to allocate carbon credits but may require that measurement and verification of emissions follow specified standards.

Mandatory standards as a command-and-control tool

Governments must decide when to impose specific requirements on firms' technological choices through mandatory measures or when to use incentives.²⁷ Examples of mandatory standards (*command-and-control tools*) include requiring machines to have emergency stop buttons or banning harmful chemicals in food. These policies define what is legal and illegal through licensing, bans, restrictions, and price controls. *Incentive-based instruments*, on the other hand, use price incentives such as government procurement, subsidies, and tax cuts, without directly controlling specifications, quantities, or allocations. In practice, the boundary between command-and-control and incentive-based instruments is often blurred; policies may combine aspects of both, showing the potential of the two approaches for

complementarity. For instance, tradable emissions standards set limits on emissions intensity but allow firms to exceed the limits by purchasing emissions credits from firms whose emissions are below the limits.²⁸

Guidelines for when to use mandatory standards instead of incentive-based instruments

There are two general guidelines for determining when mandatory standards make better sense than measures that depend on incentives. Mandatory standards are preferable when uniform compliance is needed or when they make it easier to achieve and enforce compliance.

Using mandatory standards to achieve uniform compliance

Incentive-based instruments are generally perceived as more cost-effective than command-and-control regulations because they provide ongoing motivation for innovation and efficient improvements in performance. For example, a carbon tax encourages emitters of carbon-based pollutants to cut emissions in the least costly ways, enabling companies with lower abatement costs to take more action. Although such incentive-based tools can be more efficient than mandatory measures, they also come with a higher risk of not reaching their goals. For instance, offering hospitals financial incentives to lower infection rates might prove ineffective if the hospitals' revenue mainly depends on other factors, such as the number of patients, the length of their stays, and their doctor-to-patient ratios. In such cases, enforcing basic hygiene and sanitation standards in hospitals, like handwashing stations and sterilization procedures, can be more effective. For more details on these challenges, refer to chapter 3.

Mandatory standards ensure compliance with a threshold and are therefore more suitable when not meeting the threshold causes substantial or irreversible damage.²⁹ For example, it might be

safer and more cost-effective to require specifications for the minimum strength of construction materials than to risk the substantial costs of noncompliance, such as a collapsing bridge. Requiring safety standards at nuclear power plants may also be a wiser strategy than imposing fines after a safety-related incident occurs. Conducting the cost-benefit analyses required for making such decisions is complicated. As discussed in chapter 8, the analyses involve making important value judgments, including how to price non-monetary damages (such as loss of life or health deterioration), how to value the future compared with the present (such as today's environmental investments for future generations), and how to define the boundaries of a system under analysis (such as indirect costs and benefits for people in other countries or other species).

Mandatory standards are especially useful when uniform compliance is needed: for example, to ensure that all teachers meet a certain minimum qualification, that levels of pesticide residue in foods do not exceed levels considered safe, or that all electrical equipment is safe for consumers. Uniform compliance might be required when the risk of harm is high (as in the case of safety standards), when the benefits of compliance depend on universal adoption (as in the case of hygiene protocols), or when fairness and credibility are at stake (as in education). However, at the same time, uniform compliance can also limit the government's ability to account for differences in the ability to comply, because some individuals may find it easier than others to meet a particular standard.

Using mandatory standards when they make achieving and enforcing compliance easier

Both incentive-based instruments (such as taxes and subsidies) and mandatory standards require monitoring and enforcement. However, incentive-based instruments usually need accurate measurement of performance metrics, which can be

difficult when capacity for such measurement is low. For instance, taxes are based on actual income, incentives for school performance depend on measuring student achievement, and pollution taxes rely on continuous monitoring of emissions. High-capacity environments may have effective tools for the types of measurements needed in instances like these, but in many low- and middle-income countries, limited data collection and institutional capacity hinder reliable measurement of performance.

In such settings, mandatory standards tend to be more practical, especially when compliance can be verified through observable features, documentation, or routine inspections. For example, instead of trying to assess teacher effectiveness based on changes in the results of student learning, a government might require teachers to hold a teaching certificate. Instead of taxing emissions that are difficult to track, a regulation might mandate that factories install and operate scrubbers known to reduce pollution.

Similarly, relying on a litigation-based approach to regulation, in which harm is addressed after the fact through lawsuits and liability claims, requires a well-functioning legal system, which many low- and middle-income countries may lack. Fostering compliance via insurance systems works only if insurance markets are mature enough to function properly. In such cases, mandatory standards may be easier to enforce than an approach based on litigation or incentives. Meanwhile, as this Report discusses in detail, the implementation and enforcement of standards also requires the availability of compliance infrastructure like testing laboratories (refer to chapter 3).

Mandatory standards typically provide clearer, more specific instructions than incentive-based tools, which can limit flexibility but offer practical guidance, especially in situations in which capacity is low. For example, small and medium enterprises often do not know about opportunities to save energy or the technologies needed to

implement them. Requiring the use of equipment that meets higher energy efficiency standards can guide their actions more effectively. Additionally, mandatory standards have as one benefit that providers are either compliant or not, which simplifies monitoring and enforcement and helps clarify standards. For instance, consumers can easily determine whether a product has passed a safety test or whether their accountant is certified and qualified.

When one size may not fit all

Countries generally benefit from adopting common international standards because such standards are widely recognized as best practice and trusted. For example, consider a low- or middle-income country that wants to import solar lamps for rural electrification. Lamp importers in the country may lack the technical expertise to draft detailed technical requirements in their purchasing documents. These importers can simply request that the imported lamps meet the international standard for such lamps without needing in-depth knowledge of the technical specifications. Additionally, higher demand for lamps that comply with the international standard will drive down the price, because the standard ensures the lamps can be mass produced. Conversely, if importers specify that lamps be produced to a different standard, it could increase both the production costs and the prices.

There is no single answer to the question “Does one size fit all?”. Whether to choose “one size” or not entails a set of trade-offs that vary by context. One key trade-off is that between diversity and uniformity. Diversity can foster innovation, accommodate local practices and traditions, and enhance relevance and legitimacy. Uniformity, by contrast, can enable economies of scale, reduce complexity through the reduction of varieties, and enable greater efficiency. Another trade-off is between the stringency of standards and the ability to meet or enforce them. Higher standards are desirable for quality but depend on local capacities.

This tension between ambition and capacity is at the heart of the conceptual framework presented in this Report. Importantly, the extent to which one size should fit all depends on the type of standard considered (that is, whether it is a measurement, compatibility, or quality standard).

Compatibility standards benefit the most from a one-size-fits-all approach because any deviation from the standard can cause incompatibility. For example, credit cards issued by one bank that do not adhere to common standards for data formats and security protocols may not work at another bank's automatic teller machines. At the same time, there is no guarantee that the prevailing standard is the most effective one, especially when switching imposes significant costs. Moreover, the universal adoption of a standard may also raise market power when only one or a few unique producers provide the products

for which the standard is used or any component needed to meet it.

Measurement standards also benefit from a one-size-fits-all approach, because their goal is comparability. However, some standards regimes pre-date globalization and have instead served as the foundation for economies and societies, making such standards socially, economically, and politically costly to change. As a result, these regimes may coexist if switching to a common standard is too costly. As discussed in chapter 1, despite the benefits of universally adopting the metric system, several countries still use both the metric and Imperial systems, leading to significant transaction costs. In addition, there is often no agreement on the ideal standards for benchmarking and measuring policy outcomes like achievements in the areas of education, health, or poverty reduction (refer to box 2.1).

Box 2.1 Standards for measuring poverty: A trade-off between uniformity and local relevance

A core challenge in measuring poverty lies in balancing uniformity and diversity. Uniform standards facilitate international comparability, enabling global monitoring, target setting, and resource allocation. In contrast, diversity allows national poverty measures to be adapted to local economic conditions, institutional capacities, and policy needs, enhancing their relevance and accuracy.

Countries follow different standards for measuring and setting national poverty lines, reflecting context-specific decisions based on a country's typical living conditions, consumption behavior, and policy priorities.^a For example, countries adopt either consumption- or income-based measures of poverty depending on their own specific contexts. Low-income countries often prefer to use consumption data because of the prevalence of informality, in-kind transactions, and subsistence production. In contrast, middle- and high-income countries typically rely on income data, leveraging administrative systems and formal labor markets.^b

Instruments used in surveys intended to measure poverty are adapted to local contexts, resulting in variation in definitions, item coverage, and methods for collecting data. Even in

(Box continues next page)

Box 2.1 Standards for measuring poverty: A trade-off between uniformity and local relevance (*continued*)

regard to consumption, the structure of questionnaires, recall periods, treatment of domestic production, and imputation methods differ across countries.^c These differences ensure accuracy within each country but complicate global comparability.

To allow global comparisons, the World Bank introduced an international poverty line in the *World Development Report 1990: Poverty*.^d Originally known as “one-dollar-a-day,” it is currently set at US\$3 per day per capita in 2021 purchasing power parities.^e This benchmark is converted to local currencies using purchasing power parities to account for cross-country differences in price levels. The international poverty line serves as a common threshold for identifying extreme poverty across countries and over time, enabling benchmarking of performance and tracking of global goals.^f

Yet although the international poverty line is set at the same level globally, global comparability remains imperfect. As mentioned, countries differ in whether they collect income or consumption data to measure poverty, and even within those categories, they differ in how they define and gather data. These discrepancies are essential for local relevance but introduce inconsistencies across countries. For instance, household income in one country may include certain income components that are not included in household income in another country. Consumption data may vary in regard to recall periods, whether durables are included, and the treatment of homegrown food.

To address these challenges, the World Bank is actively working to harmonize income and expenditure data across countries. Its efforts aim to align definitions, improve survey instruments, and promote methodological consistency, particularly for surveys of household expenditure, which underpin poverty estimates in many low- and middle-income countries.

Source: WDR 2025 team.

a. Allen (2017); Decerf (2023); Mahrt et al. (2022); Ravallion (1998, 2016).

b. Carletto et al. (2022).

c. Deaton and Zaidi (2002); Giambastiani et al. (2022).

d. World Bank (1990).

e. Filmer et al. (2025).

f. Jolliffe and Prydz (2021).

The need to adapt standards to local contexts is perhaps strongest in regard to quality standards. Countries or regions may face very different costs of complying with an international standard, with the differences driven by variations in production capacity, citizens’ preferences, and enforcement

capacity. But perhaps most important, quality standards for many different products and services must align with purchasing power, which is quite limited in low-income countries. Quality standards and purchasing power generally evolve together, with the latter influencing the former.

The extent to which an international standard should be adopted as is versus adapted to a local context is just one of many trade-offs involved in setting standards. Achieving scale can reduce diversity. For example, having uniform learning standards across a country decreases variation in teaching methods, leaving teachers less room to account for individual learning needs. Having subject matter experts lead the development of standards may bring in expertise but also increases the risk of capture. Trade-offs vary depending on the areas in which standards are applied, a country’s level of development, and societal preferences.

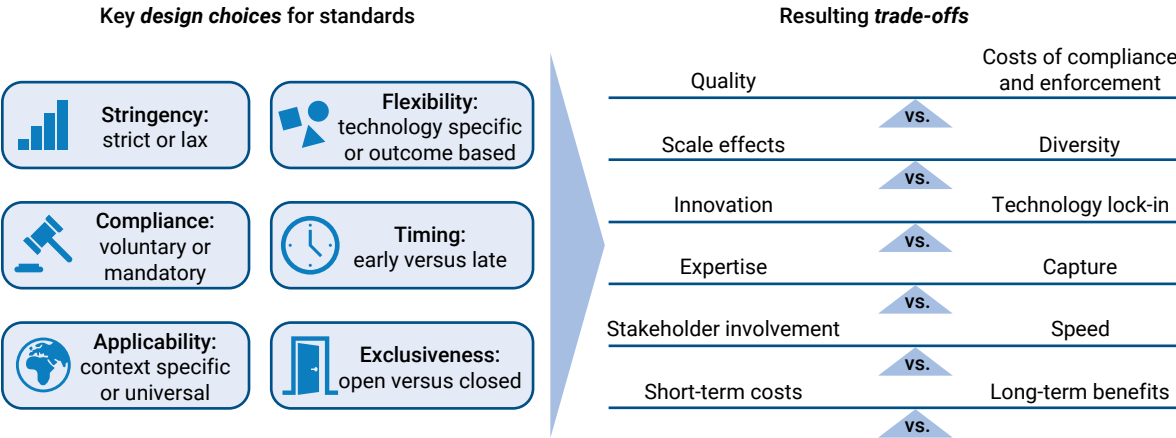
Figure 2.2 illustrates the choices that influence key trade-offs in designing standards. Analysis of ISO administrative data provides some empirical support for the existence of a trade-off between stakeholder involvement and the speed of standards development. Each additional participating country in standards development, regardless of the country’s level of development, adds only three days to the process of publishing a standard. If the secretariat for the ISO technical committee in charge of the products that the standard regulates is based in a high-income country, the publication process can be three to four months shorter (refer to spotlight 2 for details).

The costs and benefits of setting standards may be realized over different time horizons and possibly even across generations, with compliance costs incurred immediately and benefits realized in the longer term, as in the case of reductions in emissions of greenhouse gases and the impacts of climate change (refer to chapter 6). In addition, standards modify the incentives faced by consumers and providers. Standards that demand higher quality provide incentives for producers to invest in better inputs and processes that allow them to make higher-quality products at lower prices and in turn induce consumers to demand higher quality; stricter standards require development of better technology for monitoring and enforcement, implying possibly significant investment costs but also making it easier to enforce standards in the future. These dynamics highlight the fundamental way in which standards are at the heart of the development process.³⁰

A framework for transitioning toward higher quality standards

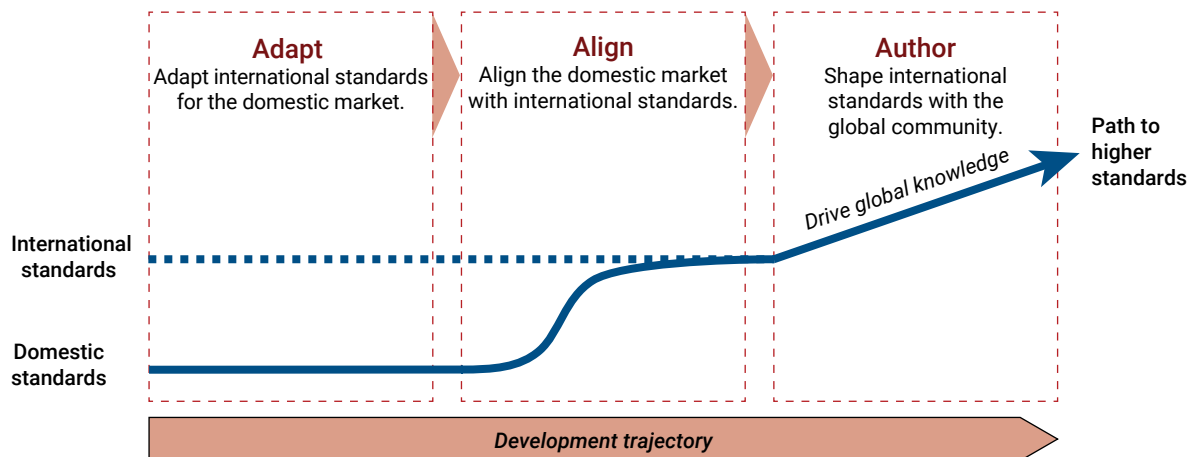
Development at the country level is about transitioning toward higher-quality goods, services, institutions, infrastructure, and quality of life, among other things. As this Report shows,

Figure 2.2 Important choices for designing standards, and the resulting trade-offs



Source: WDR 2025 team.

Figure 2.3 From adapting standards to aligning and then authoring them



Source: WDR 2025 team.

standards play a catalytic role in this journey. Figure 2.3 depicts the evolution of standards setting over the different phases of a country's development. Importantly, this trajectory may not progress uniformly across a country, which may be at several different points with respect to changes in the development of standards at the same time.

Adaptation. At low levels of development, countries may need to *adapt* international standards to local conditions, including lower capacity to meet the standards, especially when it comes to mandatory standards. Adaptation is often not an option, however, when it comes to accessing the international market. International buyers generally require products to meet international standards for safety, quality, and compatibility, and if a product does not meet these standards, it will not be accepted abroad. Therefore, the key decision regarding voluntary standards is whether or not to *adopt* them. Data from a survey of 116 ISO members, conducted jointly by the World Bank and ISO in 2025, show that ISO members adopt as is more than 90 percent of ISO standards they consider; they adapt the rest, mainly on account of differences in climate (refer to spotlight 3 for details).

When establishing mandatory standards for domestic markets, however, countries can adapt international standards. Countries therefore need to implement a dual regime in which they follow international standards for international market access but adapt standards for the domestic market to local conditions.

In the latter case, the degree of *adaptation* (that is, deviation from an international standard) should align with the country's compliance capacity with respect to the corresponding standard. Adaptation carries inherent risks, however, because domestic standards that are less strict than the corresponding international one might become the long-term norm or local industries could influence the standards-setting process, resulting in overly lenient standards. Deviation from international standards should therefore always be considered a second-best option, to be pursued only if compliance capacity cannot be increased.

Wider use of "tiered standards" can help countries avoid situations in which adaptation of international standards leads to fragmentation. This is because tiered standards provide a framework

that accommodates different levels of compliance capacity or stringency while maintaining overall compatibility with international standards. (Chapter 8 provides details on tiered standards.) Sometimes, adaptations in low- and middle-income countries may also result in standards that are more stringent than comparable international ones: for example, stricter standards on electrical safety to account for frequent power outages in a country or requirements for enriched food products to fight malnutrition where it is a particular problem.

Countries mainly find they need to adapt the stringency of international standards if they intend to use them for domestic regulation. Because the uptake of voluntary standards is optional, adaptation of their strictness may be less urgent. Still, when countries adopt an international standard as a national standard, it is important that they consult with domestic stakeholders to identify any need for adaptation to local contexts. Adaptations of this kind may be less about stringency and more about local practices and terminologies (that is, they may involve “horizontal” rather than “vertical” differences). For example, Ethiopia developed a national standard for beehives to account for the widespread use of traditional beehives, which differ from the frame beehives common in other parts of the world.

Alignment. As countries increase their compliance capacity, they should strive to *align* standards for the domestic market with international standards. This is beneficial because international standards reflect good international practices in an area that countries can learn from. Alignment with international standards is also encouraged under the WTO’s Agreement on Technical Barriers to Trade to ensure that achieving legitimate public objectives like health, safety, or environmental protection does not unnecessarily disrupt trade. Moreover, aligning domestic standards with international standards ensures that firms do not need to produce one variant of a product for the domestic market

and another for the export market. In other areas like education or governance, standards need to be more sensitive to context, but with a clear pathway for improvement, which often means harmonizing them with international standards.

Authoring. As countries develop, they should become more involved in *authoring* international standards, either the development of new ones or the revision of existing standards based on their experience and needs. Active participation in the process of developing international standards is important even if a country has limited technical expertise in whatever areas the standards govern. It allows the country to share its challenges and priorities, thereby influencing what the standard covers. Additionally, international standards development organizations serve as learning environments and help countries gain a deeper understanding of the subject matter discussed during standards development through interactions with participants from other nations and stakeholders. Of course, a country’s level of participation will depend on the country’s expertise in the sector and stakeholder interest.³¹

The journey of standards—from adoption to authoring—is not linear or uniform across sectors. Countries can move between the choices of adaptation, alignment, or authoring in different areas of society at varying speeds. For example, Ethiopia is authoring standards for teff, a local grain, while adapting standards in other areas. India is taking up leadership in development of international standards for low-voltage electrification while adapting standards for fuel efficiency. The journey embodies complex interplay among scientific and technological advancements, cultural traditions, social acceptance, economic pragmatism, business interests, and political ambition and power. Understanding the processes involved is crucial for policy makers, businesses, and civil society as they navigate the increasingly complex global landscape of standards.

Using standards to break the vicious circle of low quality in low- and middle-income countries

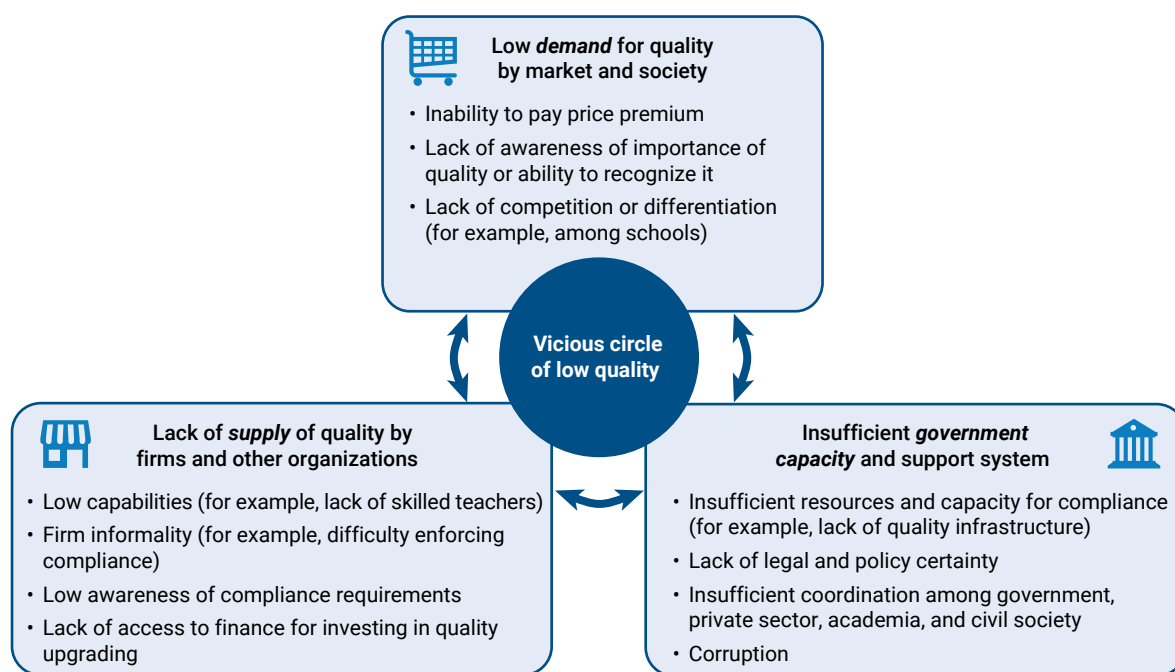
Low quality of products and services in low- and middle-income countries often results from a multidimensional vicious circle of supply and demand factors and limited government capacity, as illustrated in figure 2.4. Standards can help break the circle.

Although this Report stresses that standards are more important for low- and middle-income countries today than when high-income countries were at similar levels of development, especially as a result of increased technological sophistication and the pressures and opportunities of globalization, they are no panacea. In other words, one cannot expect the quality of production to increase just by raising standards. Sometimes, higher standards are set *after* broader socioeconomic

improvements happen, whereas at other times, they are established *before* such improvements occur. Both patterns have occurred in the East Asian “miracles” of China, Japan, and the Republic of Korea, featured in spotlight 1. These countries’ strategic and sustained use of standards contributed to their explosive growth and demonstrates that breaking the vicious cycle of low quality is possible.

Addressing quality bottlenecks. Because high quality often comes at a higher price, societal and market demand should determine the level of quality of a country’s products and services. Even when higher quality proves more cost-effective in the long term, as in, for example, the cases of energy-efficient light bulbs or appliances that last longer and reduce energy bills, the higher up-front costs required to ensure higher quality can be prohibitive for large segments of the population in low- and middle-income countries. Aside from their

Figure 2.4 Low- and middle-income countries are often trapped in a vicious circle involving low quality



Source: WDR 2025 team.

ability to pay, people may not demand goods and services of higher quality if they lack awareness of the importance of quality or the ability to recognize it.³² Moreover, consumers may be hesitant to pay a price premium if they cannot trust the quality of goods and services: for example, if there is no reliable testing and certification that would provide trustworthy market signals to consumers.³³ This matters, as studies have shown that when the market demands and rewards quality (for example, when firms export), producers do upgrade quality.³⁴ But if consumers cannot discern quality, typically because of incomplete information, producers do not have an incentive to upgrade.³⁵

Societies and domestic markets also may not demand quality because of limited competition or lack of product differentiation within such markets. For example, if there is only one school or hospital in a district, it may not have an incentive to improve quality. An active civil society, including media, consumer associations, and professional bodies, is crucial for increasing demand for quality but is often missing in low- and middle-income countries.

On the supply side—notably among firms, but also in other organizations—low capabilities constitute a main quality bottleneck. For example, firms in low- and middle-income countries may lack internal production controls or the necessary skills to meet higher quality standards, resulting in quality bottlenecks. The high levels of informality among firms in low- and middle-income countries make these deficiencies worse and create challenges when these countries attempt to impose sanctions for violations of mandatory standards or trace noncompliant products. In principle, external finance can help make these trade-offs easier to navigate, but it is usually limited. Although development is a complex issue, low-quality production is one of its most significant challenges.³⁶ Firms in low- and middle-income countries produce lower-quality products, whether measured by the unit value of exports,³⁷

by the use of advanced technologies,³⁸ or by the quality of firm management.³⁹ This quality differential leads to significant productivity differences between countries⁴⁰ and sectors.

In addition, governments in low- and middle-income countries often lack the financial and human resources needed to enforce compliance with standards or provide incentives to increase quality; the problem is compounded by insufficient infrastructure for enforcing standards such as testing laboratories. At the same time, low- and middle-income countries frequently have underdeveloped legal frameworks and judicial systems, involving things such as weaknesses in private law jurisprudence, as evidenced in insufficient laws regarding product liability or contracts. Policy unpredictability further weakens compliance in these countries because organizations and people may adopt a “wait and see” approach before increasing their compliance. Meanwhile, coordination among government institutions is often a challenge, especially because enforcement of mandatory standards typically requires collaboration among multiple government bodies at various administrative levels, as well as the private sector and civil society, which often has deeper pools of expertise.

Standards are not the only tool for breaking circles of low quality, but they can be especially important in low- and middle-income countries. For instance, standards in trade help firms access the global market, which is crucial for firms in low- and middle-income countries that face limited domestic demand and low willingness to pay for high-quality products. International standards are a key source for the diffusion of technologies and knowledge, which is even more vital in countries with limited technical expertise. The absence of standards in health and education, for example, tends to be especially harmful to the poorest segments of a country’s population, making these gaps even more costly in contexts of extreme poverty and vulnerability. Likewise, transaction costs

and the extent of market failures may be particularly high in low- and middle-income countries.⁴¹ In addition, weaker state capacity limits these countries' ability to design and enforce effective policies and worsens the impact of market failures and transaction costs in hindering the development process.⁴²

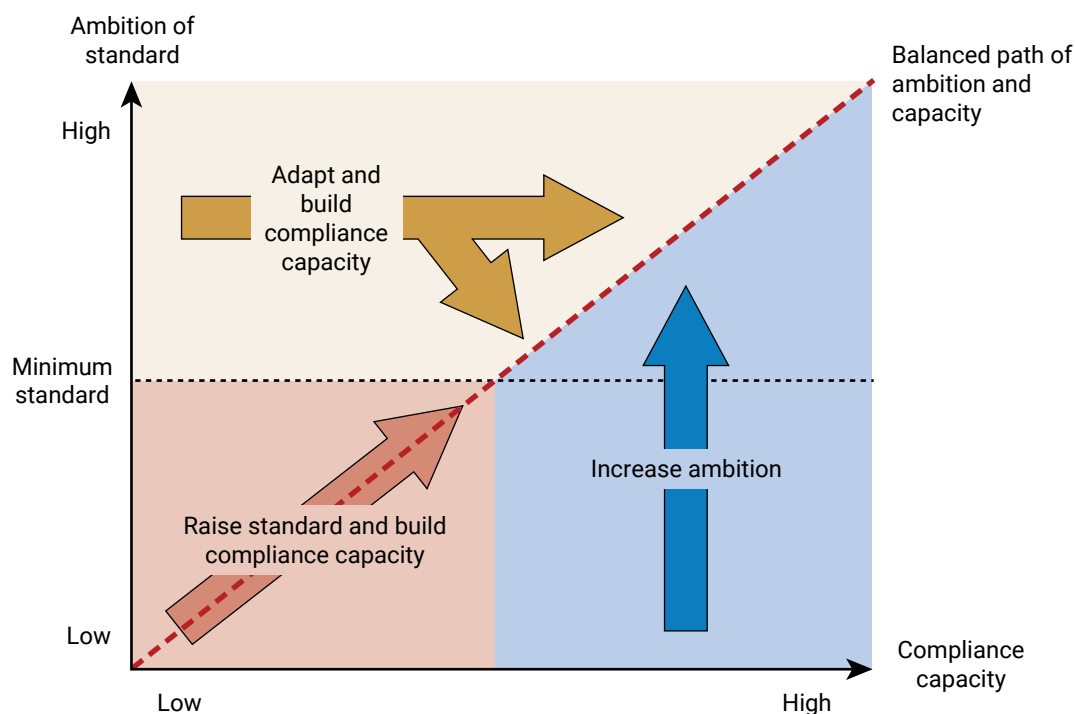
Balancing the ambition of standards with the capacity for compliance

Compliance capacity refers to the ability of stakeholders to meet voluntary standards and those used for regulation, the quality infrastructure required to verify compliance (such as the availability of laboratories), and the government's enforcement capability. Standards are pointless without implementation. For this reason, countries need to balance the ambition of their quality standards—their stringency and the range of areas they cover—with the capacity

of individuals and firms in the country to meet them. These components are interrelated. If standards are too weak, society may fall short in areas such as education, health, food safety, and environmental protection. But if standards are too ambitious, products and services may become too expensive and unaffordable to most consumers (as a result of high prices) and unprofitable to most producers (as a result of high compliance costs). In addition, setting high mandatory standards without adequate government capacity to ensure compliance may lead to uneven enforcement, possibly inviting corruption.

Figure 2.5 shows the challenges inherent in balancing ambition and compliance capacity. The red diagonal dashed line indicates the highest standard achievable for a given level of compliance capacity. A country setting a standard on the red dashed line sets the standard at the level of its compliance capacity, resulting in no

Figure 2.5 Matching the ambition of standards with compliance capacity



Source: WDR 2025 team.

compliance gap.⁴³ Three scenarios in particular can arise:

1. *Raise standard and build compliance capacity (rust-colored area at bottom left of figure 2.5).* In this area of the figure, a country has yet to meet the minimum standard in a given domain (such as food safety or labor standards). Filling the gap between actual performance and full compliance with the standard requires a combination of increasing the standard to the minimum and building compliance capacity (a move to the top-right corner of the rust-colored area). Building compliance capacity is not straightforward and will likely involve building capacity among stakeholders and investing in compliance infrastructure such as laboratories (refer to chapter 3).
2. *Adapt and build compliance capacity (tan-colored area at top of figure 2.5).* High standards and low compliance lead to uneven enforcement, weakening the very trust that standards are supposed to foster. Depending on the specific circumstances, countries may need either to invest in compliance capacity to meet the high standards or to adapt standards to the local context, or even better, to pursue a mix of the two.

For most low- and middle-income countries, compliance capacity is the binding constraint; the tan- and rust-colored areas are the relevant ones. A third scenario may be more relevant for high-income countries:

3. *Increase ambition for standards (blue area in figure 2.5).* Countries with high compliance capacity and low ambition are not fully exploiting their potential. Because it rarely makes sense to reduce compliance capacity, countries should increase the ambition of their standards, especially if the minimum standard has not yet been met.

Once countries have achieved their relative maximum on the dashed ambition-capacity line,

ideally they move along the line by incrementally increasing compliance capacity and ambition. Which one they pursue first—capacity or ambition—will depend on the sector and context.⁴⁴ Countries should set standards based on national priorities and their ability to comply with them and then gradually raise their ambitions as their capacity increases. Doing so will ensure that countries will be able to comply with their standard, regardless of their income levels. This can be referred to as a *maturity-model approach* with incremental gains over a period of time.

Setting standards without the capacity to enforce them (the tan-colored area at the top of figure 2.5) is not without consequences. In some cases, setting standards “too high” can be viewed as *aspirational* and may induce market participants to change their behaviors to meet the standard. For example, China’s ratification of the Montreal Protocol on Substances That Deplete the Ozone Layer is viewed as instrumental in spurring a series of innovations that allowed the country to develop and adopt cleaner production technologies in a widespread manner.⁴⁵ In such a case, the existence of a compliance gap or the fact that the existing reality falls short of the standard can be seen as a catalyst for development. At the same time, setting standards without the ability to guarantee uniform compliance may not only defeat the purpose of the standard but also create uncertainty about what compliance behavior is actually mandatory, potentially leading to arbitrary enforcement in a subset of market participants and paving the way for corruption.⁴⁶ In such a case, the compliance gap can become a substantial impediment to development.

The chapters and spotlights in part 3 of this Report present empirical evidence supporting the framework in figure 2.5. They show that, except in the case of environmental standards, countries follow the framework when regulating areas as diverse as health care and procurement. Most standards are set following a gradual increase along the dashed line in both countries’ ambition and their

compliance capacity, resulting in no compliance gap. For the case of environmental standards, in contrast, some countries set standards that are too high relative to their compliance capacities, and as a result, they also have large compliance gaps. This is akin to *isomorphic mimicry*,⁴⁷ in which countries set high standards, perhaps on account of external pressure, without expecting these standards to be enforced. This results in a U-shaped relationship between formal standards and development, with lower-income countries setting higher standards (while not enforcing them) than middle-income countries.

Authoring international standards

International standards are developed in various forums, including formal standards development organizations such as ISO, the IEC, and the ITU, as well as intergovernmental organizations like Codex Alimentarius (for food standards) and the ILO (for labor standards). Low- and middle-income countries need to be involved in different arenas to author international standards, and each comes with different governance models and power structures.

At ISO, member countries can send experts to working groups developing standards and delegates to the technical committees of the working groups (refer to spotlight 2 for details). However, because working group and committee meetings cost both time and money and require technical expertise, many low- and middle-income countries often participate only in the committees that are most relevant to their interests. For example, low- and middle-income countries rich in minerals generally participate in ISO committees related to mining to ensure that their national producers can comply with standards these committees develop.

Whereas before the COVID-19 pandemic, ISO held meetings in person in one of the participating countries, now most ISO meetings happen

virtually.⁴⁸ However, because technical committee meetings are conducted in English, countries, particularly those whose native language is not English, may find it hard to participate if their delegates are not fluent in English. As a result, low- and middle-income countries often find themselves “standard takers” rather than “standard makers.” High-income countries, as well as large emerging markets, in contrast, participate in many more technical committees and do so more actively, thereby establishing a greater presence in the process of developing standards. Importing countries also try to influence standards to protect their local producers.

Research shows that consensus-based decision-making is best for resolving these competing interests and encouraging adoption of standards, although it can also produce conflict and delay.⁴⁹ Although this is not a constraint in regard to mature technologies, it can be in regard to sectors in which technological change is rapid; in such sectors, the process of setting standards might shift to industry associations or individual firms.

Specific countries (or specific firms) can sometimes take a leadership role in authoring standards within specific sectors. This is often seen in regard to emerging technologies such as electric vehicles, the Internet of Things, and successive generations of telecommunications technologies (such as 5G). In some instances, a country may first develop a standard at the country level and then propose it to international partners for adoption as an international standard. Only countries with technological expertise, state capacity, political will, and concentrated production capabilities in specific goods or services tend to be influential in developing international standards.

There are apprehensions that development of standards in emerging technologies is becoming a battleground for geopolitical competition, reflecting the adage attributed to Werner von Siemens,

“Who owns the standards, owns the market.” Developing standards is not only about creating technical specifications; standards are an assertion of geopolitical influence and an attempt to set the terms of engagement, for example, for the digital age. As major powers jostle to shape the global rules of the game, they perceive shaping international standards to those developed by their own national firms as important for establishing market dominance. But authoring standards is not limited

to global superpowers. Smaller nations and even nonstate actors can play crucial roles in developing standards, particularly in emerging fields for which the rules are still being written. Estonia’s standards for digital governance and the Linux Foundation’s open-source software protocols demonstrate how focused efforts can have outsized impacts on global norms. Understanding the journey from adoption to authoring becomes crucial as countries navigate an increasingly complex world.

Notes

1. Refer also to de Vries (1998).
2. Similarly, languages are not considered a standard in this Report, even though they may be codified.
3. The ISO and IEC definition of a standard is a “document, established by consensus and approved by a recognized body, that provides, for common and repeated use, rules, guidelines, or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context” (ISO and IEC 2021, 2). Similarly, the Technical Barriers to Trade Agreement of the World Trade Organization (WTO) defines a standard as a “document approved by a recognized body, that provides, for common and repeated use, rules, guidelines or characteristics for products or related processes and production methods, with which compliance is not mandatory” (WTO 2014, 58).
4. This Report’s definition also omits the element in the ISO and IEC definition that describes standards as aiming to achieve an “optimum degree of order in a given context” (ISO and IEC 2021, 2). This phrase expresses an aspirational goal rather than a defining characteristic, and it is inherently subjective.
5. Refer to WTO (2014).
6. Refer to Standards (portal), International Organization for Standardization, <https://www.iso.org/standards.html>.
7. In a related way, standards can be categorized based on whether they focus on inputs, processes, or outcomes. Depending on the part of the value chain under consideration, the same standard may be classified as either an input or an outcome. For example, skills standards for teachers would be outcome standards at the level of the teacher, but input standards in the case of student learning.
8. David (1987).
9. Refer to de Vries (1998).
10. de Vries (1998).
11. ISO standards for management systems help improve the performance of organizations by specifying repeatable steps that organizational leaders may consciously implement to achieve their goals and objectives. The standards may also be used to create an organizational culture that reflexively engages in a continuous cycle of self-evaluation, correction, and enhancement in operations and processes through heightened employee awareness and management leadership and commitment. ISO 9001, for example, is a globally recognized standard for quality management (ISO 2015). It helps organizations of all sizes and sectors improve their performance, meet customer expectations, and demonstrate their commitment to quality. In 2023 alone, 837,978 certificates were issued attesting to ISO 9001 compliance in 1,250,243 sites around the world. This illustrates the level of importance and use of ISO’s flagship standard.
12. Bassi et al. (2024); Holmes and Stevens (2014).
13. Nyman and Begazo (2025).
14. Arabéhéty et al. (2016); Beck and de la Torre (2007); Crémer et al. (2023).
15. Takhar (2020).
16. Lynch (2025).
17. Verhoogen (2023).
18. Refer also to Akerlof (1970).
19. Clougherty and Grajek (2014).
20. North (1990).
21. WDR 2025 team calculations, using data from TRAINS [Trade Analysis and Information System] (portal), United Nations Trade and Development, <https://trainsonline.unctad.org/home>; WITS: World Integrated Trade Solution (database), World Bank, Washington, DC, <http://wits.worldbank.org/WITS/>. Refer to chapter 4.
22. The WTO’s Technical Barriers to Trade Committee agreed upon the six principles of voluntary standards development—transparency, openness, impartiality and consensus, effectiveness and relevance, coherence, and the need to consider the concerns of low- and middle-income countries—in 2000. Refer to Principles for the Development of

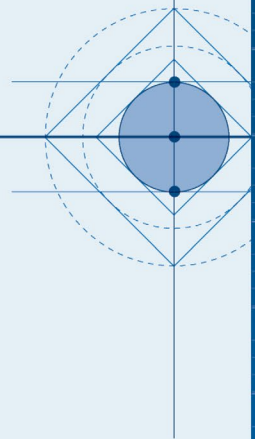
- International Standards, Guides, and Recommendations (dashboard), World Trade Organization, https://www.wto.org/english/tratop_e/tbt_e/principles_standards_tbt_e.htm.
23. To give rise to the voices of consumers in development of international standards, ISO has established a dedicated committee on consumer policy. The committee advises the ISO Council by, for example, consolidating and presenting the viewpoints of consumers on matters relevant to ISO's current and potential work in the areas of standardization and conformity assessment. Refer to ISO/COPOLCO: Committee on Consumer Policy, International Organization for Standardization (dashboard), <https://www.iso.org/committee/55000.html>.
 24. Fresso (2025).
 25. OECD (2020).
 26. Data are based on a survey conducted jointly by the World Bank and ISO among ISO members in 2025. The survey sample includes 116 national standards bodies: 13 in low-income countries, 28 in lower-middle-income countries, 34 in upper-middle-income countries, and 41 in high-income countries. Revenues from the sale of standards include revenues from subscriptions.
 27. Ambec (2025); Antweiler (2013); Goulder and Parry (2008); Sterner and Coria (2012).
 28. Fischer (2019).
 29. Weitzman (1974).
 30. de Vries and Verhagen (2016).
 31. Spotlight 3 documents how low- and middle-income countries participate in ISO.
 32. Cajal-Grossi et al. (2025).
 33. Akerlof (1970).
 34. Alfaro-Ureña et al. (2022); Atkin et al. (2017); Bold et al. (2022).
 35. Chen et al. (2022).
 36. Aghion and Howitt (2005); Hausmann et al. (2007); Hummels and Klenow (2005); Sutton and Treffer (2016). This Report defines quality broadly as a multidimensional concept that varies by context—goods, services, labor, or institutions—but has an impact on performance, safety, reliability, or customer satisfaction. More important, these attributes increase consumers' willingness to pay and often result in higher prices or market shares.
 37. Hallak and Schott (2011).
 38. Comin and Mestieri Ferrer (2018).
 39. Bloom and Van Reenen (2007).
 40. Acemoglu and Zilibotti (2001).
 41. Refer to Dixit (2003) on transaction costs and Stiglitz (2010) on market failures, for example.
 42. Estache and Wren-Lewis (2009); Laffont (2005).
 43. In practice, this need not be a straight line.
 44. The slope of the "balanced path" line also differs by sector. In some sectors, a small increase in compliance capacity can allow a country to pursue much more ambitious standards, whereas in others, even a slight increase in ambition would require substantial investments in compliance capacity.
 45. Zhao (2005).
 46. Botero et al. (2004); Djankov et al. (2002).
 47. "Isomorphic mimicry" refers to the practice by which organizations adopt the outward forms, structures, and practices of best-practice institutions without actually developing the underlying capabilities that make those institutions effective (refer to Andrews et al. 2017).
 48. In 2024, ISO held 4,959 virtual technical meetings, 2,062 hybrid meetings, and 836 in-person meetings.
 49. Farrell and Simcoe (2012); Simcoe (2012).

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SPOTLIGHT 2

International Standards Development Organizations

A variety of international standards development organizations emerged in the second half of the twentieth century, following the establishment of a core group of international bodies, including the International Telecommunication Union (ITU, founded in 1865), the International Electrotechnical Commission (IEC, founded in 1906), and the International Organization for Standardization (ISO, founded in 1947). This tripartite group is referred to as the “World Standards Cooperation” (WSC).¹ ISO and the IEC are networks (or federations) of national standards bodies that bring together a wide range of stakeholders to develop international standards. ITU functions as an intergovernmental organization. These institutions exemplify technocratic internationalism, although in many ways, their structure mirrors that of their national counterparts, because they bring together industry, academia, and other stakeholders to develop standards through consensus.

Table S2.1 highlights the remarkable growth in standards development by international standards development organizations. Since its founding,

ISO has developed more than 20,000 standards, and a newer group, the Internet Engineering Task Force (IETF, founded in 1986), has already developed more than 7,600 standards. Additionally, the development of standards within international standards development organizations has increased since the 2000s because of the growing complexity of manufacturing systems, as well as demand in new areas ranging from technology to sustainability. For example, since 2000, ISO, the IEC, and Codex Alimentarius have published about 56 percent, 75 percent, and 52 percent, respectively, of the total standards they have developed since they were established. In 2024 alone, the organizations listed in table S2.1 collectively issued more than 7,000 new or revised standards. Although the number of standards is important and impressive, equally so is the relevance of the topic areas and the quality and level of consensus of those standards. The standards development bodies included in the table have adopted working methods that ensure stakeholder engagement and impact; they also manage gaps and overlaps to reduce duplication while addressing the needs of regulators and markets.

A reproducibility package is available for this book in the Reproducible Research Repository at <https://reproducibility.worldbank.org/catalog/389>.

Table S2.1 Examples of international standards development organizations

ORGANIZATION	YEAR ESTABLISHED	TOTAL NUMBER OF STANDARDS DEVELOPED	NUMBER OF STANDARDS DEVELOPED IN 2024	NUMBER OF STANDARDS REVISED IN 2024	TOTAL NUMBER OF STANDARDS DEVELOPED AS OF 2000	TOTAL NUMBER OF STANDARDS DEVELOPED AS OF 1960
ISO	1947	20,953	1,126	671	11,461	132
Codex	1963	More than 14,000 ^a	900 ^b	Not available ^b	7,000 ^c	16 ^d
ASTM	1898	12,960 ^e	148	1,706	12,636 (as of 2015)	Not available ^f
ICAO	1947	9,018	997 ^g	408 ^g	Thousands ^h	Hundreds ^h
IETF	1986	7,661	120	47	1,748	Not applicable ⁱ
IEC	1906	7,617	455	320	5,967	146
ITU ^j	1865	6,834	240	87	2,612	405
UNECE ^k	1947	375	0	0	29 ^l	0

Source: WDR 2025 team, based on data provided by each organization.

Note: The organizations are arranged in descending order according to the total number of standards they have approved. The statistics include only standards, not amendments to standards or other types of guidance that the organizations may have issued, such as international workshop agreements, technical regulations, technical specifications, publications, and guidance notes (unless otherwise specified in the notes that follow). ASTM = American Society for Testing and Materials (originally, now ASTM International; Codex = Codex Alimentarius; ICAO = International Civil Aviation Organization; IEC = International Electrotechnical Commission; IETF = Internet Engineering Task Force; ISO = International Organization for Standardization; ITU = International Telecommunication Union; UNECE = United Nations Economic Commission for Europe.

- a. Quantitative standards only, including 6,453 Codex Maximum Residue Limits and 63 Codex Extraneous Maximum Residue Limits for pesticides, 2,748 Codex Maximum Residue Limits for veterinary drugs, 4,939 provisions regarding food additives, and more than 200 maximum levels for contaminants.
- b. Includes new and revised Codex standards (including quantitative standards), guidelines, and codes of practice. Data for quantitative standards only are not available.
- c. Quantitative standards only.
- d. Texts of standards only. Data are as of 1969.
- e. Active standards only. ASTM International has more than 68,300 historical standards.
- f. ASTM International did not provide data.
- g. New standards, recommended practices, and definitions. Data that pertain only to new standards are not available.
- h. Exact data are not available.
- i. IETF was not established until 1986.
- j. Standards for the Telecommunication Standardization Sector (ITU-T Recommendations) and Radiocommunication Sector (ITU-R Recommendations).
- k. Standards for transport only, because data for these standards are available for 1960, 2000, and 2024.
- l. Four standards on transport of dangerous goods and 25 standards for inland water transport. Data on standards developed for other types of transport as of the year 2000 are not available.

The establishment of the World Trade Organization (WTO) and the entry into force of the Agreement on Technical Barriers to Trade² and Agreement on the Application of Sanitary and Phytosanitary Measures in the mid-1990s encouraged the use of international standards published by international standards development organizations to facilitate international trade (refer to chapter 4 for details).

Although countries are encouraged to adopt international standards and withdraw national standards that conflict with international ones, legitimate deviations may occur as a result of national security, health, environmental, or geographic needs. To ensure global relevance, international standards must meet criteria such as responding to market and regulatory needs, avoiding market distortions, and supporting innovation. Active participation in the development of international standards, especially by developing countries, is therefore essential, so that the standards can directly reflect the unique conditions in these countries, which in turn encourages broader adoption.

The role and evolution of international standards development organizations

International standards development organizations offer an administrative structure and a work process that enable interested parties to develop standards in a specific area and then share them. These organizations develop voluntary standards through consensus. Standards are not created by a single entity; rather, as in ISO, they are developed by experts representing a range of stakeholders, including industry, the public sector, academia, and others. Voluntary standards can become mandatory if they are referenced in national legislation. They are then known as “technical regulations.”

Some of the more prominent private international standards development organizations, such as SAE International (formerly the Society of Automotive Engineers) and the Institute of Electrical and Electronics Engineers (IEEE), have a long history in the United States of developing voluntary standards through consensus. These organizations expanded internationally after World War II as industries globalized, and many new standards development organizations entered the field at that time as well.

ASTM International, established in 1898 as the American Society for Testing and Materials (ASTM) to ensure the reliability of steel rails, exemplifies the shift from national to global standardization. Initially focused on materials testing, particularly in the areas of metals and concrete, it formalized a participatory process in 1908 that required balanced representation from manufacturers, users, and public stakeholders. As technological advances multiplied, ASTM expanded its scope to include a growing range of industries. US industrial dominance in the early and middle parts of the twentieth century helped spread ASTM standards worldwide. Even as US manufacturing declined as the century progressed, ASTM’s technical reputation endured, leading to its rebranding as ASTM International in 2001, which signaled its shift from national body to leader in international technical harmonization.³

Over its 125-year history, ASTM has evolved into a global platform serving more than 90 industries. As of 2025, it has developed nearly 13,000 active standards, over half of them adopted by more than 140 countries. Its 30,000 members from 150 countries participate in 147 technical committees that produce six types of voluntary consensus standards, ranging from test methods to specifications, that are regularly updated to reflect new knowledge and applications. Maintaining low membership fees and an open, transparent process, ASTM fosters broad and inclusive

participation. Since 2001, it has signed cooperation agreements with 127 national and regional standards bodies, enabling them to adopt or adapt its standards. Today, ASTM standards underpin regulatory frameworks and international cooperation in sectors from construction to aerospace and organizations such as the North Atlantic Treaty Organization (NATO), Organisation for Economic Co-operation and Development (OECD), United Nations Economic Commission for Europe (UNECE), World Health Organization (WHO), and WTO.

In the realm of telecommunications technologies, the ITU Radiocommunication Sector develops and maintains a broad set of internationally recognized technical standards, known as “ITU-R Recommendations.” These cover areas such as spectrum management, broadcasting, satellite communications, and radio astronomy. Though generally voluntary, they become binding when incorporated by reference into the ITU Radio Regulations. In practice, ITU-R Recommendations are widely adopted and respected, functioning as *de facto* global standards that ensure harmonization, interoperability, and efficient use of the radio-frequency spectrum and satellite orbits. Their global acceptance has been critical for enabling innovation, providing regulatory certainty, and ensuring that radiocommunication systems operate seamlessly across borders.

Beyond radiocommunications, the ITU Telecommunication Standardization Sector sets standards for transport and access networks, cybersecurity, digital financial services, and public key infrastructures. In contrast, the Internet Architecture Board (IAB) and IETF develop the core standards that underpin the internet’s architecture, including those for fiber-optic transmission, routing protocols, and the Domain Name System, as well as management of Internet Protocol addresses. Together, these bodies create the technical foundation that allows global telecommunications and the internet to function reliably, securely, and at scale.

IETF (along with the IAB) is responsible for establishing the standards that underpin internet infrastructure, including fiber optics, routing systems, and registration of domain names and Internet Protocol addresses. IETF’s processes for developing standards are bottom-up, with multiple stakeholders participating. Decisions are made through email rather than in-person meetings to save on travel time and costs. Although the processes are inclusive in principle, they are much less so in practice. For example, in 2024, out of the 7,831 participants in all IETF activities, 85 percent were men, and 80 percent were from Europe and North America.⁴

IETF is, by design, a participative organization rather than a consultative one. Therefore, regular participation is essential, and those who participate frequently are highly motivated. On average, regular participants dedicate about nine hours per week to IETF activities. Experience is crucial, because the longer people participate in IETF, the better their understanding becomes. IETF estimates it takes 15 to 20 years of involvement for participants to feel they have a solid understanding of its processes, highlighting the significant time investment required to accomplish tasks, both personally and organizationally.⁵

At the same time, IETF’s core principles include open participation, technical competence (“engineering quality”), reliance on volunteers, decision-making by rough consensus—broad agreement without requiring unanimity—and a commitment to “running code,” meaning that standards are grounded in practical, working implementations rather than theoretical designs. These principles have enabled it to create a global internet architecture that serves billions, all with an annual budget of only about US\$7 million. Its lean, agile, and developer-driven model has allowed IETF to respond quickly to emerging technical needs. However, its inclusiveness is uneven in practice, with barriers of time, expertise, and representation limiting participation. By contrast, ISO has a

double layer of consensus—first among experts, then across countries—that can make its processes slower and can require more resources, but it can also make them more representative of diverse interests and more likely to result in broadly implementable and durable standards.

Although the internet is seen as a global technology, billions still struggle to access its full benefits because domain names and email addresses in their own languages and scripts are not available. To bridge this gap, the Internet Corporation for Assigned Names and Numbers (ICANN) has expanded the Domain Name System to include more than 26 scripts, from Arabic and Chinese to Cyrillic, and promotes universal acceptance so that software and websites recognize these multilingual addresses.⁶ Enabling users to navigate and transact online in their own scripts not only preserves cultural identity but also boosts economic inclusion. By lowering barriers for consumers and firms, it can unlock vast new opportunities in e-commerce—an estimated US\$10 billion in additional market value worldwide.

Food safety standards provide another example of international coordination. The Codex Alimentarius Austriacus of 1911 laid the groundwork for what would become, over the next century, a comprehensive global framework. Initially adopted in Europe as the Codex Alimentarius Europaeus, it focused on harmonizing testing of food samples to eliminate regional trade barriers. Later, in 1963, it joined forces with the Food and Agriculture Organization of the United Nations (FAO) and WHO to form the Codex Alimentarius Commission. The resulting Codex Alimentarius has provided guidance to governments on regulations in the area of food safety. The definitions and testing procedures shared by Codex have also served as reference points for private standards regarding food safety.

Some critics of Codex argue, however, that it is slow in developing Maximum Residue Limits for

pesticides, which refer to the maximum levels of residues legally permitted in a crop, ensuring that the amount of pesticides humans and animals consume remains within safe limits based on scientific risk assessments. For example, in the case of rice, countries worldwide have established maximum residue levels for 1,144 different pesticides, but Codex has approved Maximum Residue Limits for only 66.

Private assurance systems for food safety often depend on international norms for auditing, certification, and accreditation developed by ISO. These systems make compliance assurance more affordable and enhance legitimacy, which is crucial for widespread adoption across diverse markets.

Participation of national standards bodies in ISO

ISO is a not-for-profit organization and an international nongovernmental organization. Countries can become full members, correspondent members, or subscriber members.⁷ Each membership type has a corresponding fee that provides different rights and opportunities to engage with the ISO standards system. The membership fees and sale of ISO standards are all based on cost recovery and are used to support the operation of the central secretariat in Geneva. The various membership categories offer opportunities for countries at all income levels to participate in developing international standards, although neither correspondent nor subscriber members can take part in the governance of ISO.

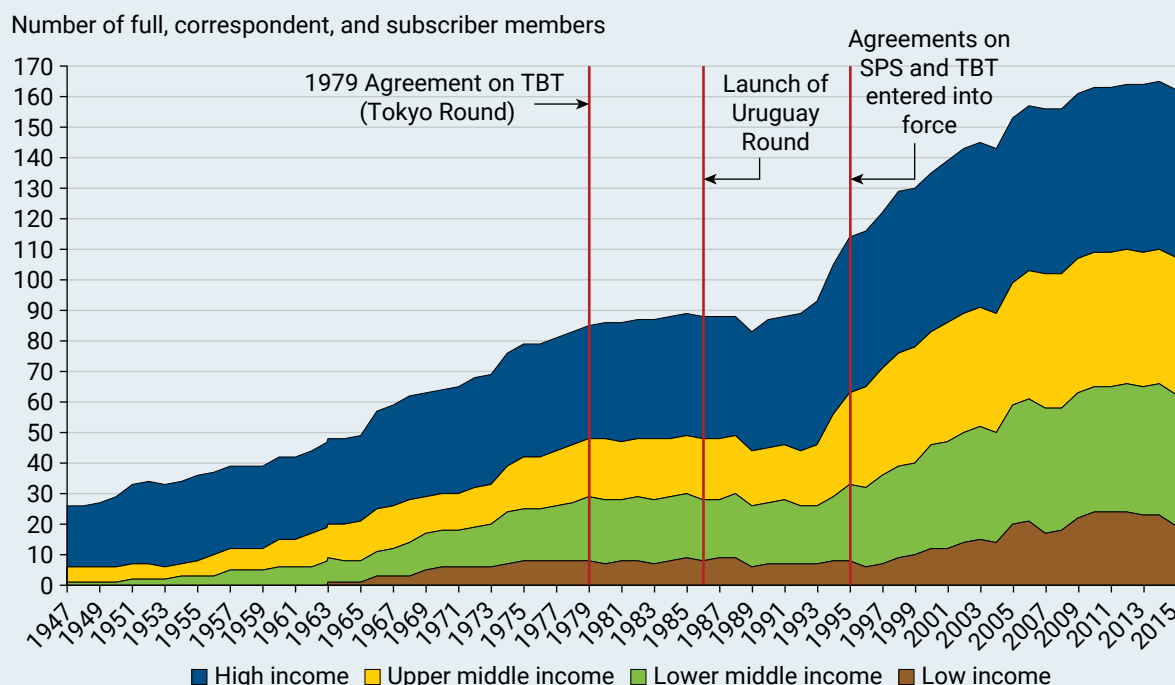
Full members of ISO can participate in developing standards, oversee the organization's governance, and sell ISO standards. Members choose to participate in committees related to national priorities and available expertise within the country among various stakeholder groups as either active, participating members, or observers.⁸

Figure S2.1 shows ISO's full membership by country income group since its founding in 1947. Whereas national standards bodies in most high-income countries have consistently been ISO members, membership among national standards bodies in upper-middle-income, lower-middle-income, and low-income countries increased significantly in 1993, following the end of the Uruguay Round of negotiations under the General Agreement on Tariffs and Trade (GATT), in anticipation of the WTO's creation in 1995.

The ISO system has 270 active technical committees, 509 subcommittees, 2,556 working groups, and 726 subgroups and ad hoc study groups.⁹

The committees cover a wide range of economic, social, and environmental sectors.¹⁰ Standards are actually developed or drafted within the working groups, which are mapped to “parent committees” that can be either technical committees or subcommittees, each with a specific title and scope of work. Each technical committee or subcommittee has a secretariat, hosted by a national standards body, that provides technical and administrative support to the committee. The secretariat reports to the ISO Technical Management Board, monitoring and reporting on the committee's progress, ensuring that it remains active, and verifying that ISO Directives and the Board's decisions are properly implemented.¹¹

Figure S2.1 Membership in ISO among low- and middle-income countries has increased



Source: WDR 2025 team, based on administrative data as of 2024 provided by the International Organization for Standardization (ISO).

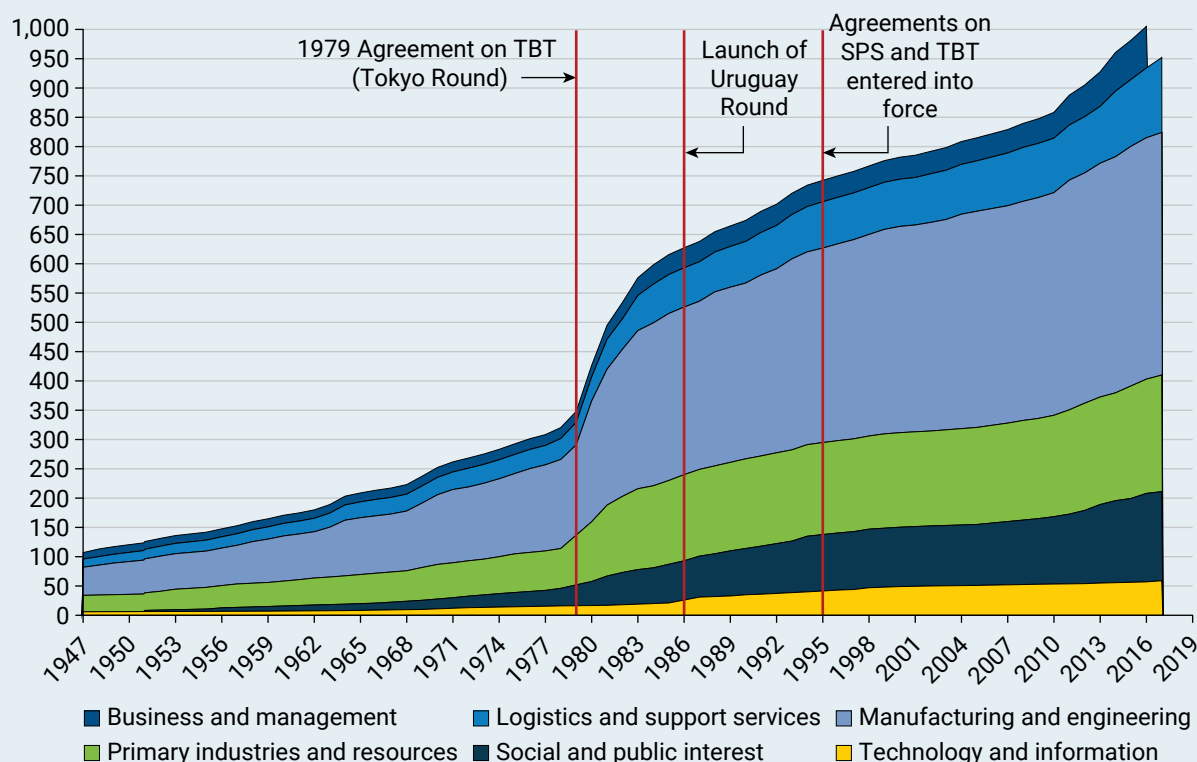
Note: The figure plots the number of national standards bodies that are ISO members by country income group over time. Only one national standards body in each country is an ISO member. “Tokyo Round” and “Uruguay Round” refer to rounds of negotiations under the General Agreement on Tariffs and Trade. SPS = Application of Sanitary and Phytosanitary Measures; TBT = Technical Barriers to Trade.

Figure S2.2 shows the cumulative number of ISO technical committees and subcommittees over time. The manufacturing and engineering sector has the highest number of committees and subcommittees. The number of committees and subcommittees increased sharply after the 1979 Tokyo Round of negotiations for GATT, which yielded the Agreement on Technical Barriers to Trade. Committees and subcommittees proliferated on account of the resulting global shift in

focus from traditional tariffs to nontariff barriers as major obstacles to international trade. The agreement specifically aimed to regulate the use of technical regulations and standards, encouraging the use of international standards as a basis for technical regulations, which led to a demand for international standards. It also aimed to promote transparency and cooperation among countries, which spurred greater engagement in activities related to international standardization.

Figure S2.2 The number of ISO technical committees and subcommittees increased sharply beginning in 1979, after the Agreement on Technical Barriers to Trade encouraged the use of international standards as the basis for technical regulations

Cumulative number of technical committees and subcommittees



Source: WDR 2025 team, based on administrative data as of 2024 provided by the International Organization for Standardization (ISO).

Note: The figure plots the cumulative number of ISO technical committees and subcommittees over time by sector. "Tokyo Round" and "Uruguay Round" refer to rounds of negotiations under the General Agreement on Tariffs and Trade. SPS = Application of Sanitary and Phytosanitary Measures; TBT = Technical Barriers to Trade.

Table S2.2 presents data from a survey of 116 national standards bodies conducted jointly by the World Bank and ISO in 2025 (refer to spotlight 3 for details). As a country's income level increases, the number of ISO and IEC technical committees and subcommittees in which its national standards body participates also increases. Whereas low-income countries participate in only 7 percent of all active ISO technical committees, high-income countries

participate in 84 percent of them. In addition, the number of delegates sent to ISO committee plenary meetings, including representatives from industry and academia and staff members of the national standards body, increases rapidly with a country's income level. These delegates provide technical expertise for developing standards and discuss the needs they expect standards to address from their country's perspective.

Table S2.2 Participation by national standards bodies in development of international standards

MEASURE	LOW-INCOME COUNTRIES	LOWER-MIDDLE-INCOME COUNTRIES	UPPER-MIDDLE-INCOME COUNTRIES	HIGH-INCOME COUNTRIES
Number of NSBs that responded to the survey	13 of 24 members	28 of 42 members	34 of 47 members	41 of 60 members
Share of NSB participation in ISO/IEC technical committees, 2024 (%)	62	86	94	90
Number of ISO/IEC technical committees that NSBs participate in, 2024	20 (3)	41 (5)	125 (48)	228 (70)
Number of delegates sent by NSBs to ISO committee plenary meetings, 2024	9 (1)	14 (3)	65 (5)	525 (58)
Share of NSBs that cover meeting expenses for NSBs that are not ISO members (%)	38	24	18	33

Source: WDR 2025 team, based on World Bank and ISO 2025.

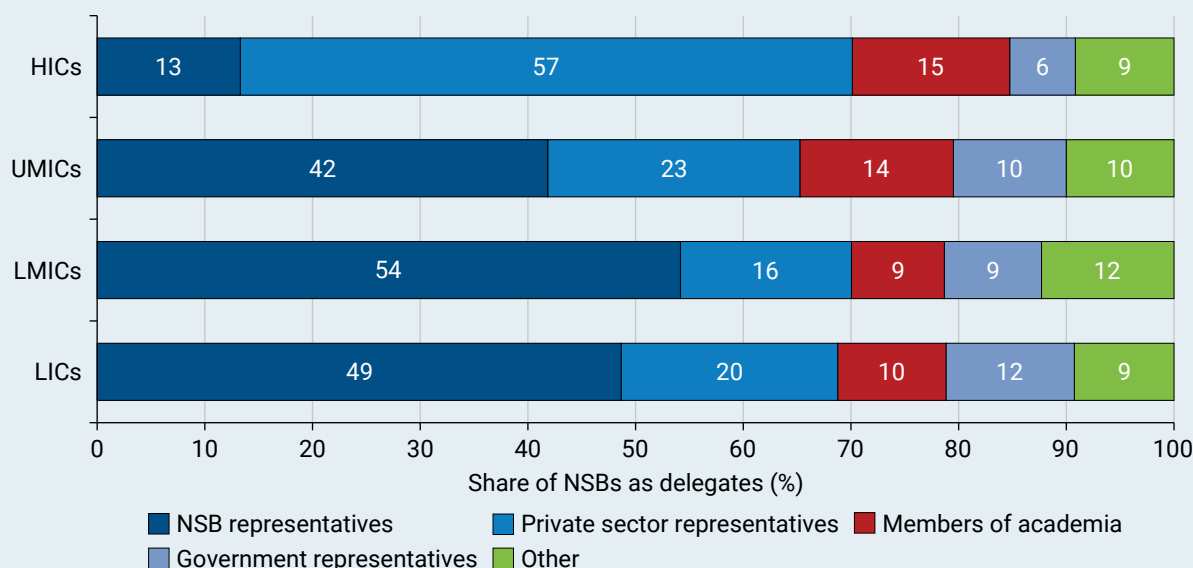
Note: Data on the number of ISO/International Electrotechnical Commission (IEC) technical committees and the number of delegates include the mean and the median (50th percentile), the latter of which is reported in parentheses. (Note that technical committees for standards involving electronics are joint ISO/IEC committees; those for standards involving other sectors are committees of ISO.) The survey sample includes 116 national standards bodies (NSBs): 13 in low-income countries, 28 in lower-middle-income countries, 34 in upper-middle-income countries, and 41 in high-income countries. Survey data were collected between March and June 2025. The share of national standards bodies presented in the table is based on the number of such bodies that responded to the survey.

Figure S2.3 shows that participation of national standards bodies in ISO committees and subcommittees, as represented by the share of these bodies represented by delegates at meetings, declines as country income level increases. In low-income countries, staff members of national standards bodies constitute nearly half of the delegates. By contrast, private sector representatives primarily lead delegations from high-income countries and account for most of the delegates.

For this Report, ISO data for every standard ever published have been analyzed, including the number and income composition of countries on the

committee responsible for the standard's development, as well as the time that elapsed from the request for development of the standard to its publication. The findings show that standards take longer to develop when more countries participate in the development process. Specifically, each additional participating country, irrespective of its income level, correlates with about three additional days from inception until publication. Furthermore, if the secretariat for the technical committee or subcommittee with responsibility for the standard is in a high-income country, the standard is, on average, published three to four months sooner.

Figure S2.3 The share of national standards bodies represented on ISO and IEC committees and subcommittees declines with income



Source: WDR 2025 team, based on World Bank and ISO 2025.

Note: The survey sample includes 116 national standards bodies: 13 in low-income countries, 28 in lower-middle-income countries, 34 in upper-middle-income countries, and 41 in high-income countries. "Other" includes representatives from nongovernmental organizations, standards applications organizations, and labor organizations. Constituent scores within bars may not sum exactly to 100 as a result of rounding. HICs = high-income countries; IEC = International Electrotechnical Commission; LICs = low-income countries; LMICs = lower-middle-income countries; NSB = national standards body; UMICs = upper-middle-income countries.

Motivation for and barriers to participation in developing international standards

Participating in the development of ISO standards requires national standards bodies and their stakeholders to invest a significant amount of time and resources. Hence, the decision regarding which ISO committees a national standards body participates in varies significantly with a country's income level and available expertise. In low-income countries, factors such as a national standardization strategy (important for 54 percent of national standards bodies in low-income countries; refer to box S2.1) and direct decisions by the national government (46 percent) mainly influence this decision.

As the income level of countries increases, decision-making shifts to an approach in which direct proposals or requests from a particular industry become the main factor that determines whether a country's national standards body participates in the development of standards for that industry and thus in the related

ISO technical committee or subcommittee. In addition, the importance of proposals from researchers (noted as important in 18 percent of lower-middle-income countries but 46 percent of high-income countries) and civil society (not noted as important in low-income countries but noted as important in 29 percent of high-income countries) increases with a country's income level. This finding demonstrates that in high-income countries, a more complex and diverse set of actors beyond just government and industry affects the standards agenda.

The main benefits, for national standards bodies in low-income, lower-middle-income, and upper-middle-income countries, of participating in the development of international standards include gaining awareness of standards in view of national adoption (cited by 46 percent, 54 percent, and 50 percent of national standards bodies in countries at these income levels, respectively) and cooperating with other countries and regional partners (cited by 69 percent, 46 percent, and 41 percent of national standards bodies in countries at these income levels, respectively).

Box S2.1 What is a national standardization strategy?

A national standardization strategy is a country's policy road map to ensure that relevant national and international standards support the country's strategic priorities. It is coordinated by the country's national standards body, which ensures that the strategy identifies, among standards under development, the most relevant ones for the national context to ensure an effective allocation of resources. One of the most critical aspects of a national standardization strategy is that it has as its foundation the country's economic, social, and environmental priorities—aligning it with the overall national strategy—and emphasizes the effective use of resources for standards development. It directly addresses both the mid- and long-term vision for the country's national standards body and can serve as a tool for strengthening the national quality infrastructure.

Source: ISO 2020.

Furthermore, as the income level of countries increases, more countries cite the importance of influencing the development and content of standards (62 percent of national standards bodies in low-income countries, 79 percent of those in lower-middle-income and upper-middle-income countries, and 83 percent of those in high-income countries). This is likely because more companies in higher-income countries want to invest in standards development to play a forerunner role.

Data on the five standards with the highest cumulative sales¹² in each country and on active participation by countries' national standards bodies in the development of these standards suggest a positive correlation: Standards developed with a country's participation are more likely to be adopted by that country and to make the list of the five most popular standards in that country.

Table S2.3 uses ISO administrative data on the composition, size, and productivity of technical committees in each sector. It reports, for each technical committee and corresponding sector, the average score on a complexity index for the products for which that technical committee develops standards. Technical committees in the food and agriculture sector and the sector covering mining of nonmetallic materials have a larger share of low-income countries as participants. Both of these sectors have low average scores on the complexity index. In fact, as the complexity of products considered by a technical committee increases, the number of participating lower-income countries declines, and the share of participating high-income countries increases. Echoing the results of figure S2.3, sectors with a higher average score on the complexity index tend to have more members that come from industry, rather than government.

Table S2.3 Composition, size, and productivity of ISO technical committees, by sector

ISO SECTORS	AVERAGE COM- PLEXITY INDEX SCORE OF PRODUCTS COVERED BY TC'S STANDARDS	AVERAGE NUMBER OF COUNTRIES IN TC	SHARE OF LOW- INCOME COUNTRIES IN TC (%)	SHARE OF HIGH- INCOME COUNTRIES IN TC (%)	AVERAGE NUMBER OF STANDARDS PER TC	AVERAGE TIME TO DEVELOP AND PUBLISH STANDARDS (YEARS)	AVERAGE NUMBER OF MEMBERS IN TC	SHARE OF TC MEMBERS FROM INDUSTRY (%)	SHARE OF TC MEMBERS FROM GOVERN- MENT (%)	SHARE OF TC MEMBERS FROM ACADEMIA (%)
Infrastructure and transport										
Transport (11)	0.3	9.6	3.3	80.4	131.4	2.9	1,485	76.7	4.1	12.5
Building and construction (22)	-0.3	4.9	4.2	66.4	26.1	2.7	395	65.8	6.4	16.8
Freight, packaging, and distribution (5)	n.a.	2.6	3.1	55.0	7.6	2.5	224	71.0	5.0	12.9
Science and environment										
Sustainability and environment (14)	n.a.	13.6	5.6	73.3	26.6	2.6	637	63.8	11.0	17.3
Energy (13)	-0.8	5.9	6.4	65.8	31.3	2.5	530	71.7	6.7	15.5

(Table continues next page)

Table S2.3 Composition, size, and productivity of ISO technical committees, by sector (*continued*)

ISO SECTORS	AVERAGE COM- PLEXITY INDEX SCORE OF PRODUCTS COVERED BY TC'S STANDARDS	AVERAGE NUMBER OF COUNTRIES IN TC	SHARE OF LOW- INCOME COUNTRIES IN TC (%)	SHARE OF HIGH- INCOME COUNTRIES IN TC (%)	AVERAGE NUMBER OF STANDARDS PER TC	AVERAGE TIME TO DEVELOP AND PUBLISH STANDARDS (YEARS)	AVERAGE NUMBER OF MEMBERS IN TC	SHARE OF TC MEMBERS FROM INDUSTRY (%)	SHARE OF TC MEMBERS FROM GOVERN- MENT (%)	SHARE OF TC MEMBERS FROM ACADEMIA (%)
Chemicals (10)	0.4	3.6	3.1	68.5	30.0	2.6	159	72.0	4.6	17.6
Ores and metals (12)	-0.2	4.7	3.8	67.3	37.0	2.5	267	71.4	2.7	20.2
Nonmetallic materials (10)	-1.1	5.7	9.3	51.8	98.9	2.6	710	62.6	9.1	21.0
Technology and innovation										
Special technologies (19)	0.2	4.6	2.9	64.0	30.9	2.7	524	65.0	8.2	21.5
Information technology, graphics, and photography (13)	0.8	9.5	1.4	85.8	149.2	2.3	3,194	69.3	9.0	17.2
Mechanical engineering (38)	0.9	3.7	2.5	67.9	29.3	2.6	371	80.4	2.0	8.8
Business management and innovation (12)	n.a.	10.2	3.1	73.6	8.1	2.7	458	67.2	7.5	11.6
Governance and safety										
Security, safety, and risk (5)	n.a.	16.8	7.5	63.4	12.2	3.2	522	65.9	7.7	10.0
Services (10)	n.a.	5.7	8.0	67.5	13.6	2.6	333	62.5	11.9	15.8
Health and food systems										
Food and agriculture (7)	-0.9	11.5	13.1	54.7	50.7	2.0	708	60.2	15.6	16.2
Health, medicine, and laboratory equipment (24)	1.1	4.9	3.5	69.0	40.5	2.6	991	62.5	8.0	20.9

Source: WDR 2025 team, based on administrative data as of 2024 provided by the International Organization for Standardization (ISO).

Note: The table includes data only for standards whose development began in 2015 or later. The number in parentheses next to each sector name indicates the number of ISO technical committees (TCs) in that sector. The complexity index score measures the average complexity of products for which a particular TC develops standards. Because scores on the index are normalized, products can have negative scores. In addition, sectors that primarily involve providing services and have no physically traded products have no index scores (n.a. = not applicable). Refer to Hidalgo and Hausmann (2009); Products (PCI [Product Complexity Index]) Rankings (dashboard), Observatory of Economic Complexity, <https://oec.world/en/rankings/pci/hs4/hs92?tab=ranking>.

Given the growing importance of international standards, it is essential to reduce barriers to participation while ensuring that increasing participation does not slow down the process of developing standards. ITU supports the long-term participation of developing countries through several complementary mechanisms:¹³ fellowships to attend meetings, translation and interpretation services, and country- or region-level programs that promote connectivity and standards implementation. Regional groups, meetings, and events provide a platform for addressing local issues and encourage broader engagement, and electronic tools ensure timely access to resources. In addition, ITU offers training on standards development, tailored for newcomers, advanced experts, and leaders, delivered both online¹⁴ and in person as needed.

Through ISO's sponsorship program, eligible developing countries receive funding to attend meetings of ISO committees and working groups linked to their national priorities. The sponsorship program is provided under the ISO Action Plan for developing countries, which is the overall framework for its technical assistance and training support that is connected to the ISO Strategy 2030.¹⁵

Recent developments aimed at increasing the speed of standards development include online standards development and virtual participation in committee meetings. ISO's Technical Management Board is tasked with monitoring the performance of committees and developing new policies and procedures to continually improve in areas such as the time to market and quality of standards produced by ISO.

Notes

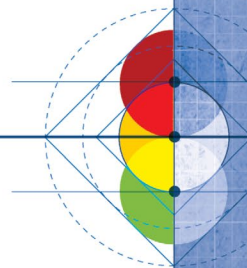
1. For further details, refer to World Standards Cooperation (dashboard), International Electrotechnical Commission, International Organization for Standardization, International Telecommunication Union, <https://www.worldstandardscooperation.org/>.
2. WTO (2014).
3. OECD (2021).
4. IETF (2025).
5. IETF (2024).
6. Refer to Universal Acceptance (UA) (dashboard), Internet Corporation for Assigned Names and Numbers, <https://www.icann.org/ua>.
7. Refer to About ISO: Members (dashboard), International Organization for Standardization, <https://www.iso.org/about/members>.
8. ISO has 130 member bodies, 39 correspondent members, and 4 subscriber members. There is only one membership per country. Participating members actively participate in the development of standards and are expected to vote on all official committee ballots, whereas observer members observe and comment on the organization's work but are not obligated to vote.
9. Refer to ISO in Figures (dashboard), International Organization for Standardization, <https://www.iso.org/iso-in-figures.html>.
10. Refer to Technical Committees (portal), International Organization for Standardization, <https://www.iso.org/technical-committees.html>.
11. Refer to Directives and Policies (portal), International Organization for Standardization, <https://www.iso.org/directives-and-policies.html>.
12. National standards bodies typically sell standards, including both ISO standards and those developed by national standards bodies, to businesses, industries, governments, and the general public within the countries they represent. The five standards with the highest cumulative sales across countries are ISO 9001 (standard for quality management systems), ISO/IEC 27001 (standard for information security management systems), ISO 14001 (standard for effective environmental management systems), ISO 45001 (standard for occupational health and safety management systems), and ISO/IEC 17025 (standard that specifies the general requirements for the competence of testing and calibration laboratories).
13. Both ITU Plenipotentiary Conference Resolution 123 (ITU 2022) and WTSA Resolution 44 (ITU 2024) mandate that ITU provide specific support to developing countries.
14. Refer to ITU-T Delegate Training Resources—BETA (portal), International Telecommunication Union, <https://www.itu.int/bsg/training-modules>.
15. Refer to Capacity Building (dashboard), International Organization for Standardization, <https://capacity.iso.org/home/about.html>; Strategy 2030 (dashboard), International Organization for Standardization, <https://www.iso.org/strategy2030.html>.

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3

Reaching the Full Potential of Standards with Quality Infrastructure



Main messages

- Standards fulfill their potential with the help of quality infrastructure: a system of public and private organizations and policies that provide services like metrology, testing, inspection, certification, accreditation, market surveillance, and standardization itself. This system turns standards from written documents into real-world results.
- Quality infrastructure serves a dual role: It underpins voluntary standards that sustain competitive markets, and it enables achievement of a range of regulatory objectives, for example, by supporting compliance with and enforcement of mandatory standards.
- The elements of quality infrastructure and good practices are universal, applying beyond industry to areas such as health, education, safety, and the environment.
- A move to higher standards must be accompanied by efforts and investments in quality infrastructure, which is a prerequisite for trust, quality, and international integration.
- Low- and middle-income countries often face a dilemma when it comes to quality infrastructure: Low demand for quality reduces their incentive to invest in quality infrastructure, yet without the latter, greater demand cannot emerge.
- Low- and middle-income countries must build quality infrastructure step by step, adapting the roles of public and private institutions as capabilities grow. First, they should establish the *basics* of quality infrastructure and use public institutions to provide quality assurance services like testing and inspection for high-stakes areas. Then, they should *broaden* the coverage and attract private providers. And finally, over time, they should *balance* their approaches by collaborating more with the private sector to provide assessments of compliance with quality infrastructure standards at scale, shifting the government's role to that of a "referee."

Quality infrastructure: A public-private system for ensuring quality and trust

Many of the benefits of standards described in chapter 2 rely on verified compliance. Consider a construction firm that needs to ensure the steel it uses has been thoroughly tested to meet the specifications for the required strength. Or a parent who wants baby food to meet strict safety standards—and relies on a trusted organization to verify the safety of the food she serves her child. Or an employer who can confirm the qualifications of job applicants by requiring candidates to present a degree from a recognized school or accredited program. In each case, the standard itself does not guarantee quality or enable trust; the standard must be part of a larger system that verifies, monitors, and ensures conformity with the standard. This system is known as *quality infrastructure*.

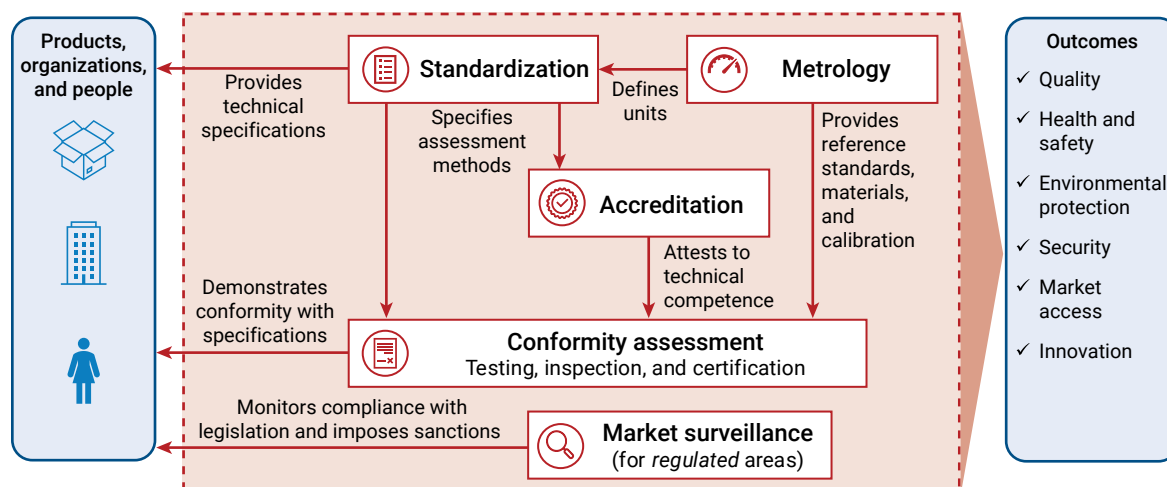
Quality infrastructure involves a network of public and private organizations and policies that support the quality, safety, and environmental sustainability of goods, services, and processes.¹ Most people recognize quality marks or labels on products, but few understand the complex system of testing laboratories, inspectors, and measurement processes that uphold standards and establish a quality infrastructure system. Although it is referred to as “infrastructure,” it should not be confused with physical structures like roads, bridges, or airports. Instead, quality infrastructure serves as the backbone or foundation of quality and safety, including the institutional framework, governance arrangements, and technical facilities necessary to ensure quality.²

Four core components of quality infrastructure that underpin voluntary and mandatory standards

Quality infrastructure serves a dual purpose: It supports the consistent implementation of voluntary standards, and it ensures effective enforcement if standards are made mandatory as part of government regulation. In both cases, the quality infrastructure system relies on four core components (refer to figure 3.1):

1. *Standardization*: Standards not only define *what* technical specifications need to be met but also specify test methods, terminologies, and other aspects. They therefore appear throughout a quality infrastructure system.
2. *Conformity assessment*: Conformity assessment involves evaluating whether the specified requirements for a product, process, system, or of a person or organization have been fulfilled.³ It includes activities like *testing* (measuring or evaluating a product’s characteristics); *inspection* (examining a product or process); *validation and verification* (confirming the plausibility or truthfulness, as the case may be, of a claim); and *certification* (confirming that a product, service, or system meets specific requirements). Entities that make products or deliver services can assess conformity themselves, through, for example, in-house laboratories for quality control (first-party assessment or self-declaration of conformity); second parties, such as buyers, can perform such assessment; or third parties, such as independent conformity assessment bodies, can perform the needed evaluation and certification. Private sector bodies, not governments, provide most of the conformity assessment around the world.

Figure 3.1 Elements of a quality infrastructure system



Sources: WDR 2025 team, adapted from Guasch et al. 2007; Kellermann 2019a.

3. *Accreditation*: Accreditation, the process of “checking those who check,” is the formal attestation that a conformity assessment body is technically competent to fulfill its tasks. It therefore ensures trust in testing, inspection, and certification.

4. *Metrology*: Metrology is the science of measurement and its application.⁴ It comprises defining internationally accepted units of measurement, realizing such measurement units by scientific means, and demonstrating traceability of measurements between science and practice (more on this shortly). An important metrology service, calibration, involves adjusting and verifying the accuracy of measuring instruments.⁵

In regulated areas—for example, in the case of mandatory standards—a fifth element of a quality infrastructure system applies:

5. *Market surveillance*: Market surveillance refers to the activities that public authorities carry out to ensure that products available in the market comply with applicable legislation.⁶ Its primary goal is to protect consumers, public health, and the environment by identifying and addressing noncompliant or unsafe products. Market surveillance is a complementary layer of control alongside conformity assessment and accreditation.

The elements of quality infrastructure work together as an interconnected system, as figure 3.1 illustrates. Standards not only specify the criteria to which a product or service must conform but also establish suitable methods for conformity assessment, which in its turn demonstrates that these requirements have been met. For example, International Organization for Standardization (ISO)/International Electrotechnical Commission

(IEC) 17025 specifies the criteria regarding technical competence and quality management that testing and calibration laboratories must meet. Metrology, in turn, underpins both standards and conformity assessment by ensuring accurate and traceable measurements. For instance, a food safety laboratory testing milk for aflatoxin contamination must calibrate its instruments using reference materials that can be traced to the national measurement standards for such contamination. Without this unbroken chain from standards to accreditation to traceable measurement, market trust and compliance would be impossible.

Intersection of quality infrastructure with various policy areas

Most countries have, rather than a single coherent quality infrastructure system, a diverse set of public and private institutions that take on one or several of the five functions of such a system. Although the core functions of quality

infrastructure are the same across voluntary and mandatory standards, the entities involved in providing the needed functions may differ, as table 3.1 illustrates. For example, a labor authority uses factory inspectors to monitor compliance with labor laws: a type of conformity assessment. A university typically must receive accreditation by a country's ministry of higher education or another institution before it is allowed to issue degree certificates. An industry group develops and certifies its own voluntary standard for sustainability to cater to a specific customer segment.

Consequently, quality infrastructure overlaps and interacts with many other policy areas, including consumer protection, trade, competition, health, education, digitalization, and the environment.⁷ As a result, countries also have different definitions of what is considered part of quality infrastructure. For example, some consider intellectual property rights, product liability, or customs to be part of it, whereas other countries do not.

Table 3.1 Illustrative examples of functions of quality infrastructure relating to voluntary and mandatory standards

QUALITY INFRASTRUCTURE FUNCTIONS	FUNCTIONS	
	VOLUNTARY	MANDATORY
Standards	• National standards bodies develop voluntary national standards and participate in development of international standards. • Private technology consortia develop interoperability standards. • Nongovernmental organizations develop sustainability standards.	• Environmental protection authorities mandate standards for clean water. • Health authorities set hygiene standards.
Conformity assessment	• Private certification bodies audit and certify food safety management systems.	• Government or private laboratories test water quality.

(Table continues next page)

Table 3.1 Illustrative examples of functions of quality infrastructure relating to voluntary and mandatory standards (*continued*)

QUALITY INFRASTRUCTURE FUNCTIONS	VOLUNTARY	MANDATORY
Conformity assessment (<i>continued</i>)	• Companies perform quality control using in-house laboratories. • Consumer groups conduct independent safety tests.	• Inspectors investigate schools and hospitals. • Private companies inspect imports for customs authorities.
Accreditation	• National accreditation bodies verify competence of private certification bodies. • Brands approve their suppliers' laboratories. • Technology firms recognize training centers that offer courses on the firms' software.	• Regulators require private testing laboratories to be accredited in regulated areas. • Education ministries accredit universities.
Metrology	• Metrology institutes provide medical laboratories with reference materials for accurate tests. • Metrology laboratories calibrate measuring instruments of secondary calibration laboratories and industry.	• Regulators require prepackaged food to contain the exact amounts their labels claim (legal metrology).
Market surveillance	Typically not performed in voluntary areas.	• Consumer protection agencies verify that products on the market are safe and legal.

Source: WDR 2025 team.

The challenge of compliance capacity in low- and middle-income countries

As chapter 2 illustrates, greater ambition in standards must be matched with stronger capacity for achieving and assessing compliance with those more ambitious standards. Quality infrastructure

is key to expanding this capacity. Only if the appropriate testing, inspection, certification, and other services are available can firms demonstrate conformity, build trust with buyers, and access regulated or quality-conscious markets. Likewise, governments can be effective only if they are able to enforce compliance with standards cited in legislation. Although quality infrastructure is

often associated with manufacturing, this Report emphasizes the role of quality infrastructure as a universal system whose functions are applicable in many areas. Understanding how the distinct functions of quality infrastructure interact, the appropriate roles of the public and private sectors, how to develop and apply the functions, and which pitfalls to avoid is especially relevant—but also challenging—for low- and middle-income countries, which face at least three key substantial challenges, which are discussed next.

Rising demand for quality infrastructure

The demand for quality is rising—both globally and domestically—while low- and middle-income countries continue to face significant constraints on their resources and capacity for assessing quality. Today's quality infrastructure systems must not only support advanced technologies but also respond to a more fragmented set of standards and stricter buyer and regulatory requirements. For example, international fashion brands require suppliers to adhere to strict standards for the accuracy of fabric colors. Testing the compliance of garment exports with these standards relies on precise metrology equipment to calibrate instruments to achieve the degree of accuracy required by such exacting color specifications. A lower-income country like Ethiopia producing garments for export in today's market must grapple with the complex demands of such testing. Higher-income countries, on the other hand, built their systems during eras of industrial modernization and earlier phases of trade integration and did not have to deal

with such demands.⁸ In addition, many low- and middle-income countries inherited quality infrastructure institutions from a colonial legacy and often focused on import substitution, which influenced their priorities for their quality infrastructure (leading to, for example, a focus on inspecting imports). Beyond these aspects of product quality construed narrowly, buyers and consumers are moving their attention more and more to the ways in which products and services are produced, including social and environmental aspects (refer to chapter 4). They therefore need to have confidence in suppliers' claims of sustainability-related performance, and quality infrastructure is vital for providing this as well.

Costs of investing in quality infrastructure

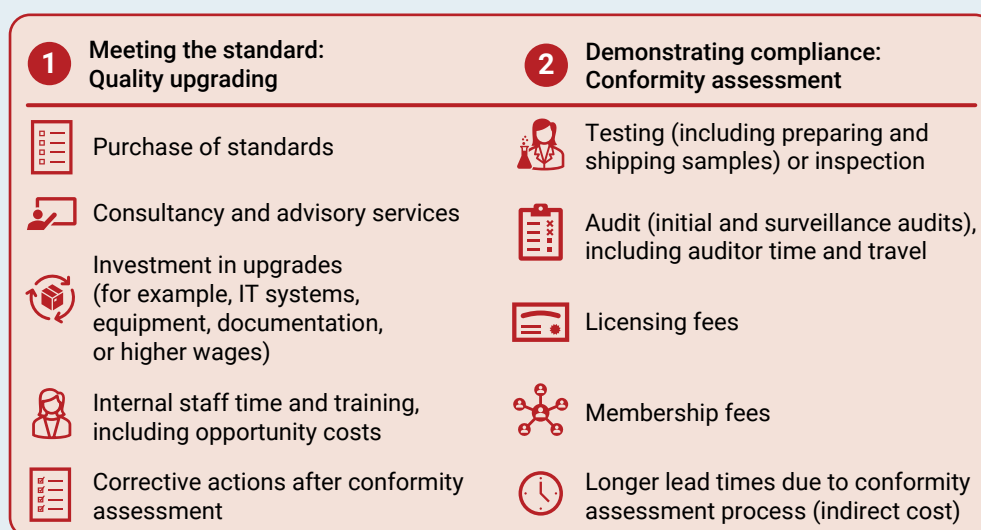
Developing a quality infrastructure system involves substantial public and private investments.⁹ It requires specialized equipment for testing laboratories and skilled personnel like auditors and inspectors. Quality assurance also needs to be in place and exercised across a country, adding to the costs and complexity of the infrastructure needed, particularly in low- and middle-income countries. In addition, a well-functioning quality infrastructure relies on international cooperation, which can be costly in terms of money, time, and resources (for example, participation in peer assessments associated with multilateral arrangements for recognition of conformity assessment). There is also evidence that low- and middle-income countries may face higher costs of compliance than high-income countries face (refer to box 3.1).

Box 3.1 Understanding the high costs of complying with standards in low- and middle-income countries

One of the challenges that firms in low- and middle-income countries face is the cost of compliance with standards, especially when these firms are trying to access export markets. Compliance costs disproportionately affect small and medium enterprises, because fixed expenses represent a larger share of their total costs. For example, small and medium manufacturers of surgical instruments in Pakistan report that compliance costs for the European Union (EU) Medical Device Regulation can reach up to €200,000 in the first year of compliance and €30,000 in subsequent years.^a These costs can be very high for small firms, which usually have no more than 20 employees and average annual sales ranging between €20,000 and €300,000. Likewise, for small and medium-size firms in East Africa involved in the coffee, cocoa, and horticulture sectors, auditing expenses for the voluntary sustainability standard GLOBALG.A.P. may range from US\$2,000 to US\$15,000.^b In addition, the average costs for updating production processes to comply with environmental and social standards can amount to more than US\$12,000 per firm. These are substantial expenses for small and medium-size enterprises in East Africa.

From a firm's perspective, compliance has two main costs: upgrading quality to meet applicable standards and demonstrating compliance via conformity assessment (refer to figure B3.1.1). During quality upgrading, firms incur costs related to consultancy services, internal staff time,

Figure B3.1.1 Key components of costs of conformity assessment from a firm's perspective



Source: WDR 2025 team.

Note: IT = information technology.

(Box continues next page)

Box 3.1 Understanding the high costs of complying with standards in low- and middle-income countries (*continued*)

training, and potential investments in equipment, infrastructure, or process upgrades. They may also need to purchase relevant standards and address any gaps between those standards and their practices and outputs through corrective actions. The associated costs vary substantially depending on the type of business, type of standard, and type of firm. The costs associated with conformity assessment include the direct costs of third-party services such as auditor time (and possibly travel), testing or inspection costs, and sometimes fees for licensing or membership. Activities related to conformity assessment can also increase lead times before products reach the market, amounting to an additional indirect cost. Aside from the initial costs, conformity needs to be maintained via surveillance audits, recertification, and continued license fees.

Depending on the firm and industry, the bulk of an enterprise's compliance costs may be either for quality upgrading or for conformity assessment. For example, if a farm is already producing organically, the majority of the costs associated with getting certified as organic may be those involved in getting the actual certificate. However, if a firm first needs to invest in a wastewater treatment plant and pay its workers higher wages to become certified as a sustainable company, then those costs may be greater than the actual certification costs. Repeated audits for several, often overlapping, certification schemes often add to these costs. Therefore, although certification can provide access to high-value customers, many firms in low- and middle-income countries may find it costly.^c

Although data for systematically comparing compliance and conformity assessment costs in high-income and low- and middle-income countries are unavailable, there is some evidence that low- and middle-income countries may face higher compliance costs. Importantly, many low- and middle-income countries lack scale, which means fewer conformity assessment bodies are available or capacity utilization rates are lower. In addition, whereas low- and middle-income countries may have lower staffing costs than their high-income counterparts, laboratory equipment and consumables are typically more expensive in low- and middle-income countries as a result of import dependence and higher capital costs. Moreover, low- and middle-income countries often lack the needed auditors and assessors, which means international experts often need to travel from abroad to conduct audits and assessments. This not only increases staffing costs but also adds travel expenditures and, potentially, costs associated with the use of interpreters. If samples must be tested abroad, firms in low- and middle-income countries incur associated shipping costs. Because the owners of certification schemes are often based in high-income

(Box continues next page)

Box 3.1 Understanding the high costs of complying with standards in low- and middle-income countries (*continued*)

countries, low- and middle-income countries can face higher licensing and membership fees.^d Furthermore, because of limited international recognition and weaker reputations of domestic conformity assessment bodies, low- and middle-income countries often face the additional burden of duplicate testing and certification to meet the requirements of foreign markets.

Sources: WDR 2025 team, based on inputs from the International Trade Centre (ITC) and ISEAL Alliance.

- a. Based on interviews by World Bank staff members with the Surgical Instrument Manufacturers Association of Pakistan (SIMAP) in March 2025.
- b. ITC contribution to *World Development Report 2025*.
- c. Verhoogen (2023).
- d. Meanwhile, several sustainability schemes adapt their membership fees to the lower purchasing power in low- and middle-income countries or of smaller firms. Similarly, importers rather than exporters often bear license costs.

Difficult political economy

Low- and middle-income countries often face a complex political economy when seeking to strengthen their compliance capacity. First, stricter enforcement of regulations such as mandatory standards, though potentially increasing safety and public welfare, can have uneven distributional impacts. Strict enforcement may disadvantage smaller firms, which face relatively higher costs of compliance, or even prompt formal firms to exit the formal sector to evade compliance costs. Second, reliance on government inspectors and testing services can introduce opportunities

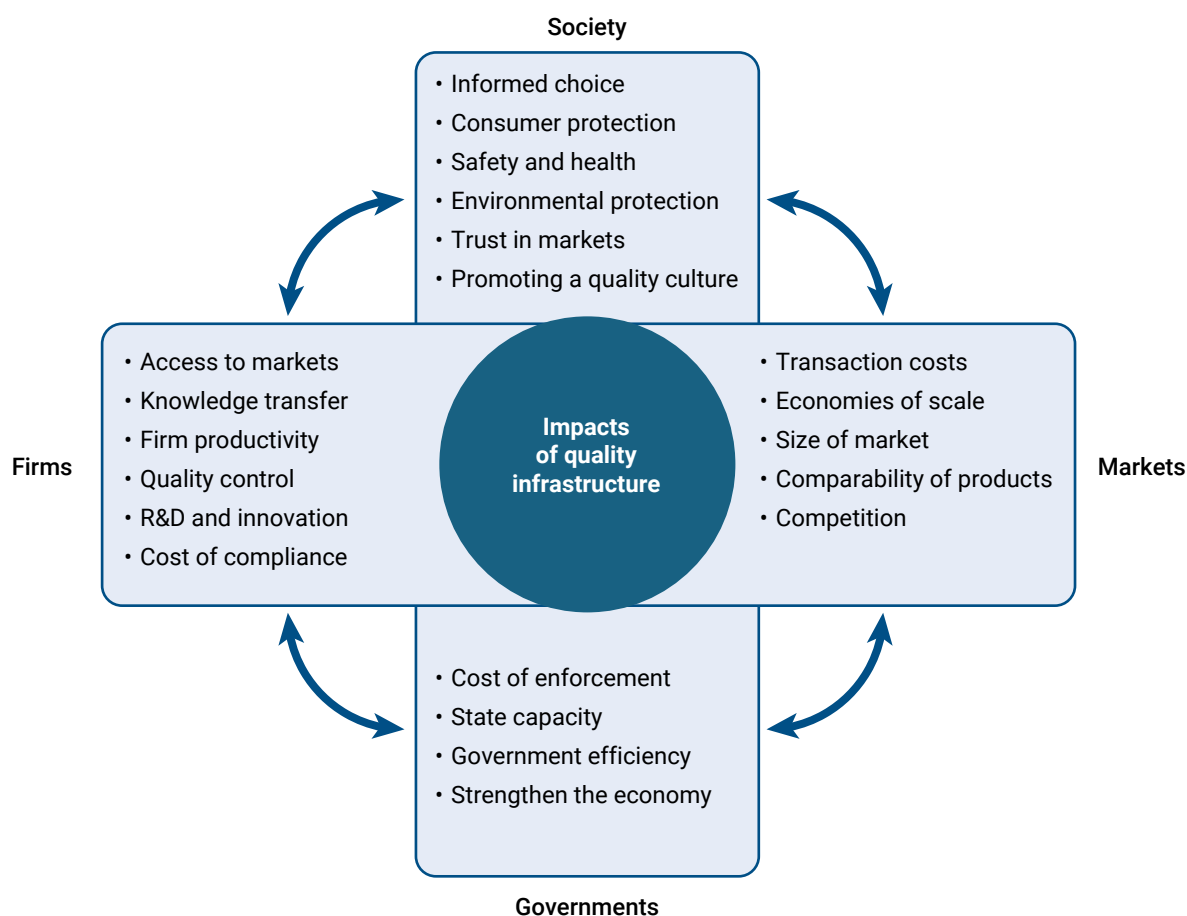
for rent seeking and corruption, particularly in contexts in which governance is weak. Third, in the absence of a broad industrial base and robust processes for governance, a few dominant firms may capture the regulatory process and shape standards and compliance procedures to serve their own interests. Fourth, investing in quality infrastructure offers long-term advantages, but these advantages may not align with policy makers' short-term political goals, making such investment less attractive. Finally, when to use voluntary standards or set mandatory standards depends on the preferences of policy makers and policy goals in a country.

Quality infrastructure benefits competitiveness and public policy

Quality infrastructure can be used in multiple ways, with positive or negative outcomes depending on how it is applied across society, markets, firms, and the government, as figure 3.2 illustrates.¹⁰ For instance, internationally harmonized standards and testing procedures can facilitate trade, whereas national deviations from these

standards and procedures risk creating technical barriers to trade. Moreover, applying quality infrastructure to different objectives often involves trade-offs. Mandatory testing and certification can enhance safety but also can raise costs of compliance with safety standards, often disproportionately burdening small and medium enterprises.¹¹ Product labels can help consumers make informed decisions, but inconsistent or misleading labeling can create confusion, inefficiencies, and even fraud.

Figure 3.2 Quality infrastructure has impacts on firms, markets, governments, and society



Source: WDR 2025 team.

Note: R&D = research and development.

Quality infrastructure offers benefits mainly through enabling standards to function effectively. Conformity assessment confirms that the requirements of a standard have been met. Metrology provides precise measurements for conformity assessment and standards. Accreditation ensures that conformity assessment is conducted only by bodies competent to do so. In this sense, conformity assessment, metrology, and accreditation mirror and reinforce the effects of standards themselves (refer to chapter 2). At the same time, quality infrastructure can provide certain specific benefits to firms, markets, governments, and society.

Firms. Testing and inspection are essential not only for demonstrating conformity, but also for learning. Many companies have in-house laboratories for quality control and research and development, enhancing productivity, fostering innovation, and reducing risks. For example, in-house testing helps prevent product failures, recalls, and damage to a company's reputation.¹² Even when laboratories are in house, however, they depend on accreditation and metrology services to function properly.

Markets. At the market level, quality infrastructure can lower transaction costs. For example, if buyers trust the accuracy and reliability of tests conducted by or on behalf of their suppliers, they do not need to scrutinize sourced products as closely as they might otherwise, simplifying transactions.¹³ Economies of scale and compatibility rely on precise and globally aligned measurements, guaranteed by metrology. Verified compliance with standards required for international market access opens up economic opportunities through trade.¹⁴

Governments. Quality infrastructure can make regulatory enforcement more effective and efficient.¹⁵ Reliance on market-based standards and private third-party certification can lessen the financial

burden of regulatory oversight, reducing or eliminating the need for significant public funding to operate government laboratories and inspection agencies. For example, in the European Union (EU), electronic signatures used in digital transactions depend on a "trust chain" of certified trust service providers. These providers are audited by accredited conformity assessment bodies, ensuring they meet the technical and security requirements outlined in EU regulations. Without this system, electronic signatures would lack the legal certainty required for secure online commerce and government services.¹⁶ Governments can also use quality infrastructure to improve the efficiency of their own operations, as by incorporating standards and conformity assessment requirements into public procurement or budgeting processes.

Society. Quality infrastructure helps build societal trust in markets by ensuring product safety and supporting other public policy goals like public health and environmental protection.

"One standard, one test, accepted everywhere"

A central benefit of a well-functioning quality infrastructure is that it fosters regional and international integration.¹⁷ Systems for conformity assessment using international standards and guides pave the way for mutual recognition.¹⁸ Test results can be recognized across borders if laboratories are accredited by bodies that are signatories to international mutual recognition arrangements for accreditation. These arrangements rely on building trust through international peer evaluations, in which accreditation bodies review each other's practices against requirements provided by internationally accepted standards (such as ISO/IEC 17011). Once a recognized signatory to such agreements accredits a conformity assessment body, other signatories accept that body's results,

reducing the need for duplicative testing and certification.¹⁹ Similarly, metrology ensures the international diffusion of measurement standards and scientific units, without which trade and science would be impossible.

The benefits of quality infrastructure depend on complementary policies. Standards for product safety are essential for consumer protection, but other policies like those regarding resolution of consumer disputes or product liability may be as important. In many low- and middle-income countries, an underdeveloped legal system may therefore be a bottleneck to quality infrastructure's delivering on regulatory enforcement.²⁰ Similarly, quality infrastructure can facilitate trade but also depends on the broader context of trade policy, logistics, and the business environment. For example, the Republic of Korea rapidly developed the capabilities of its quality infrastructure, which contributed to its economic successes, but it is difficult to assess to what extent its efforts in this area can be separated from other policies like those involving trade, innovation, and investment.²¹

Empirical evidence on quality infrastructure

Empirical evidence on the impact of quality infrastructure is scarce and recent. A literature review by Blind et al. (2025) found only 132 articles published between 1998 and 2023 that focus on quality infrastructure, and more than half of these were published in 2020 or after.²² Few of these articles applied robust empirical methods, and most are qualitative case studies or descriptions of systems. The limited size of this body of evidence partly reflects the fact that quality infrastructure has only recently emerged as a coherent concept.

Most of the empirical evidence exists for individual components of quality infrastructure, which underestimates the benefits of their interaction

and synergies. Among these components, standards and conformity assessment have been researched the most.²³ Because empirical evidence on standards is discussed throughout this Report, the analysis that follows focuses on other components of quality infrastructure.

Conformity assessment

There is a considerable body of research on the organization-level effects of conformity assessment, but mostly for high-income countries and large emerging market economies. Meanwhile, it is often difficult to differentiate the impact of implementing a standard (knowledge) from certification (signal).²⁴ In addition, certification often has only indirect economic effects. For example, German firms implement (or use) ISO/IEC 27001 on information security primarily to prevent data breaches, which means the financial benefits are mainly the avoided costs of future security incidents.²⁵

Most of the existing research has focused on certification of management systems, such as those for quality (ISO 9001) or the environment (ISO 14001). Although evidence is mixed regarding the impact of ISO 9001 certification on firms' performance, there is evidence that such certification has a positive impact on firms' revenues (refer to chapter 4).²⁶ Meanwhile, ISO 9001 has nuanced effects on innovation, with some evidence suggesting it matters more for incremental than for radical innovation.²⁷ Regarding ISO 14001, its positive effects on environmental performance are well documented,²⁸ and several studies also have found positive economic effects.²⁹ However, as noted earlier, studies generally cannot differentiate the effect of adopting a standard (implementing an environmental management system, for example) from the signaling effect of certification as having met the standard.³⁰ The macroeconomic impacts of conformity assessment are not well researched, and studies typically use proxies such as the number of certifications of quality management systems issued in

a country, which is a small subset of its conformity assessment activities overall.³¹

Accreditation. Only a few studies have assessed the economic effect of accreditation, and it has mostly been considered to be an indirect effect that operates by strengthening the credibility of conformity assessment.³² Countries with more ISO 9001 certificates not only trade more, consistent with the literature,³³ but this is even more the case if a country is a signatory to international agreements regarding accreditation, which strengthen the credibility and mutual recognition of the results of conformity assessment.³⁴ This positive effect on trade is especially applicable regarding low- and middle-income countries' access to markets in high-income countries. Similar positive economic effects of mutual recognition agreements for conformity assessment have also been shown within Europe.³⁵

Metrology. Because metrology has particularly indirect effects on conformity assessment, empirical evidence on its effects remains scarce and is often limited to theoretical models.³⁶

In one of the few econometric studies, Link (2023) found that the number of calibration tests in the United States was associated with aggregate productivity.³⁷ Similarly, Choudhary et al. (2013) found that measurement activities are important in determining the extent of bilateral EU trade within an industry.

Assessing the performance of quality infrastructure using indexes

Several indexes measure the level of quality infrastructure at the country level. For example, the Global Quality Infrastructure Index (GQII) is a composite index that builds on publicly available data such as the number of accredited conformity assessment bodies in a country, the number of certifications of calibration and measurement capabilities, the number of management system certificates issued, and membership and level of participation in international institutions that deal with quality infrastructure.³⁸ Box 3.2 provides further information on the GQII and similar indexes, as well as their limitations.

Box 3.2 Indexes that compare countries' quality infrastructure systems

Several indexes aim to benchmark the performance of a country's quality infrastructure against that in other countries in the same region or in the world.

The *Global Quality Infrastructure Index (GQII)* is a comprehensive database and ranking system that evaluates and compares the state of development of quality infrastructure across 185 countries worldwide. Developed by two consulting firms, Mesopartner and Analyticar, the index draws on publicly available data covering key components of quality infrastructure such as standardization, accreditation, and metrology, as well as related international recognition.^a It builds on publicly available data such as whether a country is a member of international organizations that deal with quality infrastructure like the International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC), and the International Bureau of Weights and Measures (BIPM); the number of ISO management

(Box continues next page)

Box 3.2 Indexes that compare countries' quality infrastructure systems (*continued*)

system certificates issued in the country; the scope of the country's accreditation; and the number of accredited conformity assessment bodies in the country.

One limitation of the GQII is that some of its components are themselves *outcomes* of a quality infrastructure system, such as the number of certificates issued, rather than measures of capabilities, which makes it more difficult to separate the specific effects of quality infrastructure from other factors like market demand that also shape outcomes. Moreover, the index cannot account for the effects of interaction among different functions of quality infrastructure. To address some of the shortcomings, the index is currently undergoing improvements to its methodology.

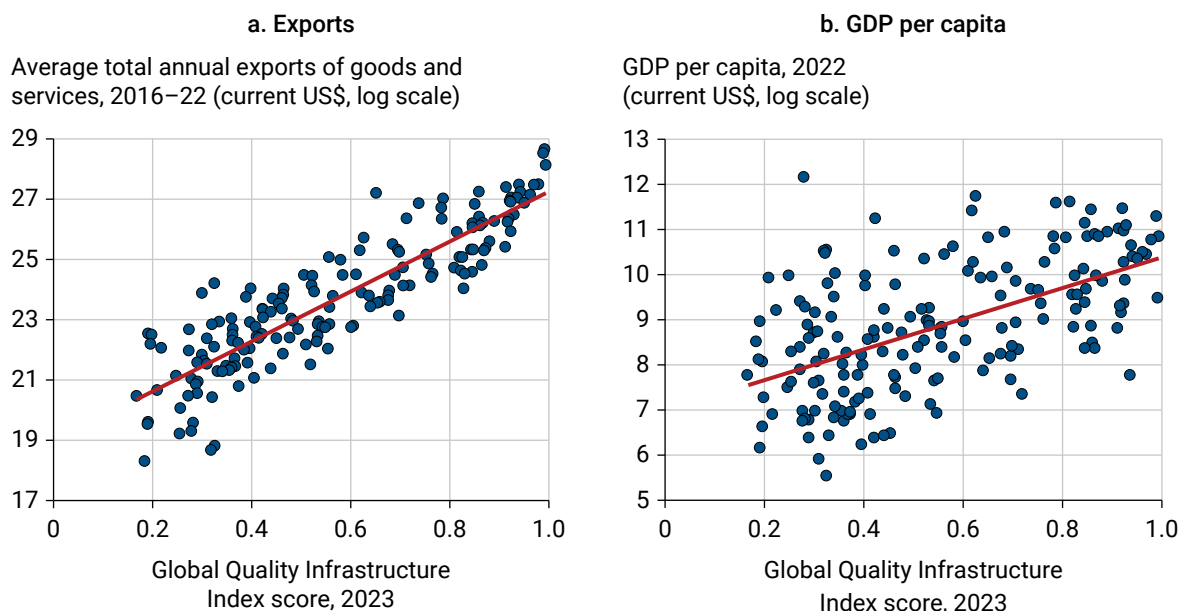
The *Quality Infrastructure for Sustainable Development (QI4SD) Index* assesses the readiness of a country's quality infrastructure to support the United Nations Sustainable Development Goals.^b Developed by the United Nations Industrial Development Organization (UNIDO) in partnership with the International Network on Quality Infrastructure (InetQI), it provides indicator data and scores for various dimensions of quality infrastructure, as well as an overall aggregate score. In addition, each country receives a score for three pillars (people, planet, and prosperity), reflecting the state of quality infrastructure in regard to social, environmental, and economic factors. Some of the underlying data are the same as those used for GQII components, such as membership status, number of accredited bodies, number of certificates issued, scope of accreditation, and metrology capacities. In addition, the QI4SD Index includes a dimension on quality policy based on a survey conducted by UNIDO in collaboration with ISO. Given that scores on the QI4SD Index and GQII are correlated, the institutions responsible for the two indexes are in conversation about devising an integrated index on quality infrastructure.

The *Pan-African Quality Infrastructure index* tracks the development of quality infrastructure across African countries, categorizing countries' quality infrastructure systems into five levels, from well-developed to very limited. It centers on members of the African Union and functions as an exchange platform between institutions that deal with quality infrastructure in member countries. There have been four editions (2014, 2017, 2020, 2023) of the index.^c

Source: WDR 2025 team, based on Harmes-Liedtke et al. 2025.

- a. For details on the index, including data, refer to Global Quality Infrastructure Index (GQII) Program (dashboard), Mesopartner and Analyticar, <https://gqii.org/>. Refer also to Harmes-Liedtke et al. (2024).
- b. Refer to QI4SD—Quality Infrastructure for Sustainable Development: About (web page), Knowledge Hub, United Nations Industrial Development Organization, <https://hub.unido.org/qi4sd/about>.
- c. PAQI (2023).

Figure 3.3 Countries with higher levels of quality infrastructure tend to perform better economically



Sources: WDR 2025 team, based on data from GQII 2023 (dashboard), Global Quality Infrastructure Index (GQII) Program, Mesopartner and Analyticar, <https://gqii.org/gqii-2023/>; World Bank.

Countries with higher levels of quality infrastructure (based on their scores on the GQII) tend to have higher total exports and higher GDP per capita (refer to figure 3.3). In addition, countries at the same level of income tend to have higher exports the more well-developed are their quality infrastructure systems.

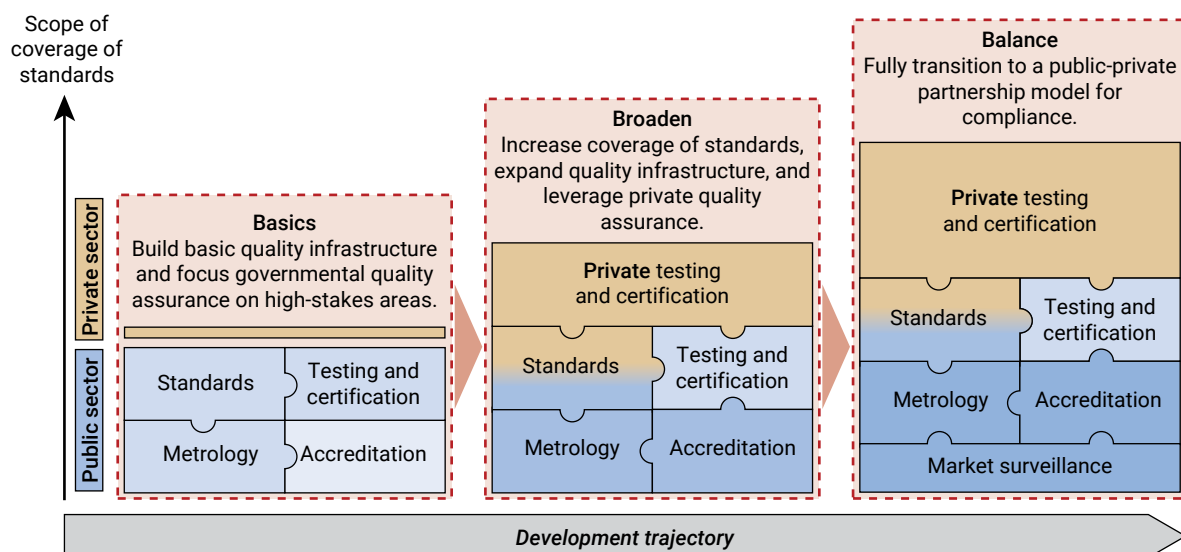
How to build a well-functioning quality infrastructure system

As countries develop, their approach to building capacity for compliance with standards needs to evolve (refer to figure 3.4). The three phases of such capacity building, which broadly align with the phases of standards setting described in chapter 2 (adapt–align–author), follow an understanding that quality infrastructure in a country needs to be established sequentially and that the role of

a country's government in ensuring compliance must evolve over time.³⁹

Basics. At low levels of development, when capacity for compliance with standards in a country is limited, it is necessary to establish basic foundations for compliance and enforcement by concentrating on high-stakes areas. For example, in the 1980s, India focused mandatory certification on specific critical products, especially those affecting public safety, infrastructure, and consumer protection, like cement and compressed-gas cylinders.⁴⁰ Compliance with export requirements is a priority for many countries at this stage, too. In this phase of building a quality infrastructure system, countries' public sectors have a strong role in carrying out services related to quality assurance because the countries may not yet have a market for private testing and certification. For instance, a state-owned conformity assessment enterprise provides most of the testing and certification in

Figure 3.4 As countries develop, they build the basics of compliance capacity, broaden the coverage of their standards, and increasingly follow a balanced approach involving the private sector



Source: WDR 2025 team.

Ethiopia.⁴¹ The government also needs to invest in the foundations of quality infrastructure, particularly standards development and metrology, which are the basis on which all other elements of the quality infrastructure depend to function. Accreditation is typically not yet developed in the country, or the country relies on foreign accreditation services.

Broaden. Over time, countries recognize the need to expand the scope of public policy objectives such as health and safety. As the coverage of these objectives grows, so does demand for providers of testing, inspection, and certification, enabling the private sector to play a greater role in these areas. This means that gradually, the government becomes less directly involved in providing quality assurance and instead focuses on ensuring the trustworthiness of private organizations, through accreditation in particular, as well as other areas.

In this phase, countries also should increasingly seek international recognition via mutual recognition arrangements through key global forums for accreditation (International Laboratory Accreditation Cooperation, or ILAC; International Accreditation Forum, or IAF); standards development (ISO; the IEC; International Telecommunication Union, or ITU); and metrology (International Bureau of Weights and Measures, or BIPM; International Organization of Legal Metrology, or OIML).⁴² For example, in the early 2000s the Kyrgyz Republic moved from a system in which its national standards body certified compliance with more than 23,000 mandatory standards to a liberalized framework that opened up to competition the testing and certification for technical regulation and also introduced accreditation.⁴³

Balance. In the third phase, countries typically have achieved comprehensive coverage of public

policy objectives related to quality infrastructure, requiring a shift in their approach to compliance. Instead of relying solely on quality assurance and enforcement by the government, countries should adopt a partnership approach in which the government acts as a “referee” and the private sector, including firms and quality assurance providers, carries out much of the conformity assessment that is needed. For regulated areas, the government focuses on market surveillance using a risk-based approach to verify whether parties are complying with mandatory market requirements like standards—and to issue sanctions when they are not. This method promotes a more agile regulatory process that leverages the respective strengths of both the public and private sectors in implementing standards and enforcing technical regulations.⁴⁴ For example, before Türkiye entered a customs union with the EU in 1995, the country relied heavily on a system of 1,500 mandatory standards, many of which required premarket inspection, testing, and certification

by the Turkish Standards Institution (TSE). By aligning its approach with that of the EU, Türkiye largely transitioned to a system relying on accredited, mostly private conformity assessment bodies and public market surveillance.⁴⁵ In this third phase, quality infrastructure also increasingly supports innovation, which involves giving private sector entities a greater role in standards development, as China and Korea did, as highlighted in spotlight 1.⁴⁶ As a last step, countries integrate their quality infrastructure systems globally through key international institutions that deal with quality infrastructure.

Although the basics–broaden–balance framework focuses on the development of institutions within quality infrastructure systems and the approach to compliance, countries also need to improve the capacity of individual institutions. The World Bank offers resources to help assess the maturity of a country’s quality infrastructure (refer to box 3.3).

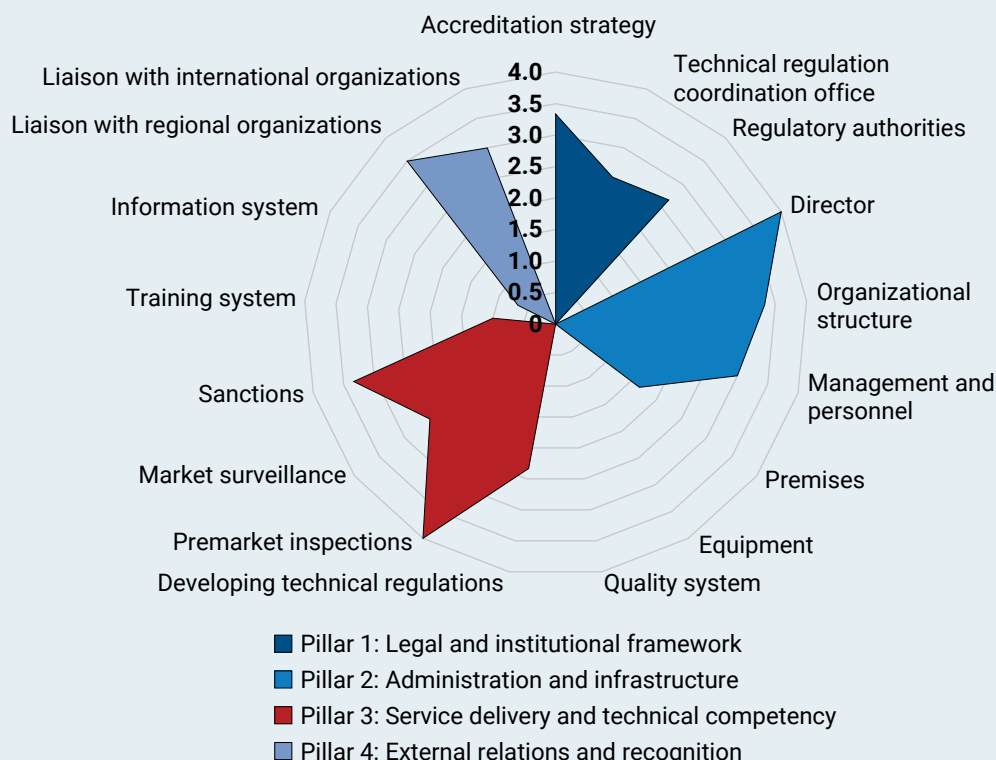
Box 3.3 Assessing the maturity of a country’s quality infrastructure: The Rapid Diagnostic Tool

The World Bank offers a range of publications to guide policy makers in developing effective quality infrastructure systems.^a An additional resource is the Rapid Diagnostic Tool, developed by the World Bank in partnership with Germany’s Physikalisch-Technische Bundesanstalt (PTB, its national metrology institute) in 2019. The first comprehensive tool to help users evaluate a country’s quality infrastructure system, it is based on a standardized questionnaire that assesses each area of a country’s quality infrastructure system across four pillars: legal and institutional framework, administration and infrastructure, service delivery and technical competency, and external relations and recognition. Responses generate scores that can be used to benchmark a country against international best practices, including visualizing its performance within each area through a radar diagram. Figure B3.3.1 shows an example of such a diagram.

(Box continues next page)

Box 3.3 Assessing the maturity of a country's quality infrastructure: The Rapid Diagnostic Tool (*continued*)

Figure B3.3.1 Assessing a country's quality infrastructure: Illustrative result using the Rapid Diagnostic Tool



Source: Kellermann 2019a.

Source: WDR 2025 team.

a. Refer to Guasch et al. (2007); Kellermann (2019a); Racine (2011).

Key trade-offs when developing quality infrastructure systems

Along this basics–broaden–balance trajectory, policy makers in low- and middle-income countries face five key interrelated trade-offs when developing effective quality infrastructure systems:

1. *Division of functions of quality infrastructure:* How can synergies among separate, specialized functions relating to quality infrastructure be utilized while avoiding conflicts of interest?
2. *Balancing the roles of the public and private sectors:* How can market failures be addressed while avoiding distortions and ensuring cost-effectiveness?
3. *Sequencing of reforms to and investments in quality infrastructure:* How can active interventions be balanced with reactive ones?
4. *Balancing the roles of quality infrastructure for effective regulation and competitiveness:* How can regulatory approaches be adapted over time?

5. *International collaboration to share resources in the area of quality infrastructure:* What institutions need to be available in a country, and where does international division of labor make sense?

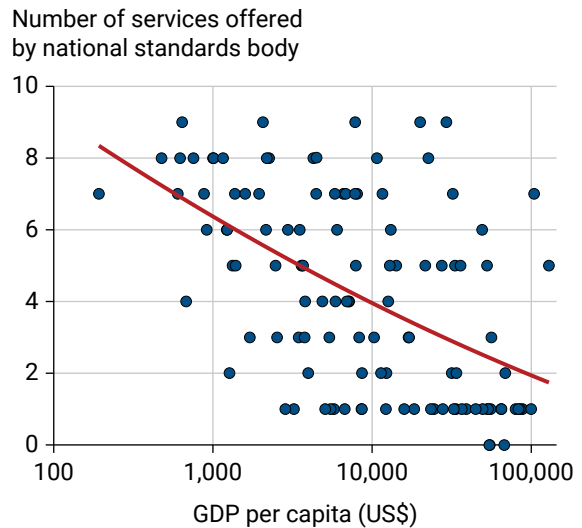
How to resolve these trade-offs shifts over the course of a country's development trajectory. Therefore, there is no single blueprint for developing a quality infrastructure system.

Division of functions of quality infrastructure

A well-functioning quality infrastructure helps address conflicts of interest that limit the effectiveness of standards. In high-income countries, separate, specialized institutions (such as the national standards body, national metrology institute, and national accreditation body) typically carry out different functions pertaining to quality infrastructure. In contrast, resource constraints in low- and middle-income countries often require the consolidation of multiple functions within a single entity. For example, Ethiopia combined all functions relating to quality infrastructure under one umbrella authority until 2010, when it separated the authority into individual entities.⁴⁷ As figure 3.5 shows, at lower levels of country income, national standards bodies are more likely to carry out a wider range of services like metrology, accreditation, and conformity assessment. Such consolidation can undermine credibility or create conflicts of interest if not carefully designed, for example, through financial separation of functions.⁴⁸

A key conflict of interest arises if the same organization conducts both conformity assessment and accreditation. Because accreditation ensures the impartiality of conformity assessment bodies, combining the accreditation and conformity assessment roles undermines trust. For example, a body certifying conformity to a sustainability standard should not also decide which other

Figure 3.5 The number of services offered by national standards bodies falls as countries develop



Source: WDR 2025 team, based on World Bank and ISO 2025.

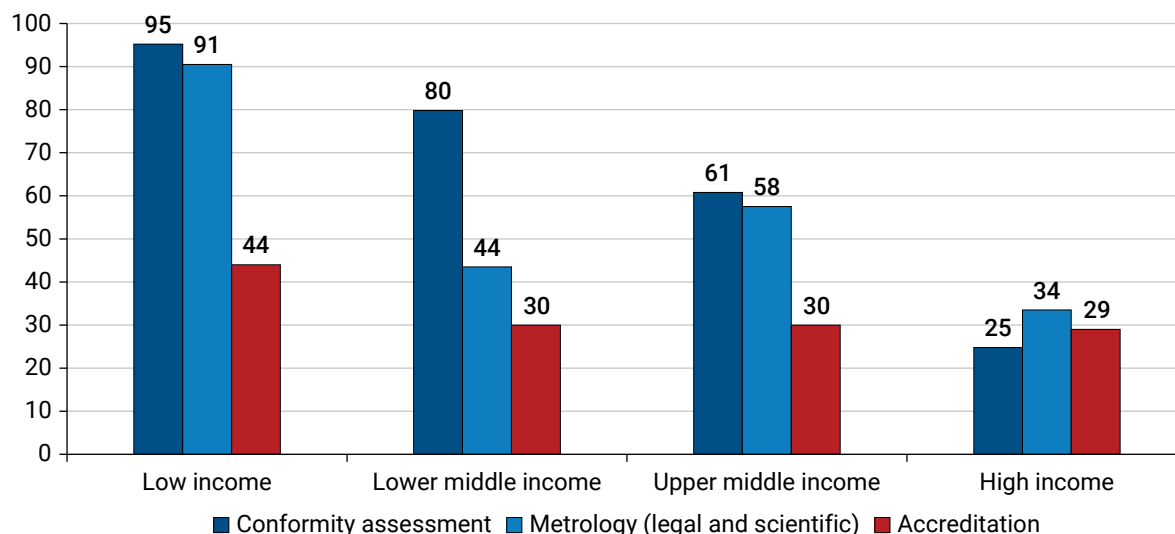
Note: The survey sample includes 116 national standards bodies: 13 in low-income countries, 28 in lower-middle-income countries, 34 in upper-middle-income countries, and 41 in high-income countries.

bodies are qualified to make such certifications: This should be left to an independent accreditor. Bodies providing both conformity assessment and accreditation potentially represent a severe conflict of interest.

Combining standardization with conformity assessment also poses risks and requires safeguards such as organizational and financial separation. A body that sets standards and certifies compliance with them may design requirements to suit its own services. The fact that a standards body's certification arm is part of the standards body may also imply that the services it provides are more "reliable" because they are part of the organization that actually develops the standards against which it is certifying. However, a combined standards and conformity assessment body is common in many low- and middle-income countries. As figure 3.6 shows, 95 percent of national standards bodies in

Figure 3.6 National standards bodies in lower-income countries tend to offer more services relating to quality infrastructure than their peers in higher-income countries

Share of NSBs that offer a given service, 2025 (%)



Source: WDR 2025 team, based on World Bank and ISO 2025.

Note: The survey sample includes 116 national standards bodies (NSBs): 13 in low-income countries, 28 in lower-middle-income countries, 34 in upper-middle-income countries, and 41 in high-income countries. The figure does not show data regarding standards development because of the lack of variation among country income groups in the share of national standards bodies that offer standards development services.

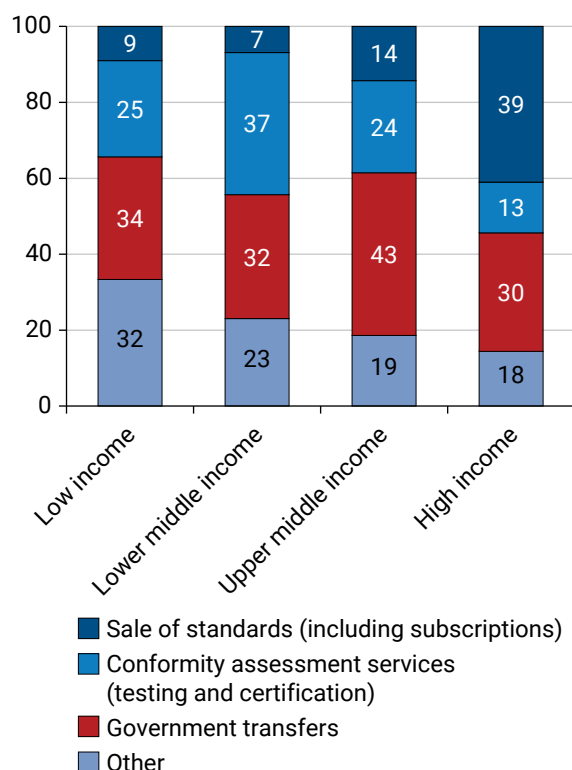
low-income countries and 80 percent of those in lower-middle-income countries are also involved in conformity assessment. The proportions decrease as countries' income levels rise, indicating a differentiation in functions of quality infrastructure over time.

Conflicts of interest may emerge when standards development organizations rely financially on conformity assessment. On average, national standards bodies earn 19 percent of their revenue from conformity assessment, but this amount rises to nearly 40 percent in lower-middle-income countries (refer to figure 3.7). To prevent certification revenues from influencing standards

development, ISO's Good Standardization Practices stipulate that standardization activities need to be independent of other activities such as conformity assessment, which in practice typically means financial and personnel separation (a "fire wall").⁴⁹ However, in low- and middle-income countries, limited resources often require conformity assessment experts to serve roles in national standards development as well. An ISO–World Bank survey of 116 national standards bodies around the world found that 22 of these bodies, mostly in low- and middle-income countries, are involved not only in standards development, but also simultaneously in conformity assessment and accreditation.⁵⁰

Figure 3.7 National standards bodies in lower-middle-income countries are especially dependent on revenues from conformity assessment services

Share of total revenues of national standards body, 2025 (%)



Source: WDR 2025 team, based on World Bank and ISO 2025.

Note: The figure shows revenue sources of national standards bodies as of 2025. The survey sample includes 116 national standards bodies: 13 in low-income countries, 28 in lower-middle-income countries, 34 in upper-middle-income countries, and 41 in high-income countries. "Other" includes revenues from accreditation, metrology, partnerships or donor funding, and training and consulting services. Shares of components within bars may not sum exactly to 100 because of rounding.

The combination of standards development and conformity assessment is also common in regard to private sustainability standards like eco-labels in sectors such as agriculture, forestry, and textiles. These labels often encounter governance issues when the same organization handles both the development of the related standards and

certification of compliance with them. This can create incentives for weaker requirements and lead to the proliferation of standards, because certification generates revenue. Organizations like the ISEAL Alliance have established codes of conduct to increase the credibility of private sustainability schemes by establishing governance requirements. To mitigate governance issues, organizations creating such schemes should use international standards for conformity assessment bodies and the guides established by the ISO Committee on Conformity Assessment (CASCO). This will ensure competence, impartiality, and consistency in certification and auditing.

Cases involving credit-rating agencies and voluntary carbon markets further highlight the importance of avoiding conflicts of interest. Prominent organizations that develop standards for voluntary carbon markets commonly benefit financially from the number of certificates issued while also accrediting the verifiers, leading to serious questions about the organizations' trustworthiness.⁵¹ Similarly, in the lead-up to the 2008 financial crisis, credit-rating agencies were paid by the issuers of the very financial products they were rating, giving the former incentives to underreport risks.⁵² Research in India emphasizes the significance of who pays for audits.⁵³ A field experiment there involving third-party environmental auditors found that when firms paid those auditors directly, the auditors consistently underreported pollution, whereas shifting payments to a central fund and introducing random audits of auditors resulted in more accurate reporting and lower pollution levels.

Balancing the roles of the public and private sectors

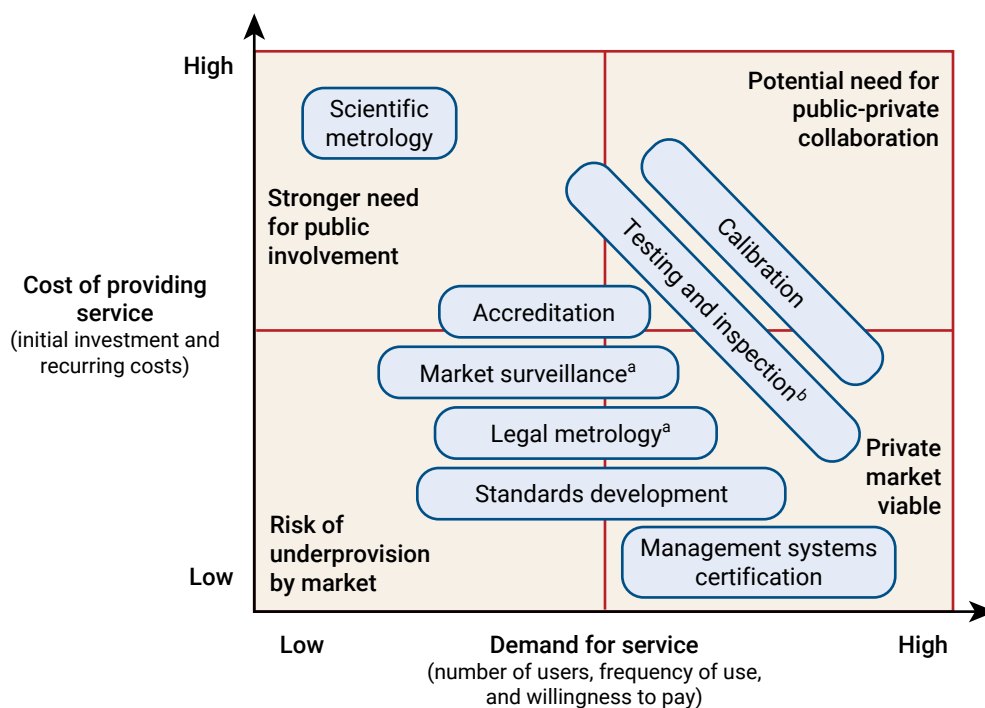
How many functions in a quality infrastructure system should be carried out by the government, by the private sector, or through a public-private partnership? The answer mainly depends on three factors: (1) the cost of providing the service, which

includes initial investment for equipment and staff capacity as well as ongoing expenses; (2) the demand for the service, which is contingent on the number of users, how often they use the service, and their willingness and ability to pay—that is, whether there is sufficient market demand; and (3) whether the function falls within a regulated area under the government’s purview. Some quality assurance functions are public goods that the market would not otherwise supply (for example, research-intensive scientific metrology in niche areas), whereas for others, there is a clear market.⁵⁴

As figure 3.8 illustrates, the costs of providing a particular service in the area of quality infrastructure and the demand for it differ widely. Although specific cost and demand data may vary, a few general patterns emerge.

Scientific metrology. Establishing and maintaining national measurement standards is extremely expensive, with only a few specialized users needing the service. Therefore, governments almost always fund and provide scientific metrology as a public good.

Figure 3.8 The need for government intervention in quality infrastructure changes with the profiles of cost and demand



Source: Adapted from Miesner 2009.

Note: This figure is a simplification. For example, it does not account for the fact that the fixed costs of providing a service would decline with an increase in the number of clients. The effect of volume on per unit costs is an important factor to consider in any specific analysis.

a. Regulated.

b. Sometimes regulated.

Legal metrology. The government ensures that measurements, like weights of goods at markets or amounts of fuel dispensed at gas stations, are accurate and fair. This involves inspecting thousands of devices nationwide, a task involving low cost per device but high total costs. Because compliance is mandatory and not driven by market forces, the state almost always takes responsibility for legal metrology. Some countries outsource routine inspections to private companies, and the government maintains oversight and enforcement responsibilities.

Accreditation. Accreditation involves significant expertise and overhead, with a relatively small number of customers because there are only so many conformity assessment bodies to be accredited. For example, it is estimated that an accreditation body needs revenues from 200–250 accreditations to break even (with each accreditation typically being renewed every four to five years).⁵⁵ Even in a large lower-middle-income country like Kenya, the government covered 80 percent of its accreditation body's budget until recently.⁵⁶

Market surveillance. Market surveillance typically involves considerable costs associated with taking product samples from the market and testing them. Because it concerns regulated areas, it is typically a government responsibility. However, it can be subcontracted to other entities, as is the case in regard to India's compulsory registration scheme for electronic products and information technology equipment.⁵⁷

Calibration. As with legal metrology, many devices in manufacturing plants, hospitals, testing laboratories, and similar settings need regular calibration. Because demand is therefore frequent and widespread, a market for calibration services can flourish. However, such a market still depends on having a sufficiently large industrial base to enable private calibration laboratories to operate profitably.

Standards development. Developing standards involves significant administrative costs, such as organizing technical committees, participating in regional and international forums, publishing standards, and maintaining information portals. Revenue from selling standards does not always cover these expenses, especially in low- and middle-income countries. However, in some high-income countries and specific sectors, the development of standards can be financially sustainable. One among many examples is the United States, with its hundreds of private standards development organizations. It is important to note that even in cases in which a national standards body is a nongovernmental institution, it has typically entered into a legal agreement with the country's government to function as the designated national standards body representing the country in international standards development organizations like ISO, the IEC, and ITU.

Conformity assessment. The most challenging area for which to determine the appropriate level and role of government involvement is conformity assessment. Product testing and inspection as well as management systems certification form the most diverse group of services in the realm of quality infrastructure, with significant variations in costs, demand, and regulation levels. The conformity assessment sector is a vital industry in itself, employing 1.2–1.7 million people globally and generating more than US\$200 billion annually in revenue across 160 countries.⁵⁸ Some specialized conformity assessment services can be costly and are sought by few organizations, whereas others have moderate costs and high market demand, such as routine chemical tests and electrical safety tests. Because of competition and volume, in well-developed quality infrastructure systems, the private sector often efficiently handles the latter type of services. Low- and middle-income countries may need more government intervention initially—for example, because of low market demand and limited regulation—but over time, governments in these countries usually step back

from providing conformity assessment services directly and allow private sector organizations to take over, while keeping and strengthening their own involvement in accreditation.

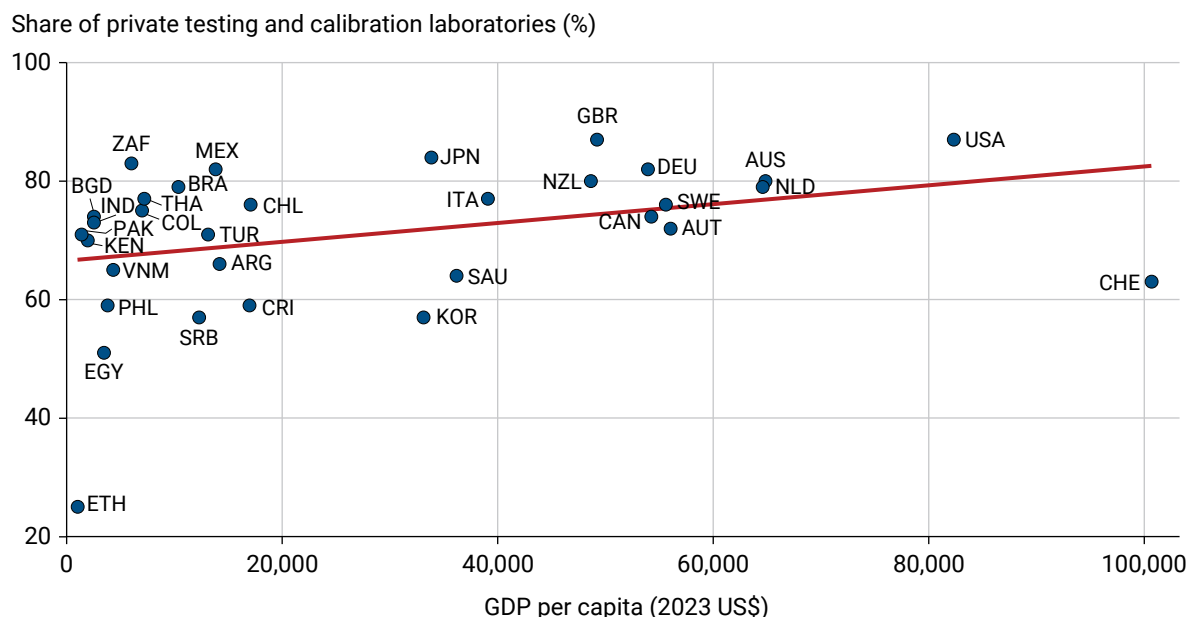
Countries show large differences regarding whether the government or the private sector operates testing and calibration laboratories. As figure 3.9 shows, across 32 countries assessed, higher-income countries tend to have a larger share of private laboratories across all accredited testing and calibration bodies. Overall, the government has a strong presence in the market for conformity assessment services, particularly in low- and middle-income countries.

Conformity assessment services that require expensive laboratories may need more government involvement. In contrast, management system certifications like those for ISO 9001

(quality), ISO 50001 (energy), and ISO/IEC 27001 (information security) primarily depend on the availability of competent auditors, not laboratory facilities. Because these services are universally applicable to many types of organizations, the potential market demand for them is substantial. They can thus be provided on commercial terms.

As countries develop, the demand for services in the area of quality infrastructure increases, shifting the roles of the public and private sectors in providing these services. As figure 3.10 shows, this particularly affects standards development and testing, inspection, and certification services, which are more likely to be provided by the government in early phases and then transition to the private sector. There is much less of a shift toward private provision in the areas of accreditation and metrology. Government provision tends to prevail for these areas in most cases.

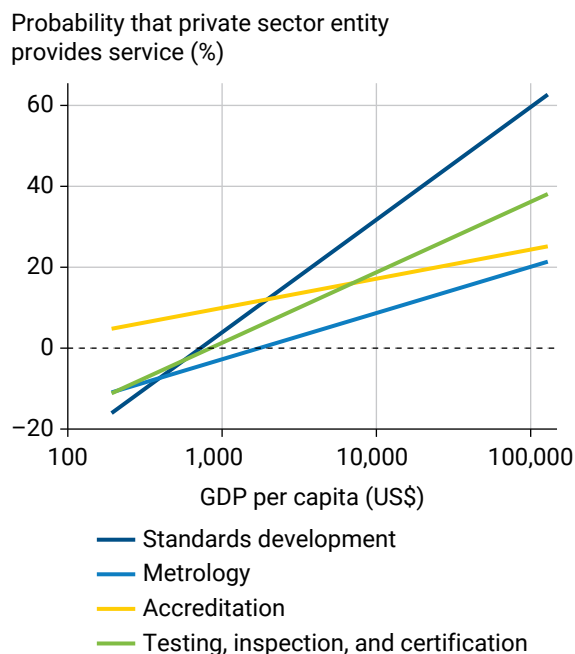
Figure 3.9 The share of private sector laboratories for testing and calibration increases as countries develop



Sources: WDR 2025 team analysis, based on data from national accreditation bodies.

Note: The data show national laboratories accredited to International Organization for Standardization (ISO)/International Electrotechnical Commission (IEC) 17025 (general requirements for the competence of testing and calibration laboratories). Each accredited facility in a country is counted as one laboratory, even if multiple accredited facilities belong to the same firm. For the country labels used in the figure, refer to ISO, <https://www.iso.org/obp/ui/#search> (select "country codes").

Figure 3.10 The share of private institutions that provide services in the area of quality infrastructure increases as countries develop



Source: WDR 2025 team, based on World Bank and ISO 2025.

Note: The figure underestimates the extent to which the private sector provides services in the areas of testing, inspection, and certification because it relies on data from a survey of national standards bodies. The private sector typically accounts for more than 60 percent of accredited testing and calibration laboratories in countries with higher income levels. The survey sample includes 116 national standards bodies: 13 in low-income countries, 28 in lower-middle-income countries, 34 in upper-middle-income countries, and 41 in high-income countries. If the national standards body in a country is classified as private and offers a particular service, it is included in the percentage of private sector entities providing the service.

Coordination or competition among institutions that deal with quality infrastructure. The question of public versus private roles in quality infrastructure is closely linked to whether services should be coordinated or offered by competing institutions, an issue shaped by political traditions and historical path dependencies. For example, in the

United States, numerous accreditation bodies compete with one another, whereas the European Union permits only one accreditation body per member country. The European Union regards accreditation as a function of public authority that supports the operation of the single market and considers competition among accreditation bodies to be risky because of concerns about a “race to the bottom.” The United States, on the other hand, views competition among accreditation bodies as a strength, with trust upheld through market discipline and international recognition. Similarly, in the United States, hundreds of standards development organizations operate in parallel, with some coordination by the American National Standards Institute (ANSI). In India, the Bureau of Indian Standards has introduced a scheme for recognizing standards development organizations to introduce more flexibility, but such organizations remain coordinated through the national standards body.⁵⁹ Although China’s quality infrastructure system is highly centralized and state led, market-driven association and enterprise standards are encouraged, but they remain under the supervision of the State Administration for Market Regulation (SAMR).⁶⁰ Ultimately, whereas competition among accreditation and standards bodies may work in some contexts like that in the United States, in low- and middle-income countries with lower demand for quality, weaker institutional capacity, and nascent markets, this type of model may be less effective or even potentially harmful.

Different approaches to competition versus coordination among institutions that deal with quality infrastructure mainly concern accreditation and standards development. In regard to metrology specifically, there is widespread agreement on the need for a single national institution because of the low commercial viability of metrology and the importance of international coordination in maintaining traceable measurements. Similarly, there is consensus that most conformity assessment

and calibration services can be left to competition among providers, as long as they all follow the same standards and have the same oversight, such as through accreditation. Similarly, no matter which body carries out accreditation, it should follow international standards for accreditation, as defined in ISO/IEC 17000, which underpins a well-functioning quality infrastructure.

Sequencing of reforms to and investments in quality infrastructure

How should low- and middle-income countries sequence development of the various elements of quality infrastructure amid scarce resources? Because quality infrastructure must function as a coherent system, its weakest link limits its effectiveness. For example, testing laboratories cannot operate reliably without access to calibrated instruments and reference materials from metrology institutes. Logical sequencing is therefore essential: Metrology underpins standards, which in turn enable testing and certification. Therefore, the basics–broaden–balance framework recommends strengthening the core functions of metrology, standards development, and conformity assessment first; accreditation follows later.

Some capacities that quality infrastructure must have are widely applicable across sectors (such as reference weights or temperature calibration), whereas others are specific to particular industries (such as testing for pesticide residues in agriculture or calibration of clean rooms in pharmaceuticals). The policy challenge is in developing both sets of capabilities: cross-cutting foundational functions and specialized capabilities in priority sectors. As economies grow, the demand for quality infrastructure services increases and diversifies. In the initial stages, needs usually include standards for food safety and construction materials as well as basic electrical standards. Over time, more advanced requirements surface, such as precision metrology for

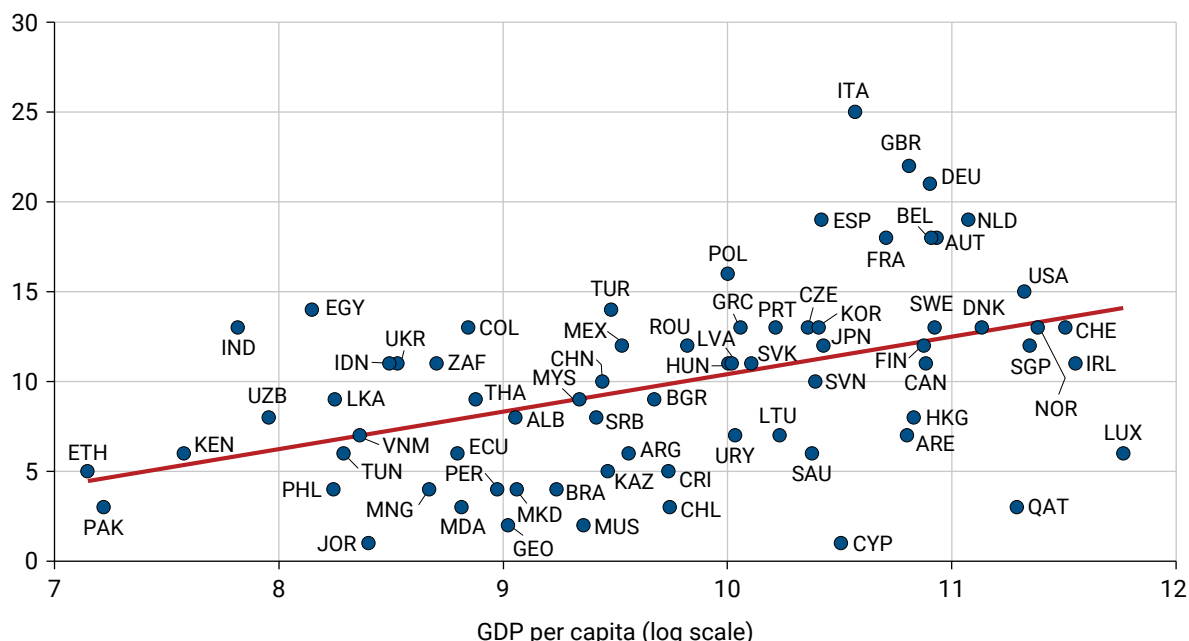
advanced manufacturing or certification for emissions of greenhouse gases. This changing demand necessitates not only expanding systems, but also upgrading capacities to provide higher-quality services. As figure 3.11 illustrates, national accreditation bodies in higher-income economies are therefore signatories to a broader range of certification areas under the IAF's Multilateral Recognition Arrangement.

There is no blueprint for sequencing. The right approach depends on national priorities, economic structure, and institutional readiness. The case of Korea, presented in spotlight 1, illustrates how a country's quality infrastructure evolves alongside its industrial development. In the early stages of development of Korea's quality infrastructure, export inspections and preferential treatment for certified products supported the growth of light manufacturing. As the country's economy shifted toward heavy and chemical industries in the 1970s and 1980s, more advanced metrology capabilities became essential.⁶¹ Later, the rise of technology-intensive electronics required a greater role for industry-driven development of standards and the strengthening of accreditation systems to ensure internationally recognized testing and certification.

As with industrial policy, governments must carefully balance active and reactive strategies when developing quality infrastructure (refer to figure 3.12). An active approach is needed to address market failures and coordination gaps, for instance, when firms do not demand quality assurance services because those services are not yet available, and providers do not offer them as a result of insufficient demand. Dilemmas of this type can trap markets in low-quality equilibriums. In such cases, government intervention (such as awareness campaigns, subsidies, or government provision of quality assurance) can help stimulate uptake. In contrast, a reactive approach delays investment until demand is clearly signaled, often

Figure 3.11 The scope of certification is greater among national accreditation bodies in higher-income economies

Number of standards for which a national accreditation body is internationally recognized



Source: WDR 2025 team, based on data from the International Accreditation Forum.

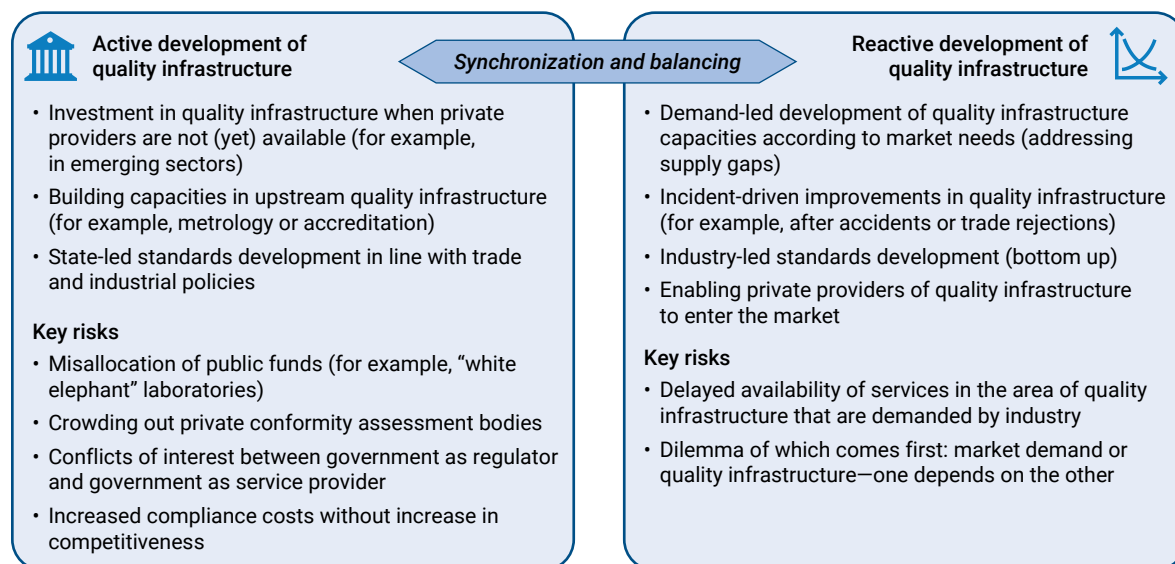
Note: The figure shows the scope of certification services to which national accreditation bodies are signatory under the Multilateral Recognition Arrangement of the International Accreditation Forum (IAF). If a national accreditation body that is a member of this arrangement accredits a certification body under a given scope, that accreditation can be recognized by other countries internationally. For example, a national accreditation body's scope might include that its accreditation of conformity assessment bodies in the area of systems for managing food safety (International Organization for Standardization [ISO] 22000) is internationally recognized. The sample includes 71 economies. For the economy labels used in the figure, refer to ISO, <https://www.iso.org/obp/ui/#search> (select "country codes").

following consumer complaints, safety failures, or export rejections. Moreover, a reactive approach may leave exporting and innovative companies no other choice but to rely on foreign conformity assessment bodies, potentially creating a path dependency, because it may be difficult for local conformity assessment bodies, once they develop, to get a share of the market at a later stage.

Both the active and reactive approaches involve trade-offs. If the government invests in public laboratories that are poorly aligned with industry needs, it creates "white elephant" facilities that

are underused and expensive to maintain. These often fall into disuse on account of lack of funding for consumables, spare parts, and similar items. Importantly, a strong government role in providing services in the area of conformity assessment risks crowding out private providers of such services. As a rule of thumb, it is better for governments to give demand-side support to firms to enable them to access conformity assessment services provided by private bodies (for example, through certification vouchers), rather than for governments to invest in providing conformity assessment services themselves.⁶²

Figure 3.12 Active and reactive development of quality infrastructure should be synchronized and balanced



Source: WDR 2025 team.

A reactive investment strategy, in which infrastructure is developed only after demand for it becomes clear, risks unavailability of services when firms initially need them, such as when they enter or attempt to enter export markets, which can delay growth and innovation. Additionally, core functions of quality infrastructure like metrology and accreditation might stay underdeveloped because their value is systemic and not directly reflected in market signals, increasing the risk of delays in providing them. Likewise, without targeted government support to build foundational capacity, both the supply of and demand for quality infrastructure can become trapped in a low-level equilibrium.⁶³

In short, sequencing reforms to quality infrastructure systems requires an iterative approach aligned with the maturity of public and private institutions, market conditions, and national priorities regarding development. To better bridge the demand and supply sides, public-private dialogue is essential, consistent with “new industrial policy” discourse.⁶⁴ Only through such dialogue

can sector-specific needs be recognized. Box 3.4 shows how different countries have adopted various paths for developing their quality infrastructure systems, ranging from an approach driven by industrial policy in Korea to a method more focused on regulation in Brazil to donor-supported upgrades to quality infrastructure in Ethiopia.

Balancing the roles of quality infrastructure for effective regulation and competitiveness

As discussed, quality infrastructure serves a dual function: ensuring competitiveness of industries and public enforcement. Although these goals may not be inherently in conflict,⁶⁵ effectively using quality infrastructure to advance both objectives requires a careful balance.

In general, standards aimed at boosting competitiveness should remain voluntary and be shaped by industry demand. In contrast, standards cited in technical regulations are typically used to achieve public policy goals such as health, safety,

Box 3.4 Quality infrastructure systems at different levels of economic development in the Republic of Korea, Brazil, and Ethiopia

The *Republic of Korea's* development of quality infrastructure is widely regarded as a model of successful catch-up industrialization, marked by strong state leadership, phased institutional development, and responsiveness to economic priorities.^a The country made metrology a priority early in its process of developing a quality infrastructure system, joining the Treaty of the Metre in 1959^b and establishing the Korea Research Institute of Standards and Science (KRISS) in 1975.^c In later phases it put in place standards and accreditation bodies such as the Korean Agency for Technology and Standards (KATS, 1983), Korean Laboratory Accreditation Scheme (KOLAS, 1992), and Korea Accreditation Board (KAB, 1995). In line with the industrial policies of the 1970s and 1980s, metrology responded to the need for accurate measurements in fields like chemicals and heavy industry. In the late 1990s, policy shifted to support small and medium enterprises, leading to targeted programs and local outreach by agencies like KRISS and the Korea Testing Laboratory. Since the 2000s, Korea has become an active participant in international standards development organizations, such as the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC), with its quality infrastructure evolving to meet the demands of advanced sectors like information technology and biotechnology. Overall, Korea's experience demonstrates how developing a quality infrastructure system often aligns with a country's broader industrial policies.

Brazil has a long experience in setting up quality infrastructure and was one of the first signatories to the Treaty of the Metre.^d However, its development of quality infrastructure was repeatedly interrupted, requiring efforts to be revisited and renewed over time. Unlike Korea, whose industrial policy regime motivated development of its quality infrastructure, regulation heavily drove development of Brazil's quality infrastructure, with an emphasis on consumer protection and compliance with national technical regulations, in addition to industrial development. This model helped consolidate multiple functions of quality infrastructure within the country's National Institute of Metrology, Standardization, and Industrial Quality (INMETRO). The resulting integrated, regulation-centered structure has enabled Brazil to build a strong and centralized quality infrastructure system. Although challenges like regulatory overlap, regional disparities in service coverage, and institutional stability still exist, Brazil's quality infrastructure is among the most advanced in Latin America.

In *Ethiopia*, the origins of quality infrastructure date to the 1950s. A major step was consolidating all functions related to quality infrastructure under one umbrella with the creation of the Quality and Standards Authority of Ethiopia (QSAE) in 1998. In 2010, Ethiopia moved toward international best practices by dividing the authority into four specialized institutions, one each for standardization, metrology, accreditation, and conformity assessment. Development partners have provided considerable support for the establishment of these

(Box continues next page)

Box 3.4 Quality infrastructure systems at different levels of economic development in the Republic of Korea, Brazil, and Ethiopia (continued)

institutions, including a project funded by the World Bank. Over the last 10–15 years, the technical capacity of these institutions has increased significantly through, among other things, upgraded equipment, the development of human resources, and stakeholder engagement. Ethiopia's experience shows that during earlier stages of development of quality infrastructure, government may play a greater role in providing conformity assessment services. The state-owned Ethiopian Conformity Assessment Enterprise (ECAE) offers services at subsidized rates, which supports firms' compliance but also limits the entry of private providers of quality assurance services, which have not yet developed in the country.

Source: Harmes-Liedtke et al. 2025.

Note: Harmes-Liedtke et al. (2025), a background paper prepared for *World Development Report 2025*, includes other country case studies.

- a. Refer to Korea's ODA (website), Ministry of Foreign Affairs, Republic of Korea (accessed May 9, 2025), https://www.mofa.go.kr/eng/wpge/m_5447/contents.do; Seo et al. (2013).
- b. Yoo (2019).
- c. Choi (2013).
- d. Harmes-Liedtke (2021a).

or environmental protection. Although there is greater certainty that technical regulations will achieve their objectives than that voluntary approaches will, the former carry risks like stifling innovation, raising compliance costs for firms, and imposing costs associated with enforcement on the government. Research shows that particularly in uncertain markets, such as those characterized by lack of technological maturity or volatile demand, voluntary standards outperform regulations in terms of innovation efficiency, because they provide flexibility and adaptability without locking firms into rigid requirements for compliance.⁶⁶ To use quality infrastructure effectively for regulation, policy makers should apply a risk-based approach to navigate the trade-offs involved in voluntary and regulatory methods.

Two key factors should guide the choice of the appropriate approach to compliance: (1) the level of risk, defined by the likelihood and potential severity of harm to consumers, the environment, or society; and (2) the probability of noncompliance, which is closely tied to both the capacity of the private sector to comply and that of the government to monitor and enforce requirements.⁶⁷ Although risk and the likelihood of noncompliance are often correlated, they are not always the same. Some sectors may have high potential for harm but low probability of noncompliance with standards and regulations, in particular, those in which firms have strong commercial incentives to comply because failure to do so would pose significant business or reputational risks. Moreover, risk preferences of society and policy makers may

influence the appropriate approach to compliance; for example, a country may be willing to tolerate higher levels of pollution than international standards might dictate.⁶⁸

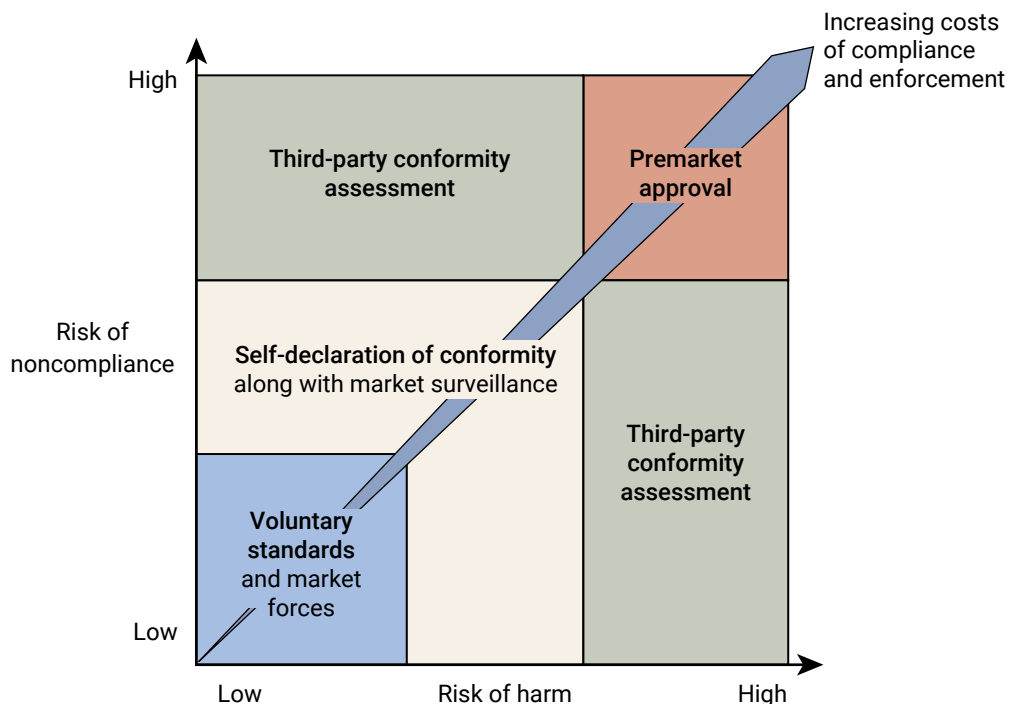
Depending on these two factors, four different approaches can be differentiated, as illustrated in figure 3.13:

- *Voluntary standards and market forces* (illustrated in blue in figure 3.13). Controlling the quality of products presenting a low risk of harm such as (nonprotective) clothing, nonelectric household items (such as brooms), and stationery (paper, pens, and so on) can typically be left to voluntary, industry-driven standards and conformity assessment, with no government involvement. In these cases, market forces,

consumer pressure, and reputation are often sufficient to drive quality.

- *Self-declaration of conformity along with market surveillance* (illustrated in ivory in figure 3.13). For areas with low to medium risks of harm, such as certain electronic products and nonstructural construction materials, governments may put regulations in place and allow firms to self-declare their compliance with the regulations. Companies will likely voluntarily use third-party conformity assessment or internal production control to mitigate the risk of noncompliance.⁶⁹ Such an approach reduces compliance burdens and leverages industry responsibility, provided it is paired with effective market surveillance (the government serves as a referee).

Figure 3.13 Risk-based approaches to compliance



Source: WDR 2025 team, adapted from data from ISO [International Organization for Standardization]/CASCO: Committee on Conformity Assessment (dashboard), <https://www.iso.org/committee/54998.html>.

Note: "Third-party conformity assessment" appears twice in the figure, as it may be needed either because of high risk of noncompliance or high risk of harm.

- *Third-party conformity assessment* (illustrated in green in figure 3.13). For products that present risks of harm that are too high (such as electrical safety and children's toys) or noncompliance too likely to permit self-declaration of compliance, regulators may mandate third-party conformity assessment before products are placed on the market. This still requires some form of market surveillance, but surveillance is not as essential as in the case of self-declaration of conformity.
- *Premarket approval* (illustrated in rust in figure 3.13). In high-risk sectors (such as medical devices, pharmaceuticals, or aerospace), regulatory systems often require stringent premarket controls. These typically include third-party testing, inspection, or certification, followed by formal regulatory clearance by a competent authority, such as the US Food and Drug Administration (FDA) or EU Aviation Safety Agency (EASA), before a product can be placed on the market. Premarket approval is designed to prevent harm in cases in which failures in quality or safety could have severe consequences and are difficult to detect or mitigate after a product is in circulation.

Low- and middle-income countries generally face a higher risk of noncompliance as a result of limited firm capabilities and weak legal enforceability of regulations. Informal firms in these countries are more prone to evade sanctions and have less ability to comply with regulatory or voluntary requirements. Similarly, governments in low- and middle-income countries often lack the capacity to operate effective systems for post-market surveillance. Consequently, it is often

advisable for low- and middle-income countries to depend initially more on third-party conformity assessments or premarket controls than on firms' self-declarations of conformity. However, premarket controls tend to impose greater burdens on industry and more expense on the government. Therefore, as a country's capacity grows, it becomes more justifiable for it to shift toward more flexible, postmarket systems that employ supplier declarations, market surveillance, and risk-based inspections.⁷⁰

To address capacity constraints, low- and middle-income countries may need to implement second-best enforcement strategies and increase their use of digital tools in assessing compliance. For example, nongovernmental organizations can help inform consumers about nonconformities with applicable standards, and public digital registries can increase transparency by sharing risk-related information. A growing array of digital solutions are improving the effectiveness of quality infrastructure, especially that for risk management, as discussed in box 3.5. In Pakistan, an experiment demonstrated that providing government health inspectors with a smartphone application for sending geo-stamped reports on rural clinics to senior policy makers increased the frequency of inspections.⁷¹

International collaboration to share resources in the area of quality infrastructure

Not all services related to quality infrastructure need to be available domestically to serve the needs of local firms. In many cases, firms routinely send product samples abroad for testing, particularly when international buyers require certification from globally recognized conformity

Box 3.5 Leveraging digital tools for quality infrastructure

A variety of digital tools can greatly improve the effectiveness, reach, and efficiency of quality infrastructure. For example, remote audits can reduce assessment costs, and machine-readable standards can be integrated into companies' operations more smoothly. Digital systems for traceability like the European Union's Digital Product Passport can assist in verifying compliance and managing risks in supply chains. Similarly, digital certificates for calibration and automated data logging enhance the reliability and efficiency of metrology and testing services. Market surveillance can also benefit from employing digital tools, for instance, using online reviews and social media content to better target unsafe products. For low- and middle-income countries, digital tools can help overcome limitations in capacity and those imposed by geography by, for example, enabling virtual training for laboratory staff or remote conformity assessment in areas that are difficult to reach. Although digital tools in quality infrastructure require investments in digital infrastructure, they can make processes more agile and cost-effective (refer to spotlight 5).

Source: WDR 2025 team.

assessment bodies. This is often an efficient and commercially sensible approach. However, reliance on foreign laboratories can create challenges when testing is time sensitive or logistics make it impractical, especially in the cases of perishable goods or bulk commodities traded on short timelines. But such considerations need to be assessed on a case-by-case basis before policy makers take steps to provide incentives to make services relating to quality infrastructure locally available.

For many low- and middle-income and small countries, regional or bilateral cooperation offers a cost-effective alternative, particularly for expensive and specialized services like accreditation and

scientific metrology.⁷² Joint investments (such as regional reference laboratories or designated national responsibilities) can ensure traceability to international standards like the International System of Units, as illustrated by examples from the Caribbean and Southern Africa discussed in box 3.6. However, political, financial, and logistical barriers frequently hinder effective collaboration, with many governments preferring domestic control over shared efficiency. When cooperation is viable, it may take forms such as bilateral service agreements or jointly funded regional facilities, but even with outsourcing, governments must retain sufficient technical expertise to manage and oversee external services. Figure 3.14 presents a decision tree that can offer guidance.

Box 3.6 Sharing resources related to quality infrastructure among countries in the Caribbean and Southern Africa

Testing energy efficiency in the Caribbean

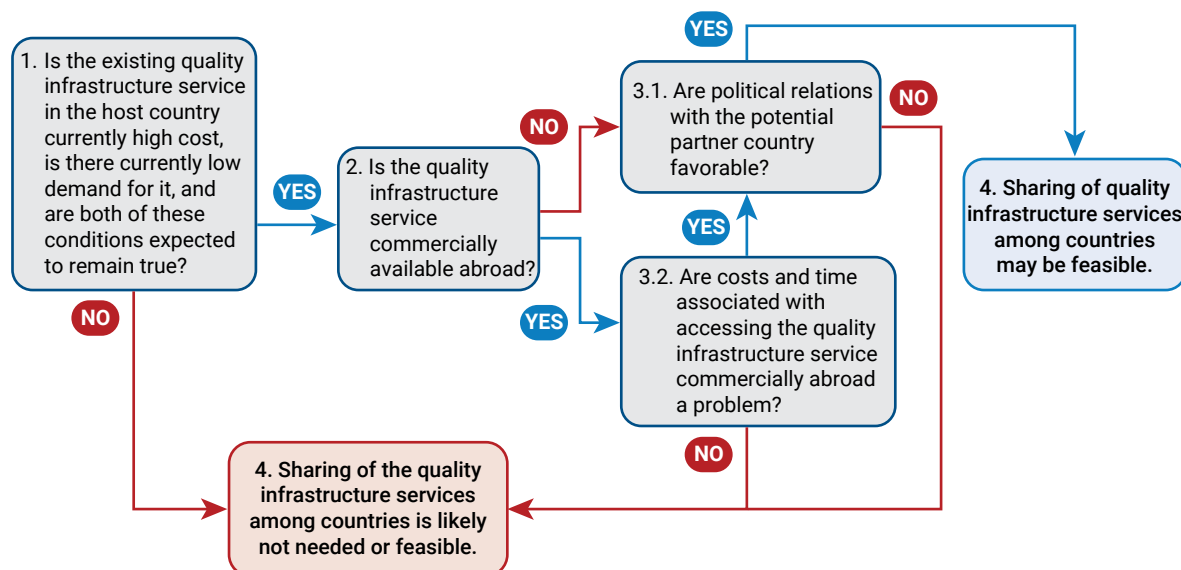
Many small island countries in the Caribbean lack the scale needed to establish cost-effective infrastructure to test the energy efficiency of appliances and equipment. Two institutions providing such infrastructure help address the region's specific challenges: the Energy Efficient Lighting Laboratory of the Trinidad and Tobago Bureau of Standards (TTBS) and the Cooling Laboratory of the Bureau of Standards Jamaica (BSJ). Each of these laboratories provides accredited testing services for different types of electric appliances to members of the Caribbean Community and beyond. A key factor in their success is that the region's program for energy efficiency labeling is coordinated at the regional level by a well-established institution, the Caribbean Community (CARICOM) Regional Organisation for Standards and Quality (CROSQ). This organization offers ongoing support to member states in developing energy efficiency standards, raising awareness of standards, and sharing results of testing through a centralized database.

Southern Africa: Regional accreditation body

When trade agreements among the member countries of the Southern African Development Community (SADC) took effect, only 2 out of 16 member countries had national accreditation bodies on account of the high fixed costs of setting up such institutions. This created a challenge in ensuring competent and mutually recognized conformity assessment across the region. Through the pooling of resources from the remaining 14 member states, the Southern African Development Community Accreditation Service (SADCAS) was established as the world's first regional, multi-economy accreditation body for verifying the competencies of conformity assessment bodies in participating countries. A key factor in this service's success has been sharing qualified assessors and technical experts. Using only 21 full-time staff but having access to nearly 100 experts in the region, SADCAS is capable of meeting the accreditation needs of the entire SADC region with support from its National Accreditation Focal Points located in member states.

Source: Physikalisch-Technische Bundesanstalt (PAB), as an input to *World Development Report 2025*.

Figure 3.14 Decision tree for assessing the feasibility of sharing resources related to quality infrastructure between countries



Source: WDR 2025 team, in collaboration with Physikalisch-Technische Bundesanstalt.

Conclusion

Quality infrastructure is often overlooked, yet it quietly supports the effective functioning of economies and governments, from enabling exports and protecting consumers to fostering innovation and environmental sustainability. For low- and middle-income countries, strengthening quality infrastructure is not just about building laboratories or metrology institutes, it is also about establishing credible institutions that can support development. That is why this Report emphasizes that the functions and principles of

quality infrastructure have universal relevance. The ambition of standards must be raised along with the capacity to comply with them. Quality infrastructure is vital to this effort, ensuring that higher standards are not only set but also met. As this chapter has highlighted, quality infrastructure is an adaptive system in public-private partnership that must evolve as countries develop. Such an evolution includes defining the types of services needed within the country, how public and private roles should shift over time, and how quality infrastructure can be effectively integrated into public policy.

Notes

1. The International Network on Quality Infrastructure (InetQI) has established the following definition of quality infrastructure: "The system comprising the organizations (public and private) together with the policies, relevant legal and regulatory framework, and practices needed to support and enhance the quality, safety and environmental soundness of goods, services and processes" (Quality Infrastructure Definition [web page],

International Network on Quality Infrastructure, <https://www.inetqi.net/documentation/quality-infrastructure-definition/>). InetQI brings together all specialized organizations that operate at an international level and are active in promoting and implementing activities related to quality infrastructure (metrology, standardization, conformity assessment, and accreditation) as a tool for sustainable economic development. For details, refer

- to INetQI: International Network on Quality Infrastructure (home page), <https://www.inetqi.net/>.
2. The Quality Infrastructure Investment (QII) Partnership, implemented by the World Bank with funds from the government of Japan, is not related to quality infrastructure as defined in this Report. The partnership aims to raise awareness of the quality dimensions of physical infrastructure. Refer to Quality Infrastructure Investment Partnership (home page), World Bank, <https://www.worldbank.org/en/programs/quality-infrastructure-investment-partnership>.
 3. As defined by ISO and IEC (2020).
 4. BIPM (2021, 7).
 5. Calibration is generally classified under metrology services, not as a conformity assessment activity. However, it can become part of a process for conformity assessment if it is performed to demonstrate that measurement equipment meets specified requirements (for example, if an accredited laboratory issues a calibration certificate that is recognized in trade or regulation). This Report therefore lists calibration under conformity assessment services.
 6. Market surveillance by regulatory authorities differs from the activities of conformity assessment bodies that conduct regular audits and inspections after completion of their assessments to ensure continued compliance.
 7. Guasch et al. 2007; UNIDO 2018a. The term “quality infrastructure” emerged as a comprehensive concept only in the late 1990s and early 2000s, but its components have been recognized and discussed separately for a longer time (Harmes-Liedtke et al. 2025). Before the term was coined, engagements either focused on individual elements of quality infrastructure or used abbreviations such as MSTQ (metrology, standardization, testing, and quality) and SQAM (standardization, quality assurance, and metrology).
 8. Harmes-Liedtke et al. (2025).
 9. Kellermann (2019a).
 10. Refer also to Blind et al. (2025); Kellermann (2019a); Racine (2011).
 11. WTO (2016).
 12. Rab and Brown (2023).
 13. Manders (2014).
 14. Moreover, quality infrastructure can also be understood as a separate economic sector or high-tech cluster. This sector employs highly qualified personnel and provides corresponding jobs.
 15. OECD (2025).
 16. World Bank (2024).
 17. The vision of “One standard, one test, accepted everywhere” has been published in different variations by different organizations, such as the European Committee for Standardization (CEN) and the European Committee for Electrotechnical Standardization (CENELEC). Refer to European Standardization: CEN and CENELEC (dashboard), European Committee for Standardization and European Committee for Electrotechnical Standardization, <https://www.cencenelec.eu/european-standardization/cen-and-cenelec/>. For example, it also was the theme of the International Organization for Standardization’s World Standards Day in 2002 (ISO 2002).
 18. Through the ISO Committee on Conformity Assessment (CASCO), ISO and the IEC have developed the ISO/IEC 17000 series of standards, which specify requirements for the competence, consistency, and impartiality of conformity assessment bodies and accreditation bodies. These documents are commonly known as the “CASCO toolbox.” Using them fosters international compatibility among conformity assessment bodies and accreditation bodies and reduces technical barriers to trade. The World Trade Organization (WTO) and its Agreement on Technical Barriers to Trade formally recognize this role. For more information, refer to CASCO Toolbox (dashboard), Committee on Conformity Assessment, International Organization for Standardization, <https://casco.iso.org/toolbox.html>.
 19. In practice, national legislation may supersede a mutual recognition arrangement based on accreditation: for example, if a regulator requires an entity to have additional recognition from conformity assessment bodies in order to conduct testing or certification in regulated areas. Accreditation is only the attestation of technical competence to conduct a conformity assessment, not an authorization for conducting assessments in regulated areas. Refer also to BMWi (2021).
 20. For further discussion, refer to UNIDO and PTB (2024).
 21. Harmes-Liedtke et al. (2025); Lee and Kim (2025).
 22. The literature review by Blind et al. (2025) focuses on the term “quality infrastructure” and does not include the elements of quality infrastructure separately, which would have increased the number of articles substantially.
 23. Refer, for example, to Blind et al. (2011).
 24. de Vries et al. (2012).
 25. Mirtsch et al. (2021).
 26. Aba et al. (2015); Castka and Corbett (2015); Manders (2014); Sfreddo et al. (2021).
 27. Clougherty and Grajek (2023); Manders et al. (2016).
 28. Boiral et al. (2018); Nemati et al. (2019).
 29. Arocena et al. (2021); Treacy et al. (2019); Wiegmann et al. (2023).
 30. de Vries et al. (2012).
 31. Blind et al. (2025).
 32. Frenz and Lambert (2014); Ramkissoon and Nisi (2024); Swann (2009).
 33. Clougherty and Grajek (2008, 2023); Potoski and Prakash (2009).
 34. Blind et al. (2018).
 35. Du et al. (2025).
 36. Choudhary et al. (2013); refer also to Birch (2003).
 37. Although calibration is mentioned under metrology here, it is also a type of conformity assessment. Refer to note 5.
 38. Harmes-Liedtke and Oteiza Di Matteo (2011).

39. These three phases also align with the four maturity levels of quality infrastructure distinguished by Kellerman (2019a): rudimentary, basic, advanced, and mature. The simplified framework presented here mainly merges the rudimentary and basic levels.
40. Kaul (2025).
41. Harmes-Liedtke et al. (2025).
42. ILAC and the IAF will form a new organization, the Global Accreditation Cooperation Incorporated, in January 2026 (refer to “Global Accreditation Cooperation Incorporated Is Registered in New Zealand,” ILAC, December 6, 2024, https://ilac.org/latest_ilac_news/global-accreditation-cooperation-incorporated-is-registered-in-new-zealand/).
43. Kellermann (2019b).
44. OECD (2025).
45. Kellermann (2019b).
46. Kellermann (2019a). Reflecting these shifts, responsibility for quality infrastructure often transitions from ministries of science and technology, in the early stages, to ministries of trade or economy, which are typically better positioned to engage with the private sector.
47. Harmes-Liedtke et al. (2025).
48. Refer to de Vries (1999); Kellermann (2019a); OECD (2018); UNIDO (2018b).
49. ISO (2019).
50. World Bank and ISO (2025).
51. Battocletti et al. (2023).
52. Bush (2022).
53. Duflo et al. (2013).
54. An example is management system certification, such as that under the popular standard ISO 9001.
55. Kellermann and Keller (2015).
56. Harmes-Liedtke (2021b).
57. Kaul (2025).
58. Refer to What Is the TIC Sector? (web page with media), TIC Council (accessed April 25, 2025), <https://www.tic-council.org/about-us/what-is-the-tic-sector>.
59. Kaul (2025).
60. Gong and Zhang (2025).
61. Lee and Kim (2025).
62. Kellermann (2019a).
63. It therefore is common practice for development partners to support both the supply and demand sides for quality infrastructure. For example, the Global Quality and Standards Programme implemented by the United Nations Industrial Development Organization (UNIDO) and funded by the Swiss government follows such an integrated approach, strengthening quality infrastructure institutions (supply), enhancing private sector capacities for compliance (demand), and promoting a quality culture to strengthen the links between supply and demand.
64. Juhász et al. (2023); Rodrik (2022).
65. Refer to Porter and van der Linde (1995).
66. Blind et al. (2017).
67. ISO (2012, 2023); OECD (2018).
68. Risk preferences are also affected by the extent of people’s awareness of risks. With greater awareness, people may opt for lower risk preference.
69. A hybrid approach combining self-declaration of conformity with mandatory third-party assessment is also possible. For example, under the European Union’s CE marking framework, legislation may require an economic operator to undergo third-party conformity assessment by an authorized body before issuing a manufacturer’s declaration of conformity.
70. BMWi (2021); UNIDO (2018b).
71. Callen et al. (2020).
72. Miesner (2009).

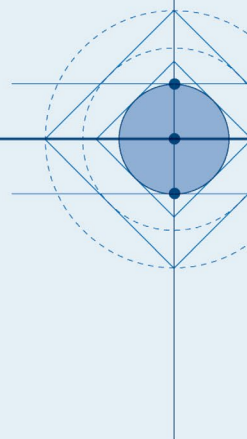
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SPOTLIGHT 3

National Standards Bodies

Most countries worldwide have a recognized national standards body that is part of their national quality infrastructure systems and tasked with developing voluntary national standards. In some countries, particularly small low-income countries, national standards bodies also offer other services related to national quality infrastructures, such as metrology and conformity assessment.¹ National standards bodies often operate as the national point of inquiry for the World Trade Organization and its Technical Barriers to Trade Agreement.²

This spotlight presents the findings from a survey of national standards bodies conducted jointly by the World Bank and the International Organization for Standardization (ISO) for the *World Development Report 2025*. The survey was sent to the 173 national standards bodies that are ISO members (130 member bodies, 39 correspondent members, and 4 subscriber members), and 116 national standards bodies completed the survey. The spotlight describes the institutional characteristics of these 116 national standards bodies and the ways in which they develop national standards, highlighting key differences across countries according to income level.

Many national standards bodies are autonomous governmental organizations created through legislative processes, such as the national standards bodies in Bangladesh and in South Africa.³ In some countries, like the United States, national standards bodies are not government organizations but rather nongovernmental organizations that governments recognize as their national standards bodies.⁴

The institutional makeup of a national standards body is closely related to the income level of the country it serves. As countries' income level increases, the number of national standards bodies that are private increases. Whereas all national standards bodies in low-income countries have public ownership, only 56 percent of national standards bodies in high-income countries are public (refer to table S3.1).

Establishment of national standards bodies in lower-income countries began later than that in higher-income countries (refer to figure S3.1). The average age of national standards bodies in low-income countries and lower-middle-income countries is about 31 years and 38 years, respectively, whereas in high-income countries it is about 62 years.

A reproducibility package is available for this book in the Reproducible Research Repository at <https://reproducibility.worldbank.org/catalog/389>.

Table S3.1 Institutional characteristics of national standards bodies

CHARACTERISTIC	LOW-INCOME COUNTRIES	LOWER-MIDDLE-INCOME COUNTRIES	UPPER-MIDDLE-INCOME COUNTRIES	HIGH-INCOME COUNTRIES
Number of NSBs that participated in the survey	13 of 24 members	28 of 42 members	34 of 47 members	41 of 60 members
Percentage of NSBs that are public	100	89	88	56
Number of full-time employees	331 (140)	300 (96)	299 (87)	161 (80)
Percentage of employees working on standards development	18 (17)	25 (16)	30 (24)	36 (29)
Percentage in which NSB controls revenues received from services	77	75	68	73
Annual budget in 2024 (US\$, millions)	7.5 (2.09)	13.6 (2.03)	6.6 (2.40)	24.4 (13.20)

Source: WDR 2025 team, based on World Bank and ISO 2025.

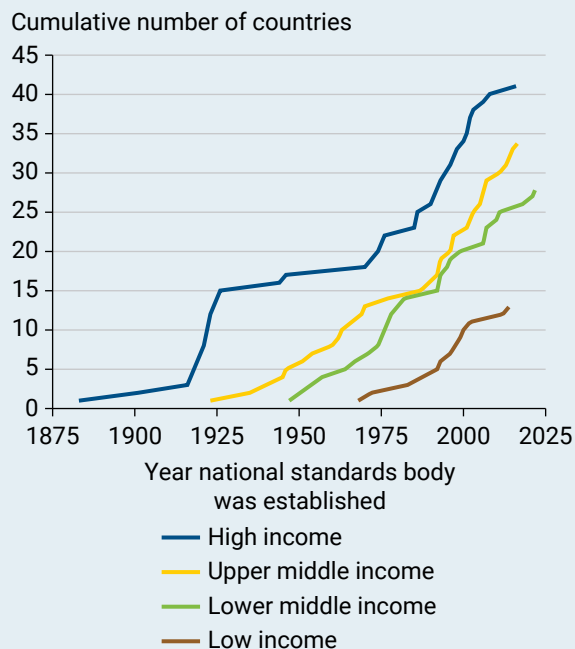
Note: Data on the number of full-time employees, the percentage of employees working on standards development, and the annual budget in 2024 include the mean and the median (50th percentile), the latter of which is reported in parentheses. The survey sample includes 116 national standards bodies (NSBs).

National standards bodies in low-income countries have nearly twice as many full-time employees on average as those in high-income countries because the former generally provide more services related to national quality infrastructures than the latter. In fact, the average share of employees in national standards bodies who are involved in developing standards rises from 18 percent in low-income countries to 36 percent in high-income countries.

In 2024, high-income countries published about five times more standards on average than low-income countries (refer to table S3.2), but the numbers are widely dispersed within each

income group. For example, the number of published standards in 2024 ranges from 0 to 8,065 among high-income countries and from 2 to 1,500 in low-income countries. The number of ISO standards adopted in 2024 ranges from 1 to 1,500 among high-income countries and from 0 to 1,100 in low-income countries. In comparison, the number of ASTM International standards adopted in 2024 ranges from 0 to 39 among high-income countries and from 1 to 13 among low-income countries, with an average of 14 percent of standards adopted. While ISO standards are adopted worldwide, ASTM International standards tend to be adopted by countries in the Middle East and North Africa region.

Figure S3.1 Establishment of national standards bodies began earlier in high-income countries than in low- and middle-income countries



Source: WDR 2025 team, based on World Bank and ISO 2025.

Note: The survey sample includes 116 national standards bodies: 13 in low-income countries, 28 in lower-middle-income countries, 34 in upper-middle-income countries, and 41 in high-income countries.

The number of standards published per employee involved in standards development also varies based on a country's income level. National standards bodies in high-income countries publish about five times more standards per employee than those in low-income countries. These differences in productivity are likely because in low-income countries, employees in national standards bodies develop standards without much help from other stakeholders, whereas in higher-income countries, industry takes more of a leading role, freeing up each employee to develop more standards.

Governance and regulatory role of national standards bodies

Across all country income levels, industry and sector associations are the single largest source of requests for standards. Their influence increases with a country's income, with associations in high-income countries driving nearly two-thirds of all requests. Government agencies also drive the demand for standards, but their influence declines with country income. The percentage of standards requested by governments declines from 37 percent in low-income countries to 29 percent in high-income countries.

Although national standards bodies publish only voluntary standards, they often assist regulatory agencies in drafting technical regulations, particularly in developing countries that may lack expertise in this area. The majority of countries across all income levels have a framework for technical regulations, but the ability to assess the impacts of standards increases with countries' income levels.

Figure S3.2 shows the distribution, by sector, of the average share of mandatory standards adopted and included in a country's technical regulations. For all country income groups, about half of the standards included in technical regulations relate to food safety and construction, although standards for food safety are more important in low-income countries than are construction standards, and the reverse is true in high-income countries.

National standards bodies have diverse roles with respect to standards at the national, regional, and international levels. Their responsibilities include developing and approving standards through their own technical committees and nominating experts aligned with their national priorities to participate in international

Table S3.2 Process of developing standards by national standards bodies

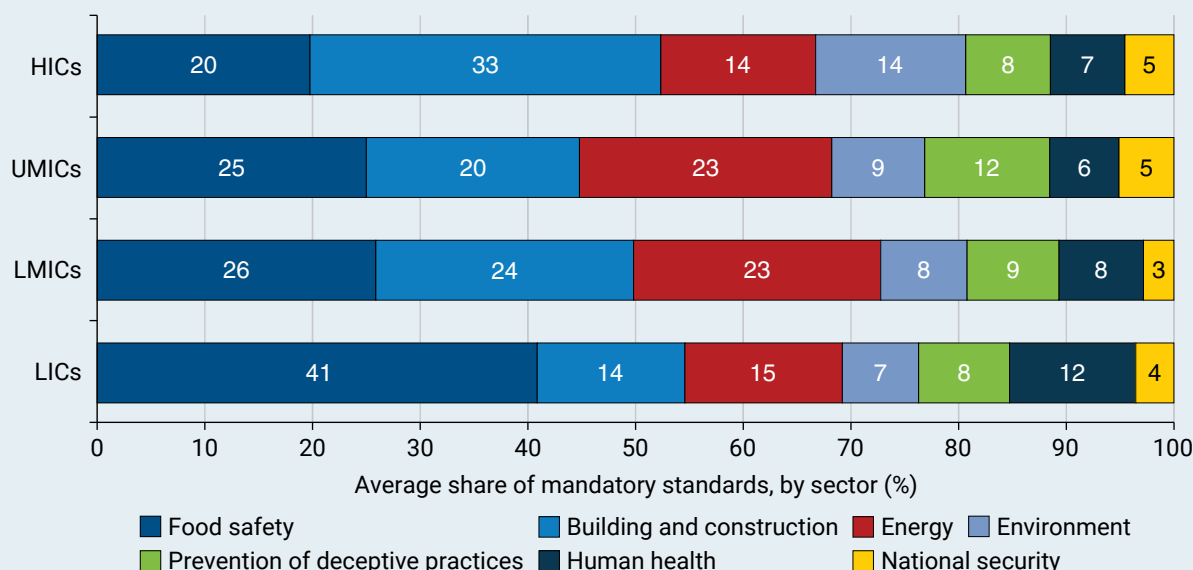
CHARACTERISTIC	LOW-INCOME COUNTRIES	LOWER-MIDDLE-INCOME COUNTRIES	UPPER-MIDDLE-INCOME COUNTRIES	HIGH-INCOME COUNTRIES
Number of published standards in 2024 ^a	276 (80)	460 (203)	981 (280)	1,402 (1,334)
Number of published standards per employee in 2024 ^b	21 (3)	37 (6)	111 (11)	103 (30)
Number of ISO and IEC standards adopted in 2024	116 (18)	249 (46)	220 (92)	510 (433)
Number of technical committees	58 (48)	119 (45)	166 (60)	201 (118)
Percentage of countries with frameworks for technical regulations ^c	69	79	82	70
Percentage of countries in which national standards body is involved in drafting technical regulations	77	79	68	35
Percentage of countries in which national standards body conducts impact assessments ^d	38	61	47	55

Source: WDR 2025 team, based on World Bank and ISO 2025.

Note: Data on the number of standards and number of technical committees include the mean and the median (50th percentile), the latter of which is reported in parentheses. The survey sample includes 116 national standards bodies: 13 in low-income countries, 28 in lower-middle-income countries, 34 in upper-middle-income countries, and 41 in high-income countries. IEC = International Electrotechnical Commission; ISO = International Organization for Standardization.

- The average number of published standards includes nationally developed standards as well as international standards that have been adopted.
- The number of published standards per employee is the ratio, in 2024, of the number of standards published by a country's national standards body to the number of employees in the national standards body dedicated to standards development.
- A framework for technical regulations defines and harmonizes how standards are applied in technical regulations across government bodies.
- Countries conduct impact assessments to evaluate the potential effects of standards before or during their development.

Figure S3.2 About half of adopted standards included in technical regulations relate to food safety and construction



Source: WDR 2025 team, based on World Bank and ISO 2025.

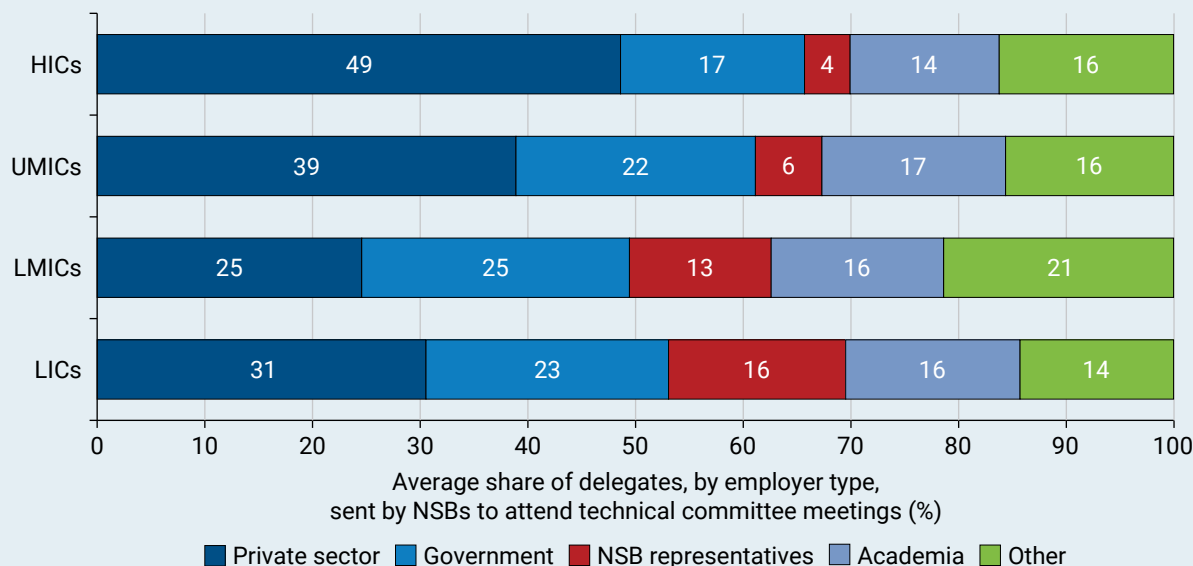
Note: The survey sample includes 116 national standards bodies: 13 in low-income countries, 28 in lower-middle-income countries, 34 in upper-middle-income countries, and 41 in high-income countries. Constituent percentages for each country income group may not sum exactly to 100 percent as a result of rounding. HICs = high-income countries; LICs = low-income countries; LMICs = lower-middle-income countries; UMICs = upper-middle-income countries.

committees in organizations like ISO. National technical committees serve as forums in which experts from industry, organizations involved in conformity assessment, consultancy, academia, nongovernmental organizations, government, consumer groups, and other stakeholders convene.⁵ Their structure can mirror that of parallel ISO committees, and such committees are called “National Mirror Committees” (refer to spotlight 2 for details). The number of national technical committees in national standards bodies tends to increase with the overall number of standards these bodies publish. Low-income countries average 58 national technical

committees and high-income countries 201. A greater number of technical committees enables a national standards body to cover a broader range of sectors.

Figure S3.3 shows the composition of national technical committees in national standards bodies by employer and country income level. Representation of the private sector increases with country income, whereas that of government agencies and staff members from national standards bodies declines. Unlike that for other groups, the share of members from academia is consistent across all income levels.

Figure S3.3 Among income groups, the private sector has the greatest representation in technical committees of national standards bodies in high-income countries



Source: WDR 2025 team, based on World Bank and ISO 2025.

Note: The survey sample includes 116 national standards bodies (NSBs): 13 in low-income countries, 28 in lower-middle-income countries, 34 in upper-middle-income countries, and 41 in high-income countries. "Other" includes representatives from nongovernmental organizations, standards application organizations, and labor organizations. HICs = high-income countries; LICs = low-income countries; LMICs = lower-middle-income countries; UMICs = upper-middle-income countries.

National standards bodies that are members of international standards development organizations decide whether the countries they serve should adopt, as national standards, the standards those organizations publish. If a national standards body has a need that no existing international standard covers, it may develop the needed standard as an "indigenous standard." National standards bodies, especially those in low-income countries, are not always familiar with all the international standards published and may develop indigenous standards even when an international one serving the

same need is available. International institutions like ISO and the International Electrotechnical Commission (IEC) have capacity-building programs to support their member national standards bodies in avoiding duplication and to facilitate the adoption of international standards (refer to box S3.1 and spotlight 2). The number of ISO and IEC standards adopted by national standards bodies increases with country income, reducing technical barriers to trade and facilitating access to international markets—and indicating greater integration with the global standards community.

Box S3.1 Enhancing collaboration between standardizers and policy makers

International standards are efficient and cost-effective tools for meeting public policy objectives because they embody a consensus of multiple stakeholders and countries. Their adoption supports policy making; enhances transparency, predictability, and accountability of the regulatory process; and stimulates sustainable economic growth.

The World Trade Organization (WTO) Technical Barriers to Trade Agreement mandates that countries use international standards when developing technical regulations. Additionally, the Organisation for Economic Co-operation and Development's guidelines on regulatory practices promote adopting international standards. The International Organization for Standardization (ISO) offers guidance and training to national standards bodies on how they can more effectively support their national regulatory processes while meeting their international trade obligations and adhering to global best practices.

In 2023, ISO released "Standards and Public Policy: A Toolkit for National Standards Bodies."^a This document offers a framework for understanding how international standards can assist policy makers and regulators in developing, adopting, and implementing policies, especially technical regulations, in accordance with the Technical Barriers to Trade Agreement.

A capacity-building program is under way to increase collaboration among national standards bodies, policy makers, and regulators, sector by sector. It includes thematic policy briefs, workshops, research initiatives, case studies, peer-to-peer sharing of knowledge, and capacity-building training. The goal is to create a global community that uses international standards to achieve public policy objectives, foster trade, and promote international regulatory cooperation.

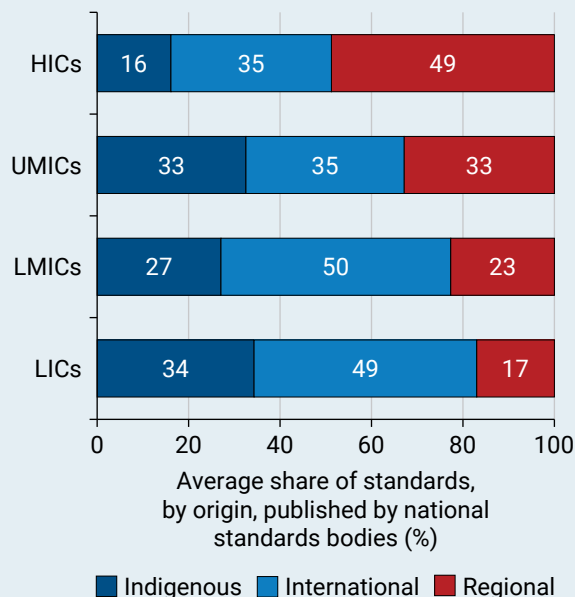
Source: WDR 2025 team.

a. ISO (2023).

Figure S3.4 reports the average share of standards published by national standards bodies based on the origin of the standard: that is, by whether the standard was developed exclusively by the national standards body as an indigenous standard, an adopted international standard, or an adopted regional standard. National standards bodies in low- and middle-income countries tend to publish more indigenous and international standards than high-income countries. In contrast, high-income countries tend to adopt more

regional standards, but the adoption of standards developed by the European Committee for Standardization (CEN) largely drives this trend. As of mid-2023, approximately 34 percent of CEN's active standards were adoptions of identical ISO standards, and the rest were developed independently by CEN. This ratio reflects ongoing collaboration between CEN and ISO and alignment of the two organizations' standards, with the goal of creating consistent standards at the European and international levels.

Figure S3.4 National standards bodies in high-income countries adopt a greater share of regional standards, on average, than those in low- and middle-income countries



Source: WDR 2025 team, based on World Bank and ISO 2025.

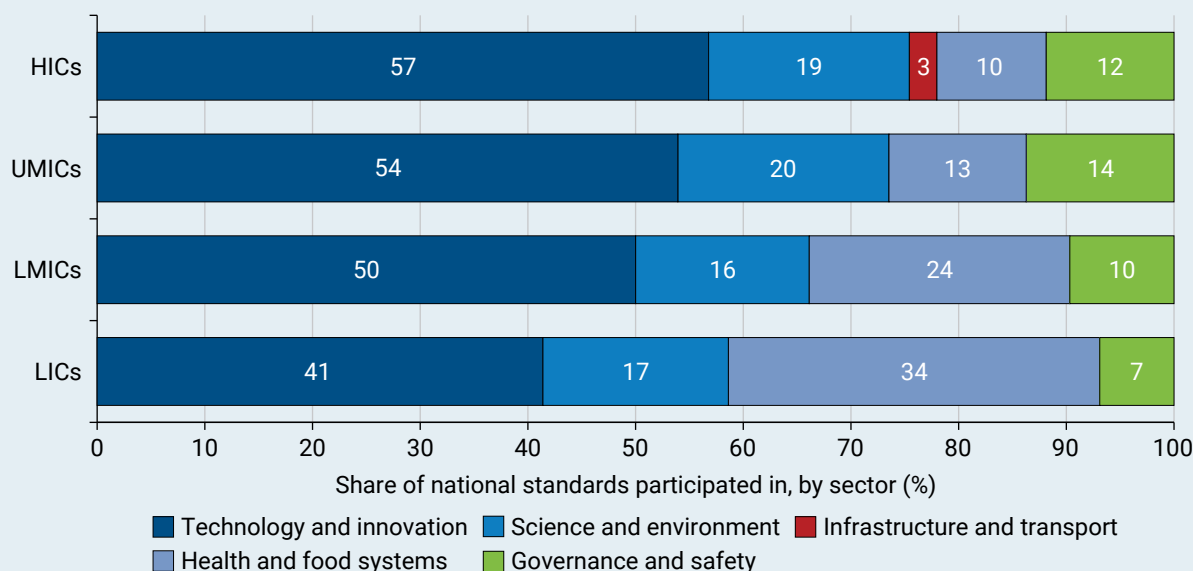
Note: "Indigenous" standards are new standards developed by a country. "International" standards are those developed by international standards development organizations and then adopted by a country. "Regional" standards are standards developed by regional standards development organizations and then adopted by a country. The survey sample includes 116 national standards bodies: 13 in low-income countries, 28 in lower-middle-income countries, 34 in upper-middle-income countries, and 41 in high-income countries. Constituent percentages for each country income group may not sum exactly to 100 percent as a result of rounding. HICs = high-income countries; LICs = low-income countries; LMICs = lower-middle-income countries; UMICs = upper-middle-income countries.

Figure S3.5 reports the share of standards in each sector whose development national standards bodies participated in.⁶ The standards with the highest participation levels in low-income countries are those in the technology and innovation sector, followed by those in the health and food systems, and then those in the science and environment sector, a distant third. Across all income levels, the standards with the highest levels of participation by national standards bodies are those in the technology and innovation sector.

Challenges national standards bodies face in adopting international standards

Across income groups, when national standards bodies choose to adapt (that is, to modify according to the ISO system) voluntary international standards instead of adopting them as is, the main reason they cite is not limited capacity to conform to the international standard, but rather local climatic conditions. In low-income countries specifically, the results of the survey suggest that these countries will simply not adopt an international standard at all if they cannot comply with it (that is, they are not equipped to implement or test to the international standard), rather than reduce its stringency in an adapted version. In contrast, countries in other income groups with limited capacity to comply with an international standard will likely adapt the standard by lowering its stringency. Furthermore, 60 percent of national standards bodies in high-income countries are more likely to decide not to adopt an international standard because they already have a comparable existing national or regional standard.

Figure S3.5 National standards bodies are more likely to participate in the development of international standards in the technology and innovation sector as country income level increases



Source: WDR 2025 team, based on administrative data as of 2024 provided by the International Organization for Standardization (ISO).

Note: Constituent percentages for each country income group may not sum exactly to 100 percent as a result of rounding. HICs = high-income countries; LICs = low-income countries; LMICs = lower-middle-income countries; UMICs = upper-middle-income countries.

All national standards bodies report that adopting international standards is important because these standards enable the countries they serve to have access to international markets and that standards are also a powerful tool for attracting foreign investment; the latter reason is commonly cited especially by national standards bodies in low-income countries. About half of national standards bodies in low- and middle-income countries also view the adoption of an international standard as a way to avoid lobbying by domestic firms and use it as a tool to overcome local resistance.

Low-income countries with lower technical capacity also cite the complexity of international standards as a reason for not adopting them.

The survey findings highlight the need for targeted capacity-building programs, particularly to raise awareness about the availability of international standards, their adoption, and their use and to increase capacity in low-income and lower-middle-income countries to conform with international standards (refer again to box S3.1 and spotlight 2).⁷

Notes

1. Refer to chapter 3 for a discussion of potential conflicts of interest when national standards bodies offer multiple services.
2. ISO (2019); ISO and UNIDO (2008).
3. The Bangladesh Standards and Testing Institution operates as an autonomous government institution. The South African Bureau of Standards was established in 1945 under the country's Standards Act. Refer respectively to Bangladesh Standards and Testing Institution (dashboard), Ministry of Industries, <https://bsti.gov.bd/>; South African Bureau of Standards (dashboard), Department of Trade, Industry and Competition, <https://www.sabs.co.za/>.
4. The American National Standards Institute is a private nonprofit organization founded in 1918 that represents the United States in international standards development organizations, such as ISO and the International Electrotechnical Commission.

Refer to American National Standards Institute (dashboard), <https://www.ansi.org/>.

5. ISO has about 275 active technical committees.
6. National standards bodies typically sell standards, including both ISO standards and those developed by national standards bodies, to businesses, industries, governments, and the general public within their countries.
7. ISO has a training program on national adoptions for developing-country members to address these needs, including tailored support for least developed countries. ISO capacity-building programs for developing-country members aim to strengthen developing countries' participation in international standardization and enhance their uptake of standards. These capacity-building programs continue to be highly relevant, and more support is needed to scale them up to better support developing-country members. Refer to ISO (2022) for details.

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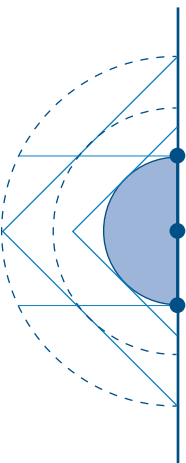
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PART 3

Leveraging Standards for Development Outcomes

Part 3 explores how countries can harness standards to advance development outcomes. Standards act as powerful levers of economic growth by diffusing knowledge, facilitating trade and investment, and enhancing productivity (refer to chapter 4). They also improve health and education, thereby strengthening human capital and long-term growth (refer to chapter 5). Yet unchecked growth can generate risks, from environmental degradation (refer to chapter 6) to financial instability, that effective standards can help manage. Underpinning all these outcomes is government capacity, itself reinforced by governance standards that promote transparency, accountability, and efficiency (refer to chapter 7).

Chapter 4 discusses how adopting voluntary standards raises the quality of a country's products and services and how international trade accelerates the diffusion of such standards. It documents the proliferation of increasingly complex and stringent standards and regulations over the past two decades and explains how low- and middle-income countries acquire tacit knowledge through foreign direct investment. The chapter also highlights the growing role of technology standards and how these countries can strategically leverage them.

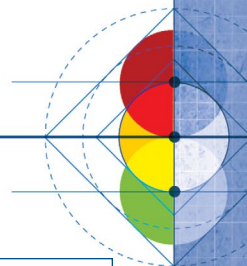
Two spotlights complement this discussion. Spotlight 4 explores how financial standards safeguard integrity and resilience while expanding access to financial services. Spotlight 5 examines how digital public infrastructure can enable inclusive innovation and more efficient delivery of services.

Chapter 5 focuses on standards in health care and education, especially during early childhood, to improve lifelong outcomes. It shows how process standards, such as

procedural checklists and standardized treatments, enhance the quality of health care, whereas standards regarding teacher qualifications, attendance, and pedagogy increase educational quality. Measurement standards are also key to driving educational reform and improving learning outcomes.

Chapter 6 examines how countries can use environmental standards to support green growth by reducing pollution and fostering adaptation to climate change, while balancing the economic costs and benefits of such standards.

Chapter 7 discusses how governance standards in three core functions—personnel, payments, and procurement—enable governments to implement policies effectively and deliver public goods and services. Leveraging such standards strengthens institutional capacity and ensures greater efficiency, fairness, and accountability.



4 Standards for a Better Economy

Main messages

- Standards are invisible engines of growth, but many developing countries are stuck in low-quality traps. Firms in low- and lower-middle-income countries that adopt voluntary standards report greater sales growth than firms in high-income countries. But high costs, uncertainty, and weak quality infrastructure continue to constrain adoption.
- Adoption of standards pays, but costs and uncertainty slow diffusion. Obtaining certification of compliance can cost up to US\$425,000 per firm in developing countries, including testing and ancillary investments. Expanding domestic capacity for auditing and testing is essential: Ethiopia has fewer than 100 auditors for International Organization for Standardization (ISO) standards, compared with 12,000 in Germany. Reducing costs would unlock productivity and export gains.
- Trade flows have become tangled in a “spaghetti bowl” of overlapping regulations. Proliferation of national standards and technical regulations has created duplication and friction across markets. Simplifying layers of regulations and aligning them with international standards can significantly reduce trade barriers.
- Streamlined, harmonized standards multiply benefits for trade and sustainability. Mutually recognized standards spare firms duplicate testing and certification, opening regional markets, especially for smaller exporters. Aligning national rules with international standards is one of the simplest ways to make trade more inclusive and sustainable.
- Foreign investment remains a route to the diffusion of higher standards, but it does not happen automatically. Tunisia’s automotive components sector—14 percent of exports and 90,000 jobs—has grown 10 percent annually since 2010 as foreign firms introduced ISO 9001 and environmental standards. Foreign direct investment (FDI) transfers not only capital, but also technology and quality practices, provided that infrastructure and local capacity keep pace.
- Technology standards will determine who benefits from the next wave of innovation. Shared standards for technology enable interoperability, ensuring that phones connect, chargers fit, and data flow securely. Yet competing standards in areas like 5G, semiconductors, and digital payments risk fragmenting markets and slowing diffusion of technology.
- Voice matters: Developing countries must help write tomorrow’s rules. Most are still technology takers, not makers. Greater participation in regional development of standards, through the African Union or the Association of Southeast Asian Nations (ASEAN), and in sectors like digital ID, e-payments, and renewables, can amplify their influence and ensure that global standards reflect development priorities.

Standards to increase quality and growth

Standards can act as powerful levers for growth and structural transformation in developing countries. They signal reliability of processes and products, reduce information asymmetries among parties to a transaction, and demonstrate commitment to specific processes for production and management. They also provide firms with access to codified knowledge that helps them learn, innovate, and integrate themselves into larger markets.

For domestic suppliers to export markets or subsidiaries of multinational firms, standards serve as a coordination device, helping synchronize sourcing, manufacturing, and testing practices across global value chains. Without the common references that standards provide, firms risk damaging

brand reputation and losing access to contracts that depend on verified quality. For local firms, standards often become the entry ticket for participating in international production networks. Supplier contracts tied to compliance with standards, through performance audits or payments linked to quality, create strong incentives for firms to invest in upgrading.

Standards make technologies compatible and interoperable, allowing firms to innovate atop existing systems rather than starting from scratch. This lowers investment risks, encourages diffusion of new ideas, and helps prevent technological lock-in. These benefits extend beyond manufactured goods to services as well. Tourism, for example, has undergone successive waves of standardization aimed initially at ensuring safety and service quality and more recently at achieving sustainability (refer to box 4.1).

Box 4.1 Tourism standards: From mandatory ratings to market-driven sustainability

Tourism standards have evolved over the past 50 years, shifting from mandatory standards for hotels to market-driven standards regarding sustainability and setting an example for other services sectors. The United Nations World Tourism Organization and the International Organization for Standardization (ISO) began developing formal standards in the area of tourism services in the late twentieth century, primarily to enhance traveler safety. The first standardized systems for rating hotels emerged in the United States in the 1950s to boost consumer confidence and increase the quality of hotel services. By the 1970s, many countries had introduced minimum mandatory standards covering room size, facilities, and service levels, often enforced by national tourism boards. These helped formalize the sector and attract both domestic and international visitors.

As environmental awareness and the concept of responsible travel gained traction, voluntary standards regarding sustainability proliferated. By 2010, more than 150 certifications, such as Green Globe, Biosphere, EarthCheck, Green Key, and Travelife, were available, addressing issues ranging from hotels' use of energy to the quality of destination-level management. The explosion of eco-labels signifying certification under these programs led to fragmentation (that is, the simultaneous existence of multiple standards for certification) and consumer

(Box continues next page)

Box 4.1 Tourism standards: From mandatory ratings to market-driven sustainability (*continued*)

confusion. To restore credibility and coherence to sustainability standards, the Global Sustainable Tourism Council (GSTC) was founded in 2010 to harmonize sustainability criteria across the tourism value chain. In 2023, Türkiye became the first country to adopt GSTC Criteria as the basis for mandatory national regulations for accommodation services.

Although rigorous evaluations remain scarce, existing studies find that star ratings for hotels correlate positively with market value, revenue per available room, and investor confidence.^a Some evidence also links adoption of standards to greater employee satisfaction, higher rates of retention, and better work-life quality, along with increased levels of investment.^b At the destination level, Blue Flag beach certification in Costa Rica and Spain has stimulated investment in hotels, particularly in high-end segments.^c

Source: Louise Twining-Ward, Prosperity Vice Presidency, World Bank.

a. Bello et al. (2022); El-Nemr et al. (2021); Martin-Fuentes (2016).

b. APO (2023); Kim et al. (2018).

c. Blackman et al. (2014); Merino and Prats (2020); Molina-Murillo (2019).

Despite the potential gains, however, many developing countries, in particular, have not realized the full benefits of adopting standards. This chapter examines why and explores the role of standards through three main channels for growth: trade, FDI, and technology.

The adoption of standards in domestic economies

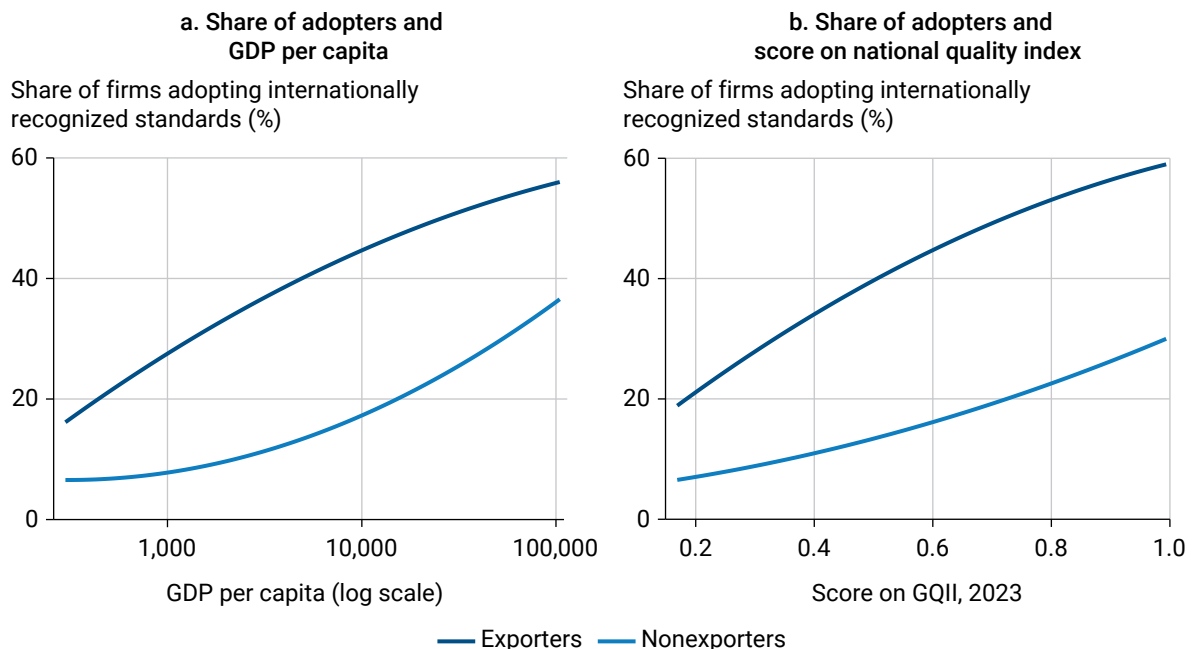
As discussed in chapter 2, producers in developing countries often operate in a low-quality equilibrium. Consumers' limited purchasing power restricts demand for higher-quality products, and firms lack both incentives and the technical capacity to upgrade. As economies develop, both the complexity and quality of goods increase,¹ and more firms adopt standards to meet evolving consumer and buyer expectations.

Successive waves of detailed data collected at the firm level by the World Bank Enterprise Surveys

confirm this pattern (refer to figure 4.1). The share of firms in a country that hold internationally recognized certifications correlates strongly with both the country's income per capita and the quality of its national quality infrastructure (discussed in chapter 3). Even in nontradable sectors such as construction and domestic transport, adoption rates for standards remain lower in developing countries² as a result of financial, technical, and informational barriers to adoption.³

Consumers' sensitivity to price over quality reinforces the trap that results from operating in a low-quality equilibrium. Firms hesitate to invest in upgrading the quality of the goods and services they produce when the returns to doing so are uncertain or when credit, testing services, or support for certification are scarce. This self-reinforcing cycle keeps firms confined to low-productivity activities, preventing them from diversifying into more complex and higher-value products.

Figure 4.1 Adoption of standards increases with a country's level of development and the strength of national quality infrastructure



Source: WDR 2025 team, based on World Bank Enterprise Surveys (dashboard), World Bank, <https://www.enterprisesurveys.org/en/data>.

Note: Examples of internationally recognized standards include quality standards (International Organization for Standardization [ISO] 9000 family), sustainability standards (ISO 14000 family), standards for food safety (ISO 22000 family), and standards for worker safety (ISO 45000 family). The Global Quality Infrastructure Index (GQII) ranks 185 countries according to the relative development of their quality infrastructure systems. For more information, refer to GQII 2023 (dashboard), Global Quality Infrastructure Index (GQII) Program, Mesopartner and Analyticar, <https://gqii.org/gqii-2023/>.

As economies grow and firms expand the scope of their products, adoption of standards accelerates. Countries adopt standards at different speeds, with developing countries often lagging higher-income ones. The key policy question is how to shorten this lag. Answering this question requires an understanding of what happens when firms in developing countries adopt standards to upgrade their production processes and products, either to meet the requirements of international buyers and access export markets or to gain shares in domestic markets. Although standards can yield substantial benefits at the firm level (higher productivity, sales, and employment), adopting them can involve high up-front costs and uncertainties.

Beyond a few macroeconomic studies on the impacts of standards,⁴ the evidence from microeconomic studies finds positive returns to adopting standards. Productivity gains range from 2.4 percent to 17.6 percent in Central America⁵ and are about 4.5 percent in China, with smaller but statistically significant effects in Southeast Asia.⁶ Firms that adopt standards grow faster, export more, and have better management systems (refer to table 4.1). Only a couple of studies examining the effects of adopting private standards find a negative impact on profitability when additional revenue from the resulting price premium does not compensate for the costs of compliance with the standards.

Table 4.1 Summary of evidence on the impacts on firms of adopting standards

OUTCOME	NEGATIVE IMPACT (NUMBER OF STUDIES)	NON- STATISTICALLY- SIGNIFICANT IMPACT (NUMBER OF STUDIES)	POSITIVE IMPACT (NUMBER OF STUDIES)	SHARE OF STUDIES IN DEVELOPING COUNTRIES (%)	SHARE OF STUDIES IN PEER- REVIEWED PUBLICATIONS (%)	SHARE OF STUDIES USING AN ECONOMETRIC FRAMEWORK (%)
Sales growth	0	0	12	42	100	67
Profit growth	2	1	13	56	100	69
Employment growth	0	0	2	50	100	100
Wages	0	0	3	67	67	100
Productivity	1	1	7	67	78	89
Exports	0	2	4	67	100	67

Source: World Bank 2025a.

Note: The table summarizes results of 28 studies; 26 of these studies were peer reviewed, and the remaining 2 are working papers at international institutions. "Number of studies" represents the number of evaluation studies for an individual standard. Some studies evaluate more than one standard and, therefore, appear more than once in the table.

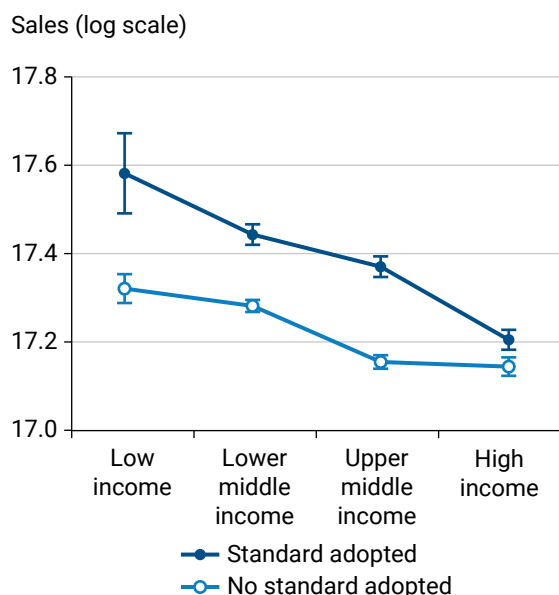
Adopting standards appears to have greater benefits in developing countries, where standards help firms credibly signal quality to foreign buyers.⁷ Data from the latest World Bank Enterprise Surveys show that firms in low- and middle-income economies earn the highest sales premium (that is, the additional sales associated with adopting a standard), on average, from certification (refer to figure 4.2). Firms in high-income countries, where quality expectations are already embedded, experience a smaller sales premium.

If adoption is profitable, why does diffusion of standards remain slow? The main reason lies in the high fixed costs, uncertainty, and limited access to finance that characterize markets in many developing countries. Adopting standards requires not only paying certification fees, but also reconfiguring production processes, training staff, and often acquiring new technologies.⁸

A survey of 22 firms in Ethiopia seeking certifications for mandatory domestic quality standards

found they considered the process complex, time consuming, and expensive.⁹ A seminal study examining the impacts of technical barriers to trade—technical regulations in foreign markets—on exporters in developing countries finds that each 1 percent increase in investment needed for compliance with regulations raises production costs by 0.06–0.13 percent, with average fixed costs of about US\$425,000 per firm.¹⁰ A study of Colombia's Nespresso supplier program finds that achieving the yields and quality levels in coffee crops that the program requires makes it necessary for firms to invest an additional US\$297 per hectare of coffee planted and costs them an extra US\$0.11 per kilogram of coffee produced in operating costs, including those for improvements in environmental practices, harvesting methods, and worker protections. Program farmers face a total production cost of approximately US\$1.33 per kilogram of coffee while earning approximately US\$2.60 per kilogram, representing a 10 percent increase in gross earnings compared with nonprogram farmers.¹¹

Figure 4.2 Firms in lower-income countries gain proportionately more sales from adopting voluntary international standards than do firms in more developed countries



Source: WDR 2025 team, based on World Bank Enterprise Surveys (dashboard), World Bank, <https://www.enterprise-surveys.org/en/data>.

Note: The figure shows the conditional prediction for average log sales by income level and whether firms adopted a voluntary standard, based on a regression of firms' total sales controlling for employment, capital intensity, and sector.

Limited access to credit, managerial know-how, and domestic facilities for testing needed to demonstrate compliance with standards further amplifies the challenges developing countries face.¹² Germany has more than 12,000 auditors for ISO 9001; Ethiopia has fewer than 100. Even if nominal certification fees are comparable across countries (refer to table 4.2 for those associated with ISO 14001), firms in developing countries have relatively higher total compliance costs because ancillary investments—for technology, consulting, and logistics—represent a much larger share of their total costs. When domestic testing for compliance is unavailable, samples must be sent abroad, significantly increasing expenses.¹³

Figure 4.3 shows that the likelihood a firm will adopt standards increases with firm size and country income level. In lower-income countries, small and medium enterprises (SMEs) face disproportionate obstacles, because their size makes the fixed costs of certification harder for them to absorb.

Table 4.2 Examples of certification costs for firms in selected markets for meeting the ISO 14001 quality standard

COUNTRY	INITIAL CERTIFICATION COSTS	SURVEILLANCE AND RECERTIFICATION COSTS
Developed countries		
Germany ^a	Small companies pay total costs of about US\$3,000 (€2,613), larger ones up to US\$11,500 (€10,017).	Not available.
United States ^b	Initial certification costs for small businesses with fewer than 10 employees and a single location range from US\$5,000 to US\$8,000. These costs increase with an organization's size and complexity.	External consultants charge US\$500 to US\$1,500 per day for additional technical assistance. Budget for annual audit costs as part of the three-year certification cycle also need to be considered.

(Table continues next page)

Table 4.2 Examples of certification costs for firms in selected markets for meeting the ISO 14001 quality standard (*continued*)

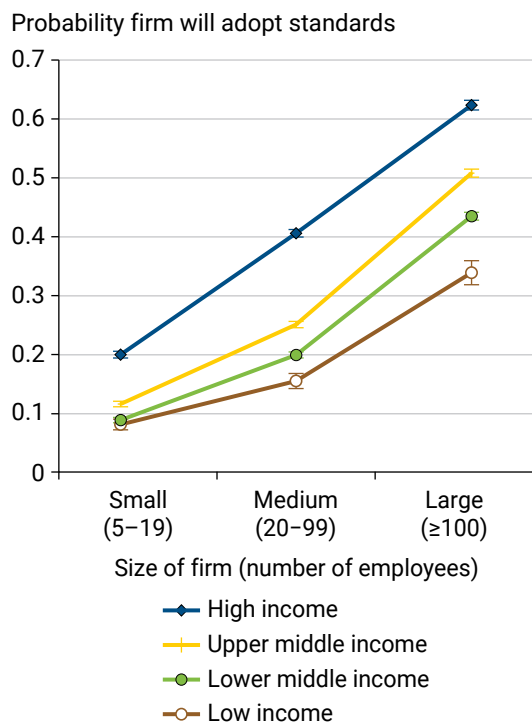
COUNTRY	INITIAL CERTIFICATION COSTS	SURVEILLANCE AND RECERTIFICATION COSTS
Developing countries		
Bangladesh ^c	ISO registration cost: US\$458–US\$606 (Tk 53,000–Tk 70,000). ISO certification fee: US\$87 (Tk 10,000).	Renewal fee: US\$43 (Tk 5,000). Inspection fee: US\$35 (Tk 4,000).
Brazil ^d	Certification fee: US\$1,096 (R\$5,760) for microentrepreneurs; US\$1,800 (R\$9,700) for small businesses.	Implementation cost (consulting and project support): US\$2,783 (R\$15,000) for both microentrepreneurs and small businesses.
China ^e	Application fee: US\$940 (¥6,765).	Annual management fee: US\$942 (¥6,765). Full-day rate for consultant: US\$959 (¥6,900).
Ethiopia ^f	The cost, including implementation and accreditation, ranges from US\$700 to US\$5,000 (Br 106,838 to Br 763,125).	Not available.
Mexico ^g	Certificate issuance fee: US\$546 (Mex\$10,000).	For three-year certification cycle: US\$1,147 (Mex\$21,000) per auditor per day. For administrative fee: US\$137 (Mex\$2,500).
Viet Nam ^h	Total costs typically include those for consulting by providers of certification services ranging from US\$1,035 to US\$1,862 (D25,000,000 to D45,000,000). Some providers of certification services may also charge training fees.	Not available.

Source: WDR 2025 team.

Note: ISO 14001 is a standard for environmental management. ISO = International Organization for Standardization.

- The costs depend on the specific industry, location, size of the company, and other factors. Refer to Kosten für die ISO 14001-Zertifizierung [ISO 14001 Certification Cost] (website), Integrated Assessment Services, <https://iasiso-europe.com/blog/iso-14001-certification-cost/>.
- The costs may vary depending on business size and complexity, number of employees and sites, geographic location, industry standards, and other factors. Refer to Compliance Monitoring: Understanding ISO 14001 Certification Cost (dashboard), BPR Hub, <https://www.bprhub.com/blogs/iso-14001-certification-cost-analysis>.
- The costs listed are for ISO certification in general, including that for ISO 14001. Prices may vary. Refer to ISO Registration in Bangladesh (website), HelpInk Consultancy, <https://helpinkbd.com/iso-registration-in-bd/>.
- These are the prices charged in 2016 by Sebraetec, a private nonprofit organization supporting the development of small business activity. Sebrae (Serviço Brasileiro de Apoio às Micro e Pequenas Empresas [Brazilian Support Service for Micro and Small Enterprises]) may subsidize parts of the expense according to the rules regarding eligibility for such subsidization. Refer to Sebrae (2016).
- The year of the price data is unspecified but is likely 2023. Refer to Authentication Service Pricing and Fee Disclosure Information (website) [in Chinese], BSI Management Systems Certification (Beijing) Co., Ltd., British Standards Institution, <https://www.bsigroup.com/globalassets/localfiles/zh-cn/pdf/2023/bsi2023.pdf>.
- The costs are for overall ISO certification, including that for ISO 14001. The ISO certification costs depend on multiple factors, such as the ISO standard involved, its complexity, the processes involved, a firm's number of employees, its number of operations or locations, the certification body involved, and the accreditation authority involved. Refer to ISO Certification in Ethiopia (dashboard), Auditmindz, Genveritas Technologies Private Limited, <https://auditmindz.com/iso-certification-in-ethiopia/>.
- These are the prices as of late 2023. Refer to MB Certification México (2023).
- Factors affecting the cost include company size, prior experience with ISO 14001, existing facilities and systems, and geographic location. Refer to ISO 14001 Environmental Certification Costs (dashboard), Vinacontrol CE, <https://vnce.vn/chi-phi-chung-nhan-iso-14001>.

Figure 4.3 The larger a firm's size and the higher the income level of the country where it is located, the more likely it is to adopt standards



Source: WDR 2025 team, based on World Bank Enterprise Surveys (dashboard), World Bank, <https://www.enterprisesurveys.org/en/data>.

Although the potential benefits of standards are clear, the high and uncertain costs of adopting them still deters many firms from doing so. Adoption is therefore concentrated among large firms and exporters that can internalize investments undertaken to increase quality. For smaller domestic producers, certification often remains out of reach.

Few studies directly measure how standards affect actual quality of products, presenting a gap in the available evidence. Because quality is hard to observe, researchers rely on proxies for quality such as productivity, wages, or sales. One study

of Chile's technical regulations found that greater regulatory stringency increased firms' efficiency and quality mainly by reallocating market shares from low-quality to higher-quality firms, rather than by raising quality across all firms.¹⁴

In sum, rates of adopting standards in developing countries remain low. Although causal evidence shows that certification improves firm performance, only better-performing firms are more likely to adopt standards. The binding constraints on adoption are high costs, market uncertainty, and weak support systems, especially for SMEs.

Government actions that can facilitate the diffusion and adoption of standards and improve quality

Facilitating change rather than mandating standards

Mandatory standards, embedded in regulations, are appropriate in sectors in which low quality presents high social risks (for example, health, safety, and the environment). But beyond these sectors, enforcing standards through regulation can backfire. Regulations can increase quality at the aggregate level and reduce negative externalities resulting from firms' production processes, but they often do so by reallocating market shares from low-quality to higher-quality firms,¹⁵ because not all firms can comply with them. Excessive or poorly designed regulations may force firms out of business or into informality, weakening competition (refer to box 4.2).¹⁶ Chapter 8 discusses how rigorous assessments of regulatory impact can help governments balance the trade-offs involved.¹⁷ Technical assistance is needed to support developing countries that lack the capacity to implement diagnostics of this kind.

Box 4.2 The varied effects of standards on competition

Standards shape competition in multiple ways. They can promote efficiency and merit-based rivalry but can also create entry barriers or reinforce market power if poorly designed.^a Private standards may skew value chains toward firms and countries able to meet demanding conditions for compliance,^b effectively transferring profits from suppliers to buyers through certification costs and restrictive contractual terms.^c Standards can boost the efficiency of innovation in markets with high levels of uncertainty but hinder it in those in which uncertainty is low.^d Standards may also serve as covert tools of protectionism to exclude foreign competition.^e

Four main risks can arise when standards are set or applied in an anticompetitive manner:

- *Raising barriers to entry.* Overly stringent standards may exclude smaller players. For example, cement standards in Nigeria effectively limited competition, benefiting the dominant firm, Dangote.^f
- *Facilitating collusion.* Some collective standards promote information sharing that reduces price competition, such as airline alliances sharing data on routes and pricing or industry-wide sustainability schemes requiring firms to disclose their cost structures.
- *Reducing innovation and variety.* Highly prescriptive standards, such as certain building codes or requirements regarding material content, can inhibit innovation, including the development of green technologies, by adding too much rigidity in the specifications for materials and technologies.
- *Enabling abuse of dominance.* Private labels by major retailers can entrench buyer power,^g as in the case of Peru's brewing industry, in which a leading firm restricted a rival's access to the country's Bottles Interchangeability System.^h

The overall effect of a standard on competition depends on the governance associated with the standard: whether small producers have a voice in the standard-setting process, whether standards are voluntary or mandatory, and whether there are safeguards against incumbents' setting thresholds above what is necessary for safety or performance.

Source: Nyman and Begazo 2025.

a. Das and Donnenfeld (1989); Gagné and Larue (2016).

b. Henson (2025).

c. For example, refer to Yu and Bouamra-Mechemache (2016).

d. Blind et al. (2017); Wen et al. (2022).

e. As argued by Fischer and Serra (2000); Marette (2018).

f. Nyman and Begazo (2025).

g. Nyman and Begazo (2025).

h. Casarin et al. (2020).

Treating standards as part of a broader policy package

Standards yield the greatest benefits when combined with complementary policies. In the cases of China and the Republic of Korea, standards were part of broader strategies for development that included export promotion, knowledge transfer driven by FDI, and industry incentives (refer to spotlight 1). Member countries of the Organisation for Economic Co-operation and Development (OECD), as well as China, Korea, and Singapore, have implemented a variety of policies to complement standards, including subsidizing costs of certification through vouchers, grants, or subsidized loans. Evidence on the optimal combination of policies is scarce and largely context specific; however, successful countries such as the ones mentioned here have invested in an export-oriented strategy, promoted a culture of quality, made gradual investments in national quality infrastructure (refer to chapter 3), and implemented a strategy for facilitating access to external knowledge.

Developing conditions that enable firms to upgrade quality

Many developing countries pursue fragmented industrial policies and maintain incentives misaligned with upgrading quality. When regulations result in less efficient or lower-quality firms receiving more resources than they would in a well-functioning market, or when operational costs are high, firms have little reason to invest in upgrading. Within the framework of the *World Development Report 2024: The Middle-Income Trap*, standards support the “infusion” process—the transfer and domestic diffusion of foreign technologies and production practices—but to accelerate this process, the ability of markets to expose firms to the threat of entry and competition must be preserved.¹⁸ Standards are most effective when business environments are predictable, financial systems provide access to long-term credit, and

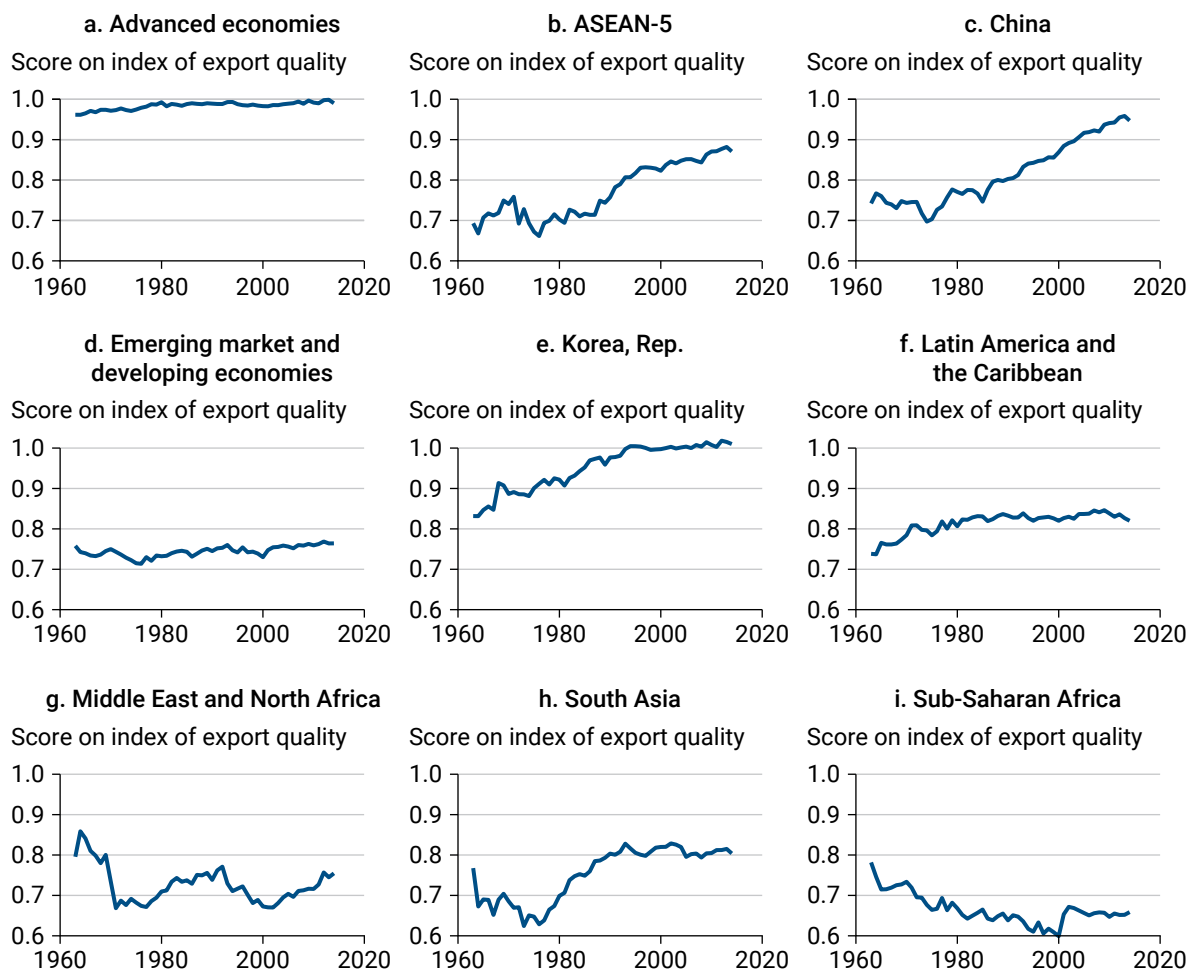
firms can rely on affordable services provided by national quality infrastructure.

Standards for international trade

Standards shape trade by determining which products and producers can participate in global markets and under what conditions.¹⁹ They function as the language of exchange, defining product characteristics, labeling requirements, and testing procedures, as well as methods for assessing conformity with the standards’ requirements that make transactions across borders predictable and safe. When harmonized across countries, standards reduce trade costs, expand market access, and strengthen trust among buyers and sellers.²⁰ For example, adopting ISO standards has increased exports in Argentina,²¹ Spain,²² and the United States.²³ But when standards are fragmented or overly stringent, they can act as technical barriers to trade, excluding producers in developing countries.

Evaluating the role of standards in trade is particularly important because the gap between developed and developing countries in quality of goods and services produced has not narrowed over time, except, notably, in some East Asian economies. Figure 4.4 shows the evolution of the International Monetary Fund (IMF) index of export quality from 1960 to 2014.²⁴ Advanced economies continued to produce higher-quality products—and higher-quality versions of the same products—than developing countries over that time period. Only East Asian countries, notably China and Korea, made substantial progress in closing the gap.²⁵ South Asia improved rapidly in this regard until 2000, but as of the mid-2010s, the Middle East and North Africa and Sub-Saharan Africa produced exports that were lower in quality than those they produced in the 1960s. Because exported goods are typically of higher quality than those sold domestically, the actual quality gap in production was likely even larger than the index suggests.

Figure 4.4 Export quality has evolved much more and much faster in some regions and countries than in others



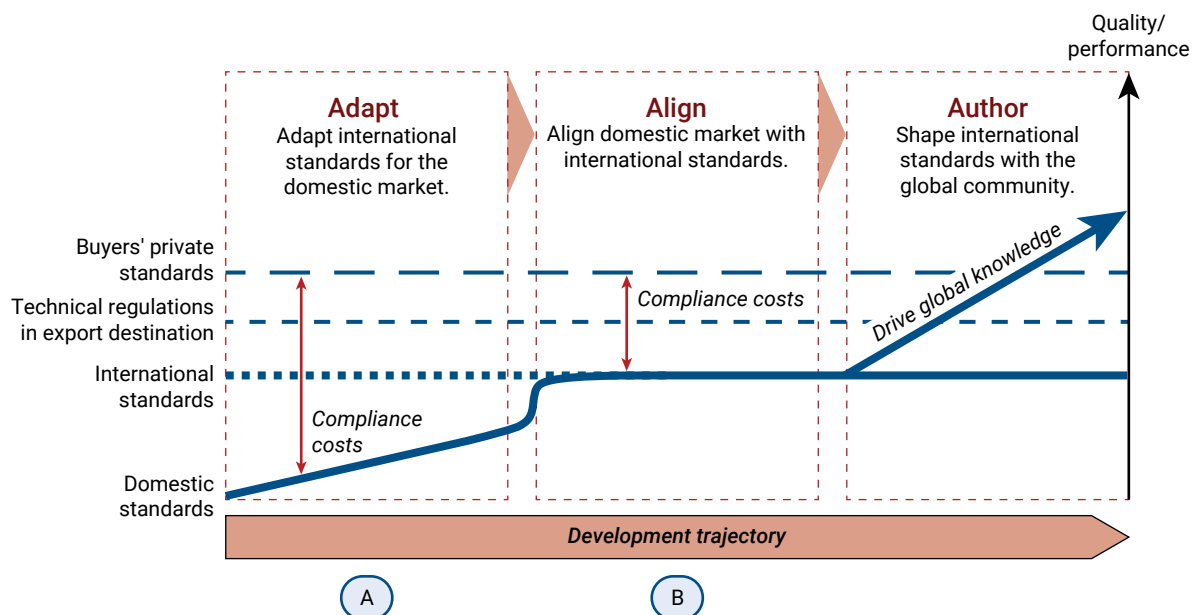
Source: WDR 2025 team, based on data from Henn et al. 2013.

Note: The figure traces the evolution of export quality from 1960 to 2014, using the International Monetary Fund's index of export quality, which measures the overall quality of exports from each country. The baseline methodology (refer to Henn et al. 2013) estimates quality based on unit values and is a modified version of Hallak (2006). Scores on the index typically range between 0 and 1.2, with higher values indicating higher levels of quality. Refer to Export Diversification and Quality (July 2017) (dashboard), International Monetary Fund, <https://www.imf.org/external/datamapper/datasets/SPRLU>. The ASEAN-5 are Indonesia, Malaysia, the Philippines, Singapore, and Thailand. ASEAN = Association of Southeast Asian Nations.

Although the differences between export quality in developing countries and that in developed countries partly reflect structural factors, they also indicate that standards have not yet fulfilled their potential to help developing countries upgrade the quality of the goods and services they produce and accelerate their economic development.²⁶ When a firm decides to export, it weighs the costs

and benefits of complying with technical regulations in destination markets, along with the private standards buyers often require firms to meet. Figure 4.5, expanded from the conceptual framework of chapter 2 (refer to figure 2.3), shows that firms in low-income countries at the *adapt* stage (labeled A in the figure) incur higher costs of complying with regulations in destination markets

Figure 4.5 Countries should set standards along their development trajectories in relation to international trade



Source: WDR 2025 team.

than do firms in advanced economies at the *align* stage (labeled B in the figure). This is because the gap in the stringency of regulations in source and destination markets is greater in low-income countries than in more advanced ones. Some destination markets set technical regulations above international norms, sometimes to shield domestic producers. Buyers' private standards tend to be even more stringent, compounding the costs that exporting firms encounter. As a result, many firms in developing countries avoid markets with onerous standards and regulations, redirecting their exports toward less demanding destinations. For example, Burundi exports most of its rubber to Peru, whereas Mexico's rubber exports mainly go to high-income markets such as China, the United States, and the European Union, which have comparatively more demanding requirements for their imports. The aggregation of firm-level choices regarding export destinations determines how standards shape global trade patterns.

Understanding the impact of standards on trade requires distinguishing among different types of standards. Most international standards, whether public or private, are voluntary. But governments also impose *technical regulations*, which are mandatory because they are written into law. These can be based on international standards, as encouraged under World Trade Organization (WTO) rules, or diverge from them. Together, they form a major class of *nontariff measures*: policy instruments other than tariffs that affect trade.²⁷ Nontariff measures include both technical measures, such as sanitary and phytosanitary regulations and technical barriers to trade, and nontechnical measures, such as quotas or price controls.²⁸

Sizable differences in standards and enforcement across countries create significant barriers to trade and slow progress in narrowing the gap in quality of goods and services between developed

and developing countries. Firms must often redesign products or repeat costly testing and certification to satisfy buyers in different markets, discouraging small and medium exporters in particular. For instance, a textile manufacturer in Pakistan reports spending about US\$5,000 per year for each of 15 sustainability standards and labels required by international buyers, many of which cover similar social and environmental criteria but demand separate audits.²⁹ Over the past two decades, both the number and complexity of standards and technical regulations have grown sharply. The next subsection documents this growth and examines its trade implications for developing countries.

The proliferation of standards in international trade

The shift from tariffs to nontariff measures

The composition of trade policy has changed dramatically over time. The share of global trade regulated by technical nontariff measures rose from less than 15 percent in the late 1990s to nearly 90 percent by the 2020s. Notifications to the WTO³⁰ of new sanitary and phytosanitary measures and technical barriers to trade increased more than 10-fold between 1995 and 2024, from 587 to 6,481.³¹ Nonagricultural goods, which formerly had a lower incidence of nontariff measures than agricultural goods, now have a comparable rate (refer to figure 4.6, panel a).

The restrictiveness of a nontariff measure is captured by its *ad valorem equivalent*: the tariff rate required to achieve the same impact on trade values as the nontariff measure, and thus the rate that would have the same effect on trade values. High-income countries impose not only more nontariff measures³² than low- and middle-income countries (refer to figure 4.6, panel b) but also more restrictive ones with

higher *ad valorem* equivalents.³³ In recent years, developing countries have also expanded their use of technical nontariff measures.

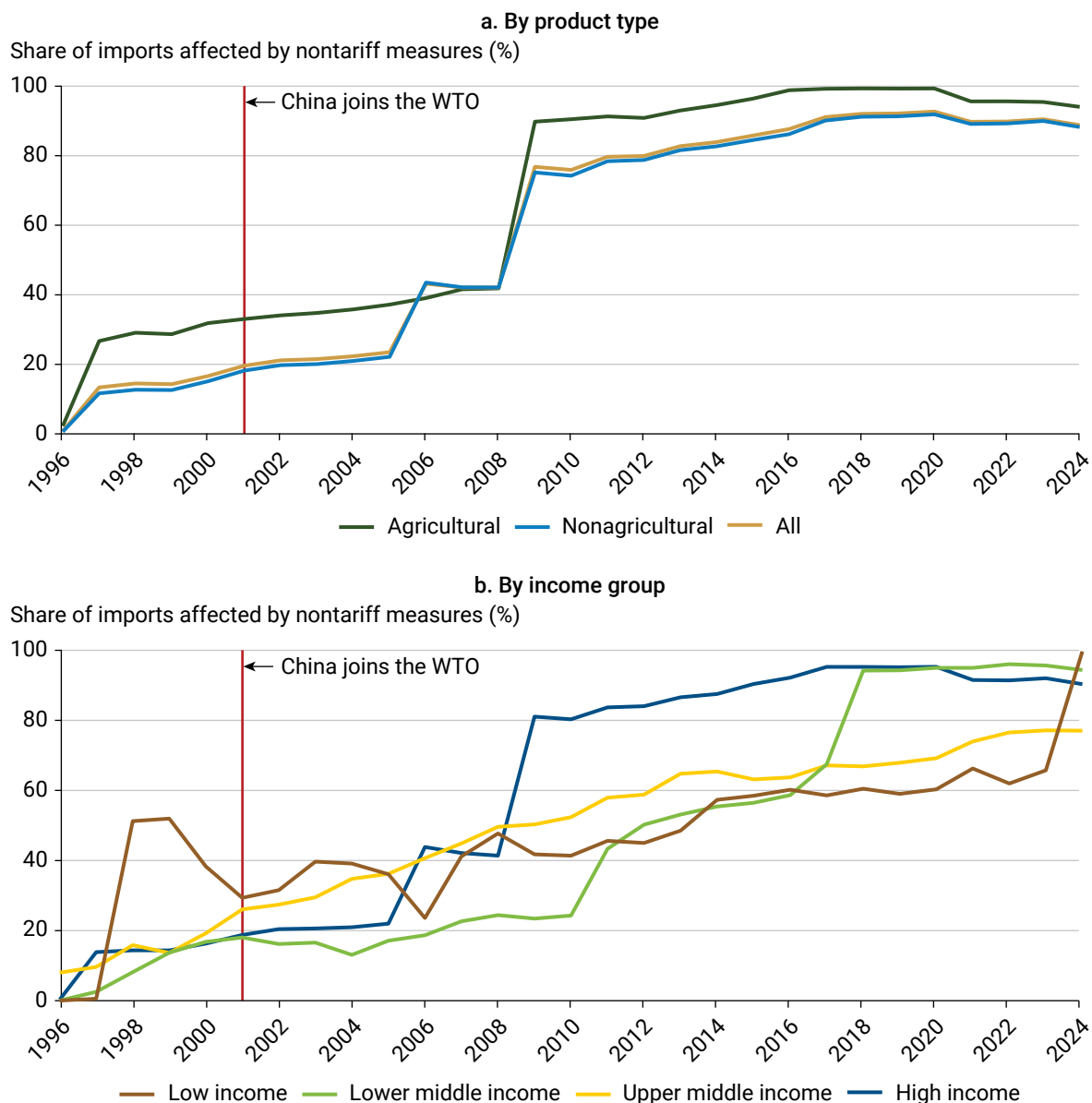
Veiled protectionism?

What explains the surge in technical regulations: legitimate public policy goals or disguised protectionism? Between the establishment of the WTO in 1995 and the early 2020s, the value of global merchandise trade more than quadrupled, from US\$4.4 trillion in 1996 to US\$18.6 trillion in 2021. Over the same period, average rates for most-favored-nation tariffs—the standard tariff rates that WTO members apply to imports from other WTO members—fell by 44 percent, from 13.2 percent to 7.4 percent. As the rates for these tariffs declined, however, many countries substituted nontariff measures, which are harder for exporting countries to challenge under WTO rules because they are technical in nature and countries often justify them by referring to safety or quality concerns.³⁴

Higher-income importing countries with an abundance of capital are particularly prone to replacing tariffs with nontariff measures, which can be more sophisticated protectionist instruments (refer to box 4.3). In contrast, developing-country exporters with an abundance of labor are more likely to face policy substitution of this kind. Technical nontariff measures are most likely to be imposed by one country in a pair of trading partners that are already linked by agreements that limit use of tariffs for protection of domestic producers, as well as among groups of countries that emulate one another's measures in response to changing consumer preferences or regional coordination.³⁵

Yet evidence also shows that countries often tighten technical regulations following surges in imports, suggesting that they sometimes use nontariff measures to shield local producers.³⁶

Figure 4.6 Technical nontariff measures now affect most imports



Sources: WDR 2025 team calculations, based on data from TRAINS [Trade Analysis and Information System] (portal), United Nations Trade and Development, <https://trainsonline.unctad.org/home>; WITS: World Integrated Trade Solution (database), World Bank, <http://wits.worldbank.org/WITS/>.

Note: The figure plots the share of imports regulated by technical nontariff measures: sanitary and phytosanitary measures, technical barriers to trade, and preshipment inspections. The sample includes all countries surveyed for the TRAINS database since 2020 and all nontariff measures enacted since 1996. WTO = World Trade Organization.

These regulations also affect essential goods, sometimes impeding trade among developing countries and the availability of food to respond to humanitarian crises (refer to box 4.4). For example, despite dairy's role in ending undernutrition,

numerous and divergent nontariff measures pertaining to dairy imports among developing countries increase compliance costs and thus can restrict dairy trade, especially for smaller dairy operators in Africa.³⁷

Box 4.3 Are food safety regulations protecting consumers or producers?

The Codex Alimentarius provides international benchmarks for food safety regulations, setting Maximum Residue Limits for pesticides, for example, to protect consumers and facilitate trade. Developing countries typically adopt Codex Maximum Residue Limits directly as national standards (refer to spotlight 2 for details on Codex Alimentarius). As they industrialize, they generally expand the number of pesticides covered and diverge from Codex levels, sometimes tightening limits.

Analysis for this Report using data from FoodChain ID shows that low- and lower-middle-income countries usually mirror Codex values for pesticide limits, upper-middle-income countries apply them on average but with more variation, and high-income countries set median Maximum Residue Limits that are stricter than those that Codex recommends. This partly reflects wealthier consumers' preferences for more stringent safety requirements, but the data also suggest that some governments lower Maximum Residue Limits strategically to protect domestic producers, especially for crops that can be grown domestically.

Source: WDR 2025 team.

Box 4.4 Some regulations may undermine international responses to humanitarian crises

Millions of people rely on humanitarian food assistance each year. Agencies such as the World Food Programme (WFP) pre-position food stocks in regional warehouses to respond quickly to emergencies, but inconsistent or overly strict national regulations often slow delivery.

For example, limits imposed by products' shelf life or sourcing restrictions can prevent the release of pre-positioned food, increasing lead times and delivery costs. In one case, a destination country rejected 12,500 metric tons of wheat flour because it contained a few dead insects, a level permitted under international norms but not under the country's national standards. The rejection caused losses of about US\$1.7 million, equivalent

(Box continues next page)

Box 4.4 Some regulations may undermine international responses to humanitarian crises (*continued*)

to 3.4 million school meals. To comply with that country's national standards, WFP now spends US\$60,000 annually on additional inspections, resources that could instead fund 120,000 more meals.

A 2019 incident in Uganda, in which fortified cereal contaminated with tropane alkaloids caused illness and fatalities, highlighted gaps in global guidance on food safety for humanitarian contexts. In response, the Food and Agriculture Organization (FAO) and the World Health Organization (WHO) issued new guidance on tropane alkaloids, and Codex is developing a code of practice. But much remains to be done to harmonize crisis-responsive standards for food safety and strengthen capacity for implementing them.

Source: VAM [Vulnerability Analysis and Mapping] Resource Centre (dashboard), World Food Programme, <https://resources.vam.wfp.org/>.

The main challenge for developing countries is not only the number of standards and regulations confronting them as they try to export goods and services but also the diversity and complexity of these standards and regulations. Rather than facing a single coherent rule book, exporters confront a spaghetti bowl of overlapping technical requirements, each with its own conformity assessment.

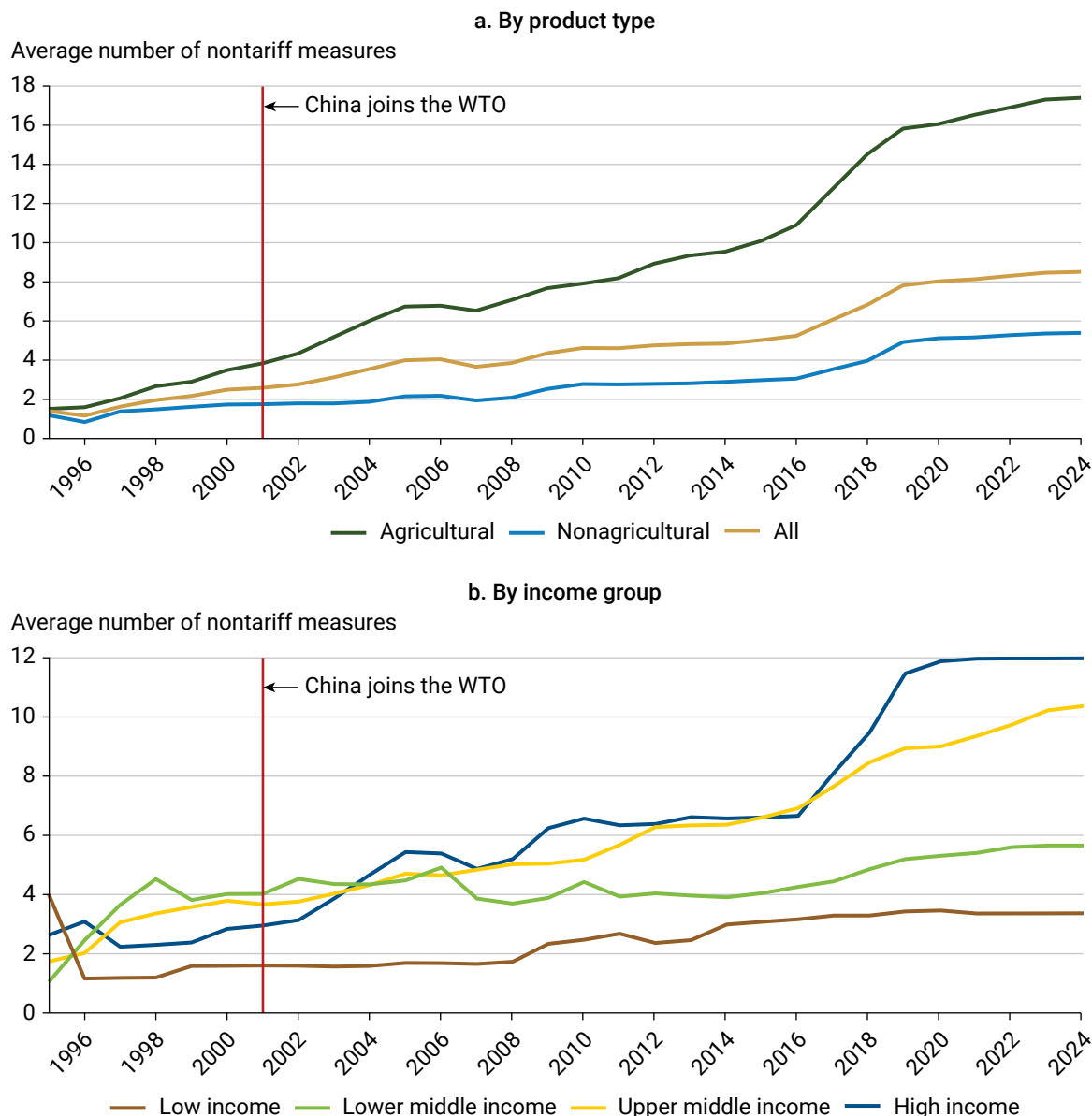
Today, exporting countries must comply with an average of 9 technical regulations to enter a foreign market, compared with just 2 three decades ago. High-income markets typically impose more than 12 requirements; low-income markets fewer than 4 (refer to figure 4.7). For agricultural and food products, exporters often face both sanitary and phytosanitary measures and technical barriers to trade, meaning more than 15 distinct technical regulations on average.³⁸

Beyond their sheer number, technical regulations vary widely across markets. The concept of

regulatory distance measures the divergence between two countries' regulations.³⁹ A distance of 1 implies that the regulations in the two countries concern entirely different products or characteristics; a distance of 0 would indicate complete harmonization. In 2001, the average regulatory distance between the European Union (EU) and low- and middle-income countries exceeded 0.9, meaning almost no overlap.⁴⁰ The average distance between the EU and high-income countries was 0.7. Although the regulatory distance has narrowed over time among countries in all income groups, it has fallen faster among rich countries, widening the gap in market access between high-income and low- and middle-income countries.

Nontariff measures also affect trade in services. Recent analysis using data from the World Bank–WTO Services Trade Policy Database and scores on the associated Services Trade Restrictions Index⁴¹ finds that low- and middle-income countries still impose more restrictions on trade in

Figure 4.7 Developing countries face many more technical regulations than developed countries because of the nature of their exports



Source: WDR 2025 team calculations, based on data from TRAINS [Trade Analysis and Information System] (portal), United Nations Trade and Development, <https://trainsonline.unctad.org/home>.

Note: The figure plots the average number of technical nontariff measures—sanitary and phytosanitary measures, technical barriers to trade, and preshipment inspections—regulating each import market (origin-destination-product). The sample includes all countries surveyed for the TRAINS database since 2020 and all nontariff measures enacted since 1996. WTO = World Trade Organization.

services than high-income countries, though the gap is closing.⁴² For example, between 2016 and 2019, 50–60 percent of knowledge services such as law or engineering required professional examinations in both groups of countries. Today, the share has dropped below 40 percent in lower-middle-income countries but remains above 50 percent in high-income ones. Regulations on services are often even more restrictive than non-tariff measures on goods, yet their effects on trade are harder to measure.

The emergence of private standards as a response to new regulations and increased demand

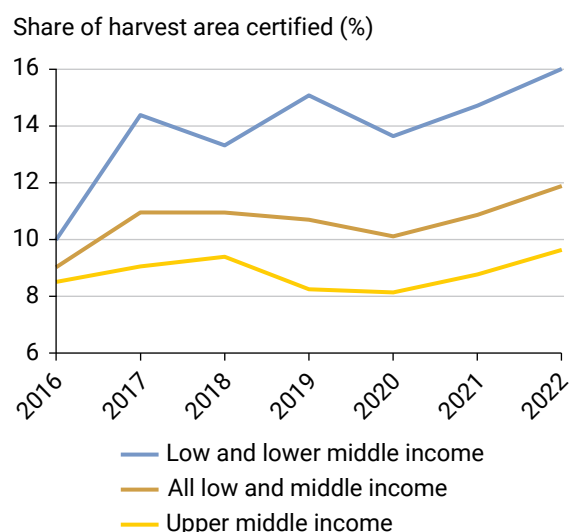
The rapid growth of private standards reflects increasing regulatory demands and consumer expectations. These standards, developed by non-governmental organizations, industry groups, and global buyers, play a central role in global value chains, especially in countries where public capacity for enforcement of standards is weak.

Compliance with private standards is typically written into contracts between suppliers and buyers. By creating predictable rules, private standards have facilitated the expansion of outsourcing and offshoring in manufacturing and services since the 1990s. In food safety, they initially served as marketing tools for product differentiation but soon became mechanisms for managing regulatory and reputational risk after a series of safety crises in the 1980s.⁴³

However, proliferation of private standards led over time to some duplication.⁴⁴ Suppliers selling to multiple retailers often needed multiple certifications, each requiring audits and documentation, even when standards covered similar criteria.⁴⁵ Consolidation and benchmarking have eased this problem somewhat: today, five or six major standards for food safety dominate global certification.

Private standards have since extended into environmental and labor domains. The share of farmland certified under major sustainability schemes, such as Fairtrade, Rainforest Alliance, and GLOBALG.A.P., has grown by nearly 50 percent in recent years, mainly in low- and lower-middle-income countries (refer to figure 4.8). Although areas certified under such schemes remain small relative to total production, adoption of the schemes is accelerating.

Figure 4.8 Private sustainability standards cover a growing share of harvest area



Sources: WDR 2025 calculations, based on FAOSTAT (dashboard), Food and Agriculture Organization of the United Nations, <https://www.fao.org/faostat/en/#home>; State of Sustainable Markets, 2024 (dashboard), International Trade Centre, <https://standardsmap.org/en/trends>.

Note: The figure reports the share of total harvest area for eight key commodities (bananas, cocoa, coffee, cotton, oil palm, soybeans, sugarcane, and tea) certified across 12 private sustainability standards (4C, Better Cotton, Bonsucro, CmiA [Cotton made in Africa], Fairtrade, GLOBALG.A.P., Organic, ProTerra, Rainforest Alliance, RSPO [Roundtable on Sustainable Palm Oil], RTRS [Roundtable on Responsible Soy], and UTZ). High-income countries are excluded from the figure because almost none produce the commodities the figure covers. Low- and lower-middle-income countries are combined on account of the small sample size.

Early sustainability initiatives sought to raise awareness of sustainability and offer price premiums for commodities provided sustainably⁴⁶ but faced challenges related to excessive certification, limited benefits for producers,⁴⁷ and high monitoring costs in fragmented supply chains. Evidence on their effectiveness is mixed.⁴⁸

Next came buyer-led sustainability programs, like Nespresso's AAA Sustainable Quality Program in Colombia in conjunction with Rainforest Alliance, which provide premiums, technical assistance, and long-term sourcing, enhancing quality and incomes through higher prices firms can charge for commodities they produce but also requiring firms to make substantial investments.⁴⁹ Similarly, in the garment sector, companies like Gap use labor audits to influence sourcing. These programs foster long-term relationships and trust to ensure compliance.

More recently, multibuyer and industry-led initiatives like the Better Work program and the Accord on Fire and Building Safety in Bangladesh have aimed to harmonize standards, strengthen their credibility, and reduce redundant audits. The approaches taken by these initiatives improve efficiency and trust but can also dilute standards or concentrate influence among private actors, raising concerns about accountability and sovereignty. Legal challenges to the accord in Bangladesh illustrate these tensions. Moreover, the benefits of certification often remain confined to producers that participate in supply chains, as shown in Costa Rica, where wage gains in certified sectors have been offset by declines elsewhere.⁵⁰

Whereas compliance with technical regulations allows products to *cross borders*, compliance with private standards determines whether they can *reach the shelf* after they do so. On average, exporters of major agricultural commodities face three or four private standards, each with different criteria.⁵¹ For instance, among the four major

coffee certifications—4C, Fairtrade, Organic, and Rainforest Alliance—the share of overlapping criteria in any pair ranges from 42 to 71 percent.⁵² The variation in certification criteria pushes firms toward maintaining multiple certifications or market specialization.

Smallholders and firms with limited technical capacity often find certification too costly,⁵³ which can exclude them from high-value markets.⁵⁴ Private standards are most prevalent in countries with strong governance and quality infrastructure, whereas those with weaker systems struggle to support producers' compliance with such standards.⁵⁵

Governments are beginning to reference private standards in new due-diligence regulations. The EU's Regulation on Deforestation-free Products (referred to less formally as the European Union Deforestation Regulation, or EUDR),⁵⁶ for example, does not formally recognize any private standard but allows importers to rely on data used for certification under private schemes to demonstrate their compliance with the regulation. In response, Rainforest Alliance revised its 2024 criteria to align with EUDR rules regarding traceability and land use.⁵⁷

The impact of the proliferation of standards and technical regulations on international trade

What impact does this proliferation of standards and regulations actually have, especially on exports from developing countries? A substantial body of evidence shows that adoption of standards by developing countries can increase those countries' exports, largely by improving quality and increasing comparability and trust. But when importing countries adopt new standards or technical regulations, the effects on exporters in developing countries are more ambiguous.⁵⁸ For exporters in developed countries,

the adoption of standards abroad generally has a positive impact on exports.⁵⁹ For exporters in developing countries, however, the impact is generally negative,⁶⁰ unless the standards adopted abroad are harmonized, either through adoption of international standards⁶¹ or mutual recognition of standards among destination countries.⁶²

More recent evidence has focused on how increasing technical regulations in destination markets are influencing exports. The evidence generally finds a negative effect, especially in regard to developing countries (refer to figure 4.9). For example, sanitary and phytosanitary measures such as limits on aflatoxin have a stronger negative effect on exports from developing countries than on those from high-income countries.⁶³ They cause firms in developing countries to exit export markets, especially SMEs, which cannot cover the costs of compliance.⁶⁴ In the case of Maximum Residue Limits, the wider the gap is between exporter and importer market limit for a particular product, the more exporting firms in the exporting country exit the market for exporting the product to the importing country. Similarly, firms from developing countries, especially low- and lower-middle-income countries, that export food and feed products to the EU and the United States are more likely than countries at other income levels to have their products refused at the border (refer to figure 4.10).

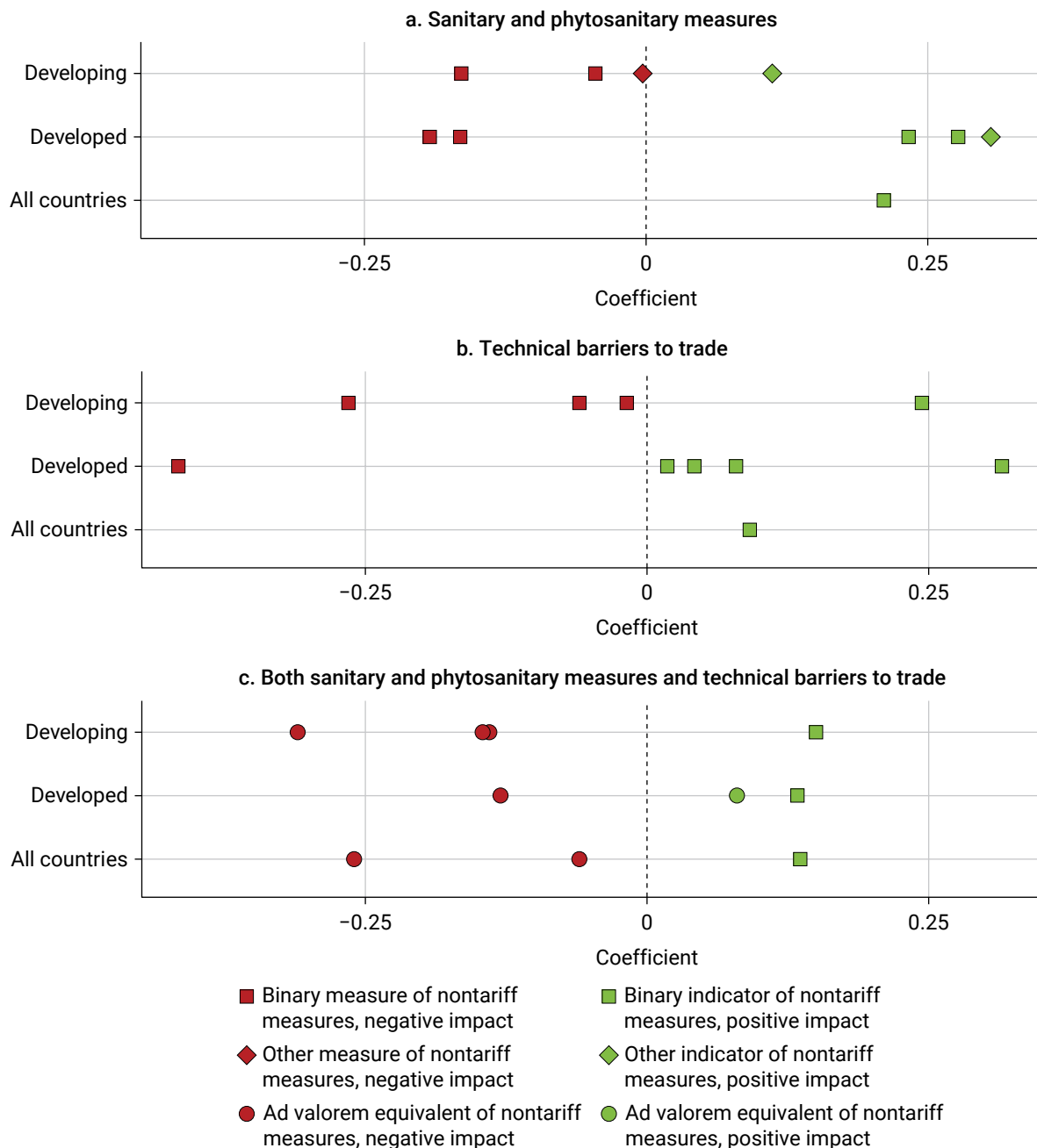
For higher-income countries that impose stringent regulations, imports generally shift toward other higher-income trading partners, particularly those that impose similar regulations. This increases the concentration of trade among higher-income countries.⁶⁵ For lower-income countries that cannot comply with strict regulations, exports generally shift toward their lower-income trading partners that do not impose such regulations. This increases the concentration of trade among developing countries.

Together, these effects can increase the segmentation in global markets.

Moreover, the recent surge in nontariff measures imposed by developing countries, discussed earlier in the chapter, creates the possibility that regulations will reduce overall exports from developing countries, rather than just reallocating them. Firms facing more regulations across all markets will have nowhere to go but out of business. In some cases, technical regulations can even cause harm to the countries that implement them. For example, in 2021 Sri Lanka temporarily banned fertilizer imports, with the goal of becoming the world's first fully organic country. The plan backfired when the country's farmers were unable to adjust quickly enough to the ban and rural income plummeted.⁶⁶ In Indonesia, technical regulations on imported inputs reduced exporters' ability to scale up production quickly, limiting the benefits of the unexpected positive shocks to demand.⁶⁷

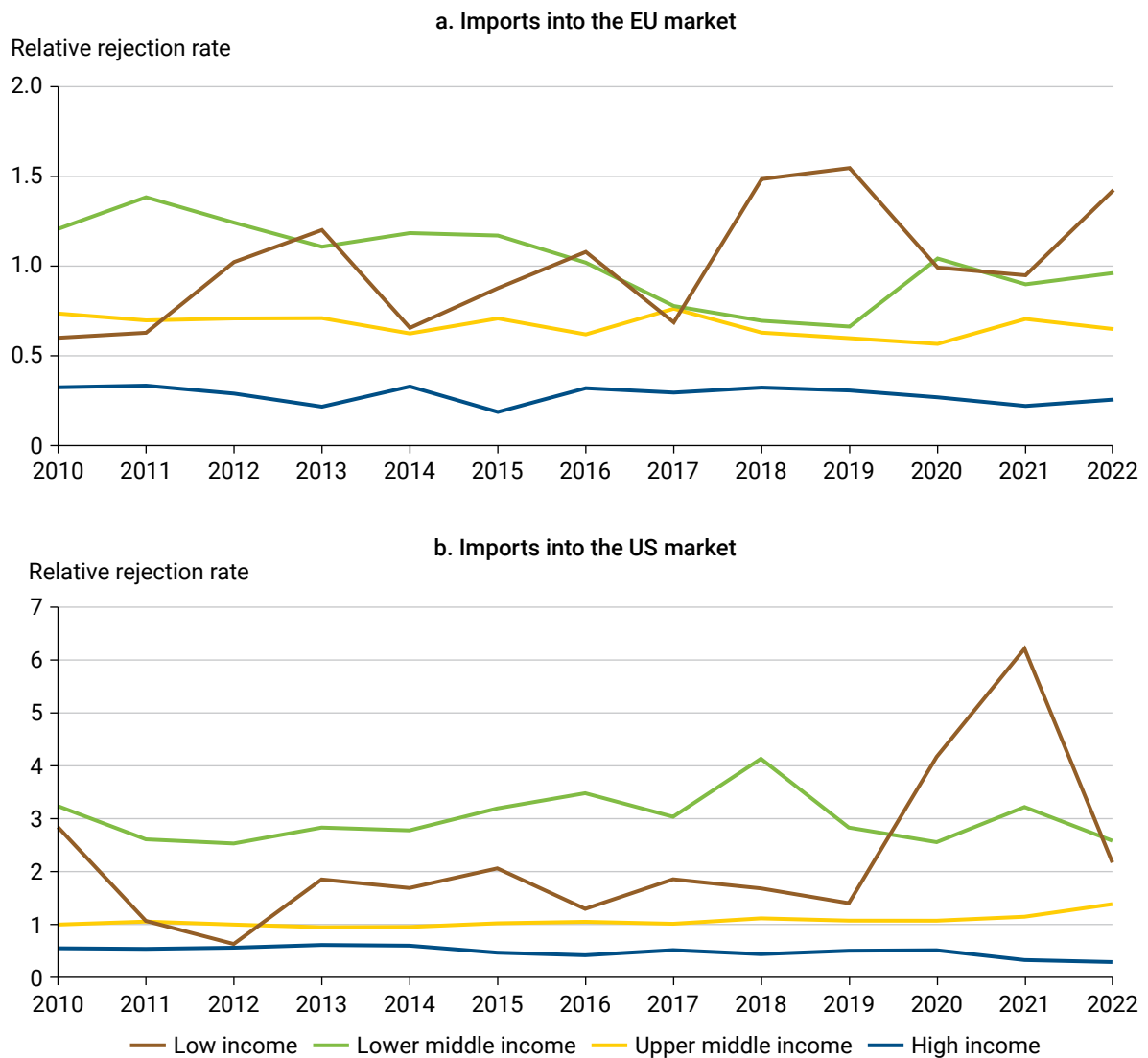
On the one hand, technical barriers to trade can have a negative impact on exports from developing countries.⁶⁸ As with Maximum Residue Limits, the effect is stronger when there is less overlap between the limits for a particular product in the exporting country and the limits for that product in the importing country.⁶⁹ The high costs of testing, certification, and inspection procedures are particularly detrimental to developing countries, highlighting the need for greater availability of quality infrastructure services in those countries.⁷⁰ On the other hand, some technical barriers to trade can have a positive impact on exports from developing countries.⁷¹ This is particularly true in regard to labeling requirements,⁷² which can increase demand by signaling product quality. Quality signaling has greater benefits for firms in developing countries, which may not require such labeling for the domestic market, as this type of signaling can make their products more competitive in export markets.

Figure 4.9 Technical nontariff measures generally have negative impacts on exports from developing countries



Sources: WDR 2025 team analysis, based on Disdier et al. 2008; Fernandes et al. 2019; Fontagné and Orefice 2018; Fontagné et al. 2015; Hoekman and Nicita 2011; Iodice and Reverdy 2025; Murina and Nicita 2017; Zavala et al. 2023.
 Note: The figure shows point estimates of coefficients from regressions in selected studies. The dependent variable is log exports by origin country. An *ad valorem equivalent* is a conversion of a nontariff trade barrier into an equivalent percentage tariff.

Figure 4.10 Low- and lower-middle-income countries experience high refusal rates in exports of food and feed to EU and US markets



Source: WDR 2025 team calculations, based on data of SCA: Standards Compliance Analytics (portal), United Nations Industrial Development Organization, <https://hub.unido.org/sca/#/>.

Note: An exporting country's relative rejection rate (in a specific import market for a particular year) is calculated as the ratio of its share of total rejections in that import market to its share of total imports in that market for that year. The figure covers imports of animal, agricultural, and food products. EU = European Union.

As mentioned, an increase in the number of private standards has accompanied the expansion of technical regulations. Evidence regarding the impact of private standards on firms and workers is mixed, and the effect depends on whether consumer willingness to pay higher prices outweighs the costs to producers of upgrading and certification.⁷³ When the effect of consumer demand dominates, standards can increase the likelihood and sales of a firm's exports,⁷⁴ but if the costs of upgrading and certification are large enough, they may reduce a firm's sales and earnings.⁷⁵ Private standards can facilitate access to premium markets, enhance product quality, and foster stronger ties to supply chains,⁷⁶ sometimes delivering significant income gains to producers, as Nespresso's AAA Program has shown.⁷⁷ They also support sustainability through better management of resources, reduced pollution, and protection of biodiversity⁷⁸ and can improve labor conditions, as evidenced by Gap's audit-based sourcing model for labor.⁷⁹ However, evaluations of certifications provided by nongovernmental organizations often report only modest impacts dependent on the context.⁸⁰

Private standards can also impose negative externalities at the market level. As more firms become certified, the average quality of certified firms may fall, weakening the effects of consumer demand.⁸¹ At the same time, standards can raise local wages, generating costs that spill over to noncertified firms.⁸² The spaghetti bowl of private standards can complicate the effects of both of these factors, reducing the ability of any one standard to signal quality and multiplying the costs of compliance with standards overall.

How developing countries should deal with a spaghetti bowl of regulations and standards

The proliferation of standards and regulations, coupled with the rise of industrial policies

and global uncertainty, poses a formidable challenge for developing countries. Yet these challenges can be managed—and even leveraged—if countries strengthen their domestic quality infrastructure and adopt coherent trade and regulatory strategies.

The recommendations in this subsection build on discussions in chapter 3 (on developing robust national quality infrastructure) and the previous section (on increasing the quality of domestic products and services). Together, they provide a road map for turning standards from barriers into enablers of trade and growth.

Reduce trade costs by revising existing nontariff measures. Nontariff measures can serve legitimate public purposes but often impose high costs related to compliance. Governments can lower these costs through three key actions:

- *Using good regulatory practices.* Define clear policy objectives and regulate only when necessary. Favor voluntary standards when possible to avoid overregulation. When regulation is required, choose a standard at the appropriate level—international, regional, or national—and adapt it only as justified by local conditions. Good regulatory practices such as stakeholder consultation, assessment of regulatory impact (refer to box 8.2 in chapter 8), and regular review ensure transparency and efficiency. Interagency committees or frameworks for technical regulation can also promote coherence across ministries and help governments adapt regulations to evolving technology.
- *Increasing transparency.* Provide timely, accessible information on import requirements, ideally through online portals for trade information or digital tools that allow firms to anticipate regulatory changes and adjust production accordingly.⁸³

- *Reducing costs of certification.* Strengthen national quality infrastructure (refer to chapter 3) to expand access to affordable testing, metrology, and certification services. Allow competition among service providers, including accredited foreign entities, to enhance quality and reduce costs. Transparent accreditation also facilitates mutual recognition agreements with trading partners.

Align regulations and maximize existing regional and international trade agreements. Full regulatory harmonization—making technical regulations identical across countries—requires a great deal of resources and time and often favors developed countries.⁸⁴ For most developing countries, *regulatory alignment*—reducing discrepancies between a country’s regulations and those of other countries and building equivalence—is a more practical and beneficial approach. Governments can support such alignment in various ways:

- *When possible, base regulations and procedures for assessing conformity on international standards,* as recommended in WTO agreements. If international standards are not the most suitable option and need to be adapted to local conditions, make adaptation transparent and base it on strong assessments of the standards’ impact.
- *Where differences exist, countries should rely on equivalence or mutual recognition of procedures for assessing conformity,* so that tests and certifications in one country are accepted as valid in other countries. Mutual recognition agreements can reduce costs and facilitate trade by enabling countries to accept one another’s regulations or procedures for assessing conformity, though compliance with the importing country’s standards is still required.⁸⁵ For developing countries, mutual recognition

agreements offer strategic advantages in regard to market access, but successful negotiation depends on technical details, trust, and capacity building, which require support from development partners.

- *Engage multilaterally.* Multilateral engagement through the WTO’s technical barriers to trade and sanitary and phytosanitary committees remains essential. These committees provide forums that allow early dialogue before new measures enter into force, encourage regulatory transparency, and promote the diffusion of good practices.

Clarify the role of private standards in public policy. Governments need to clarify how private standards interact with public regulation. Direct regulation of private standards is rarely feasible, but governments can play a coordinating and oversight role. Public agencies and national standards bodies can convene stakeholders to share information, benchmark private standards against international ones, and identify when coregulation or third-party assurance might be appropriate. Some countries integrate private standards into pathways for complying with public regulations. For example, as noted earlier, under the EUDR, importers may use certification under private schemes to demonstrate due diligence.

Implement reforms that facilitate trade. Cumbersome procedures and poor coordination among border agencies exacerbate the costs of regulation. Implementing measures to facilitate trade can reduce these frictions.⁸⁶ Priority actions include simplifying border procedures, adopting risk-based inspection systems, introducing prearrival processing, and implementing electronic single windows for certification and clearance. Digital certification platforms can streamline verification and reduce delays, particularly for perishable goods. Coordinated border management between customs and

standards authorities prevents redundant checks and increases efficiency. Such reforms yield large gains in competitiveness for exporters and importers alike.

Raise awareness and build technical capacity. Capacity building is essential for enabling firms, especially SMEs, to navigate complex standards and regulations. Governments should invest in programs that promote awareness of new requirements, in technical training, and in targeted support for upgrading production processes. Training in good agricultural practices, good manufacturing practices, and sector-specific international standards can increase firms' readiness for export markets. Public-private partnerships can help tailor training programs to industry needs, enabling firms to anticipate and meet evolving requirements imposed by standards.

Close the participation gap in development of international standards with changes in priorities and better coordination. Developing countries remain underrepresented in international standards development bodies such as Codex and ISO. Greater participation by these countries is crucial for ensuring that global standards reflect the countries' realities. Governments should make funding and training for experts a priority so these experts can engage effectively in international committees. Governments should also concentrate their efforts on sectors with high export potential. Coordination across ministries, national standards bodies, industry, and research institutions is vital, as is support from development partners to build technical expertise and institutional continuity.

Taking action in this area is urgent. This section has documented a process over the past few decades of gradual substitution of nontariff measures for tariffs, but with the current rise in tariffs, if nontariff measures are not reduced, protectionism will increase significantly and make

market access even more difficult for developing countries, kicking away the trade ladder to development.

Using foreign direct investment to accelerate the diffusion of standards and quality upgrading

FDI has long been a catalyst for growth—driving capital flows, technology transfer, and job creation—while increasingly serving as a vehicle for diffusing international standards.⁸⁷ Through investment, multinational enterprises embed globally recognized standards in their local operations, strengthening regulatory frameworks, corporate governance, and environmental and labor practices in host countries. This process promotes convergence of institutional quality across countries, increases the quality of products and services, and builds capabilities among domestic firms.

The relationship also runs the other way. Countries that adopt and enforce international standards tend to attract more FDI, as credible regulatory frameworks signal stability in a country's regulatory environment and reduce the related operational risks. By aligning local rules with global practices, governments create an environment that fosters not only investment, but also the diffusion of knowledge, technology, and good practices across their economies.

Adopting standards to attract FDI and motivate investors

Standards can make investment environments more predictable and transparent, but their influence depends on the motives and origins of investors. FDI is not homogeneous: Firms invest abroad for different reasons—whether to access new markets, secure resources, improve efficiency, or acquire strategic assets—and firms with each type

of motivation respond differently to standards.⁸⁸ Investors that seek efficiency, aiming to reduce costs and serve export markets, are particularly sensitive to international standards, especially when selling to tightly regulated markets such as the European Union. For these investors, strong and harmonized standards decrease uncertainty regarding local conditions and facilitate integration into global supply chains. By contrast, market-seeking investors, focused on serving domestic consumers, may make adapting to local standards a priority, even when those standards are less stringent than international ones.

The source of investment also matters. Investors from countries with weaker standards or lower enforcement may not demand strong compliance in host economies unless pressured by buyers, as has been observed in joint ventures in China⁸⁹ and investments by BRIC countries (Brazil, the Russian

Federation, India, China, and others).⁹⁰ Conversely, firms from countries with stricter regulatory regimes may relocate production to jurisdictions with looser standards to reduce compliance costs, a trend consistent with the pollution haven hypothesis (refer to chapter 6).⁹¹

Although the size of the host market remains the strongest factor motivating FDI,⁹² adoption of international standards in areas such as product quality, corporate governance, environmental sustainability, and labor regulations can create a more predictable and transparent investment climate, which in turn reduces risks for foreign investors and attracts FDI. Aligning with global standards also indicates regulatory stability and a dedication to best practices, making countries more attractive for high-quality FDI (refer to box 4.5). Over time, this positive cycle boosts investor confidence and promotes deeper international integration.

Box 4.5 Global standards as catalysts for attracting foreign direct investment

Quality standards (International Organization for Standardization [ISO] 9000) and environmental standards (ISO 14000)

Adoption of ISO 9000 by domestic firms signals strong quality management and has been associated with increased inflows of foreign direct investment (FDI), especially in less-developed countries.^a This finding is supported by newer evidence^b showing that ISO certification attracts more FDI from developed to developing countries. Market pressure, particularly from global buyers, has prompted domestic firms to adopt ISO 9000 and ISO 14000, with governments in Japan and Taiwan, China, actively promoting certification to prevent losses of exports and attract FDI.^c

International Financial Reporting Standards

Adoption of International Financial Reporting Standards (IFRS) enhances countries' financial transparency and decreases information asymmetry among potential investors, making countries more appealing to investors (refer to spotlight 4 for details). Studies show adoption of these standards increases foreign ownership of mutual funds^d and boosts

(Box continues next page)

Box 4.5 Global standards as catalysts for attracting foreign direct investment (*continued*)

FDI inflows into developing countries.^e However, the effect varies. Whereas several studies indicate a positive relationship in Africa,^f others caution that without broader institutional reforms, adoption of IFRS alone may not improve FDI.^g Overall, international standards, combined with strong institutions and policies that are friendly to investors, can significantly enhance a country's attractiveness for FDI.

Source: WDR 2025 team.

a. Clougherty and Grajek (2008).

b. Naumann et al. (2024).

c. Corbett (2006).

d. DeFond et al. (2011).

e. Gordon et al. (2012); Lungu et al. (2017).

f. Akpomi and Nnadi (2017).

g. Nnadi and Soobaroyen (2015).

Domestic regulations regarding environmental protection, labor conditions, safety, and national security are binding requirements that can either support or hinder investment. In environments with high degrees of informality, strict labor regulations can backfire, pushing firms out of the formal sector and reducing productivity and wages. Poorly designed laws protecting employment risk undermining both worker protection and economic efficiency.⁹³

Ultimately, the impact of standards on attracting FDI hinges on striking the right balance: Standards need to be high enough to ensure quality and credibility but not so burdensome that they deter investment. Overly complex, overlapping, or poorly coordinated regulations can create uncertainty for investors and raise the costs of entering domestic markets, particularly in developing countries with limited administrative capacity. Aligning domestic standards with international norms, while streamlining procedures for compliance, helps attract high-quality FDI oriented toward sustainability and long-term development.

FDI and the diffusion of standards

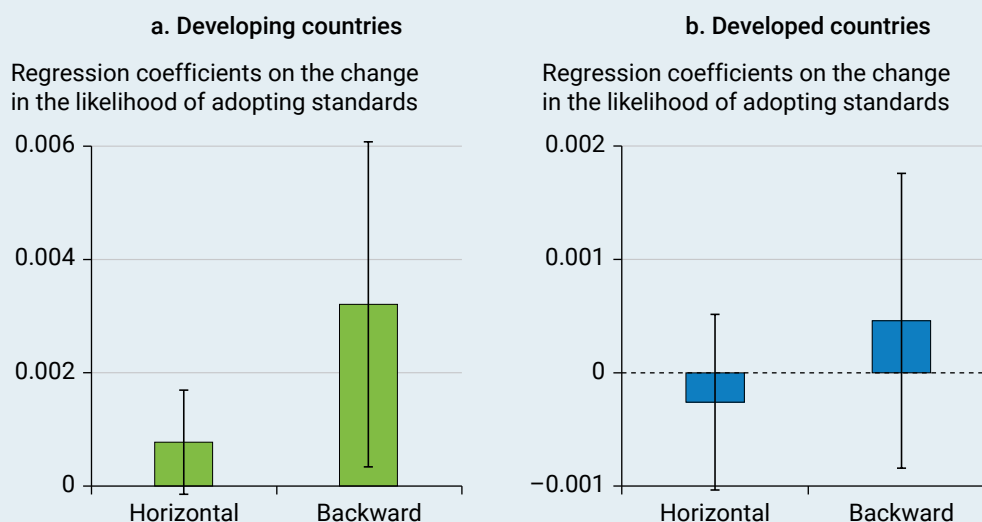
FDI can promote the adoption of international standards through multiple mechanisms. First, direct links between domestic and foreign firms, such as joint ventures and strategic partnerships, allow domestic firms to absorb the practices of multinational enterprises, which are often superior.⁹⁴ Second, FDI spillovers can promote greater adoption of standards through links in value chains (refer to box 4.6), labor mobility, and market restructuring that shifts industrial composition toward more competitive sectors.⁹⁵ Third, institutional upgrading is catalyzed when local firms align with regulatory frameworks introduced or reinforced by foreign investors.⁹⁶

However, whether FDI can promote the adoption of international standards depends on whether countries address structural constraints and market failures that limit the direct and spillover impacts of these standards on domestic economies. On the demand side, high entry costs and regulatory uncertainties can increase perceived

Box 4.6 Diffusion of standards driven by foreign direct investment and upgrading of capabilities in supplier networks

The diffusion of standards is stronger among suppliers to value chains in developing countries than among other domestic firms in those countries, according to data from the World Bank Enterprise Surveys and fDi Markets. This is because these suppliers must comply with the quality, environmental, and labor standards of multinational enterprises to remain in good standing as suppliers. Figure B4.6.1 illustrates this pattern. As firms upgrade their capabilities, they often increase their efficiency and competitiveness. Such upgrading has a less significant impact in high-income countries, where firms already operate under well-established regulatory frameworks and industry standards. Moreover, developed countries typically enforce stringent policies and already adopt standards at high rates, further reducing the potential impact of FDI on the diffusion of standards to these countries.

Figure B4.6.1 Higher FDI inflows are associated with a greater likelihood of adopting international standards in developing countries, particularly for local suppliers



Sources: WDR 2025 team, using data from and methods of Eora National IO [Input-Output] Tables, KGM and Associates, <https://worldmrio.com/countrywise/>; OECD 2023; World Bank Enterprise Surveys (dashboard), World Bank, <https://www.enterprisesurveys.org/en/enterprisesurveys>.

Note: The figure shows the estimated effect of higher inflows of foreign direct investment (FDI) on the likelihood that firms will adopt an international quality standard and certification for it. It displays estimated coefficients (bars) and 95 percent confidence intervals (whiskers) from a Probit regression analyzing the effect of greenfield FDI on firms' adoption of certification for international quality standards, following Javorcik (2004), but using investment counts instead of foreign ownership shares in calculating horizontal (same industry) and backward (local suppliers) links. It differentiates horizontal spillovers from vertical backward spillovers (among suppliers). The unweighted regression includes country, sector, and year effects, covering only domestic firms, with countries classified according to World Bank income groups.

Source: WDR 2025 team.

risks for foreign investors. On the supply side, domestic firms often face gaps in the skills required to enter foreign markets, limited access to finance, and weak innovation systems, all of which can reduce their ability to benefit from FDI. Other barriers, such as inadequate infrastructure or the dominance of certain industries by state-owned

enterprises, hinder efforts to strengthen links between multinational corporations and local firms. When foreign investors plan to export goods or services back to their regions and those regions have high standards, these investors may pressure host countries to adopt international standards, as discussed in box 4.7.

Box 4.7 Standards induced by foreign direct investment drive transformation in the automotive sector

Multinational enterprises have introduced strict standards for quality and sustainability, such as International Organization for Standardization (ISO) 9001 and International Automotive Task Force (IATF) 16949,^a into their operations in host countries. Increasingly, many automotive manufacturers are setting more ambitious targets in response to global commitments related to climate and market-driven sustainability goals. For example, Mercedes-Benz aims to be carbon neutral by 2039 and in the future will work only with suppliers that are completely carbon neutral.^b As multinational enterprises push for targets of this type, suppliers are compelled to upgrade their practices or risk exclusion from global value chains.

Tunisia's automotive components sector: Upgrading sustainability practices

Tunisia's automotive components sector has become a magnet for foreign direct investment (FDI) from Europe on account of the country's proximity to much of Europe, skilled labor force, and integration into the European Union's automotive supply chain. The sector, which accounted for 14 percent of Tunisia's exports and employed more than 90,000 people as of 2021,^c has experienced an average growth rate of 10 percent since 2010 as a result of foreign participation. The global push toward sustainability means that the Tunisian automotive industry must meet environmental regulations and cut its carbon footprint earlier than 2050. The Tunisian Automotive Association (TAA) has responded to this requirement by promoting adoption of environmental, social, and governance sustainability practices among local companies and supporting compliance with environmental goals, fair labor conditions, and good governance practices.^d

COFICAB: A case of upgrading driven by FDI

Firms like COFICAB Group, a producer of cables, show how integration into global networks of multinational enterprises can speed up the adoption of international standards. As a supplier to major automakers, including Volkswagen (VW), Bayerische Motoren Werke Aktiengesellschaft (BMW), and General Motors (GM),^e COFICAB has embedded global standards into its operations, including ISO and IATF certifications of quality, environment, and

(Box continues next page)

Box 4.7 Standards induced by foreign direct investment drive transformation in the automotive sector (*continued*)

worker safety. COFICAB is committed to achieving carbon neutrality by 2050. By 2025, the company aims for a 20 percent increase in energy efficiency, a 20 percent utilization of renewable energy, and a 20 percent reduction in its carbon footprint. Its quality management system is certified under ISO 9001 and IATF 16949, under ISO 45001 for health and safety at work, and under ISO 14001 for environmental management systems.

China: Standards diffusion through joint-venture FDI

China's experience shows how regulatory frameworks tied to FDI can promote the adoption of international standards. For decades, foreign automakers seeking access to the Chinese automobile market were required to form joint ventures with Chinese firms and comply with requirements regarding technology transfer and localization of operations. These conditions, along with the implementation of Euro 1 emissions standards in the European Union, which set stricter requirements for vehicle emissions of various pollutants, compelled foreign companies to introduce more advanced and cleaner technologies into their joint ventures in China.^f Although the main motivation for foreign investors was market entry, these arrangements contributed to the diffusion of environmental standards and the strengthening of domestic technological capabilities. At the same time, local partners helped foreign firms navigate domestic regulations. Since December 2021, however, China has relaxed these requirements, eliminating caps on foreign equity in manufacturing of passenger vehicles and allowing wholly foreign-owned enterprises.

Source: Adapted from Sawaqed 2024.

- a. For more information, refer to About IATF 16949:2016 (dashboard), International Automotive Task Force, <https://www.iatfglobaloversight.org/iatf-169492016/about/>.
- b. Mercedes-Benz Group (2025).
- c. AfricanManager (2022).
- d. Khdimallah (2024).
- e. FIPA (2022).
- f. Gallagher (2006); Saikawa and Urpelainen (2014).

Despite the successful cases discussed in box 4.7, evidence of positive impacts of FDI on diffusion of standards is limited to certain sectors and regions. In some countries in Latin America, the presence of affiliates of multinational enterprises has not significantly influenced the adoption of ISO 9000 series standards.⁹⁷ This may be because multinational enterprises often

operate in sectors in which quality standards have a lower priority or are less stringent, such as extractive industries; these enterprises have weaker links with local suppliers and SMEs; and when adjusted for per capita income, standards may cost relatively more in these countries than in advanced economies that are the source of FDI.

Aligning policies and building capacity to harness spillovers of foreign direct investment

Increasing geopolitical tensions and regulatory fragmentation are changing the relationship between FDI and the diffusion of standards. Standards that were originally developed to promote labor rights and environmental protection are increasingly being used as tools of industrial and strategic policy, especially in high-income countries, with an increase in the number of processes for screening investors and investment. This may have contributed to the fall in recent years in FDI flows to developing countries to their lowest level since 2005.⁹⁸

From the investor's perspective, higher costs related to regulatory compliance, potential delays in project implementation, and stricter processes and procedures for obtaining necessary approvals—all driven by these increased tensions and fragmentation—can discourage positive investment decisions. But with unilateral actions growing, developing countries need to strengthen their domestic institutions, support regional cooperation, participate in multilateral efforts to increase transparency (discussed in chapter 8), and align their policies with investor motivations to maximize FDI's role in upgrading standards and encouraging sustainable development.

Specifically, to maximize the benefits from the relationship between FDI and standards, policy makers should consider the following:

Excessive regulatory screening may backfire. Mechanisms put in place to screen investment, though justified for strategic sectors or national security, can increase uncertainty regarding investment conditions among potential investors and deter inflows. The use of such mechanisms has decreased in high-income countries: About 70 percent of OECD member countries maintained such mechanisms three decades ago, but

fewer than one in six still followed this practice by 2015–16.⁹⁹ In contrast, many developing countries continue to impose entry restrictions that deter FDI, as shown by average scores for developing countries on an OECD index that measures countries' restrictiveness regarding FDI.¹⁰⁰ Empirical studies¹⁰¹ demonstrate that reducing screening intensity can increase FDI inflows, particularly into the services sector, which shows the greatest responsiveness to regulatory certainty.

The positive spillovers of standards cannot be forced; instead, compliance with standards needs to be facilitated. Multinational enterprises operating in developing countries often transmit global standards promoted by high-income countries. The EU's 2024 Corporate Sustainability Due Diligence Directive, for instance, mandates that large companies prevent human rights and environmental violations across their supply chains, many of which include firms located in developing countries. Although initiatives of the type represented by this directive can foster improved environmental and managerial practices, they risk overwhelming local firms in developing countries that are unprepared for full compliance. In East Africa's food processing sector, only about 6 percent of SMEs have adopted stringent international standards for safety, like Hazard Analysis Critical Control Points, or quality, such as those from ISO, despite the firms' broad adherence to international good practices in hygiene and management, on account of the costs associated with adherence. Critics argue that imposing the full burden of compliance with international standards on suppliers¹⁰² ignores the socioeconomic realities in developing countries and excludes some suppliers.

Moreover, the diffusion of standards from FDI to local firms is not automatic. Enforcing standards requires infrastructure and institutional capacity that many developing countries lack. In Indonesia, improvements in energy efficiency led by multinational enterprises reversed when those enterprises exited, because once the enterprises

were gone, the country lacked testing capacity or systems for enforcing the improvements made by local firms.¹⁰³ This example highlights the need for local capacity building and sustained partnerships to complement the implementation of standards.

Investment policies should be aligned with international practices, and regional and multilateral cooperation should be promoted in order to harness FDI to support the diffusion of standards. Given the existing geopolitical tensions and regulatory fragmentation noted earlier, multilateral efforts like the WTO's Investment Facilitation for Development Agreement offer a promising framework for increasing regulatory transparency and reducing barriers to trade.

Standards for technology and the diffusion of technologies to developing countries

Technology is essential to economic growth.¹⁰⁴ It enables interoperability, ensuring that products, devices, and systems can work together, and defines the performance, safety, and compatibility requirements that make markets function. When widely adopted, technology standards can unleash powerful *network effects*—when the value of a technology grows as more people use it—lowering costs and expanding access. But when standards are fragmented, technologies become incompatible across markets, limiting scale and discouraging investment. Likewise, when a few firms capture the benefits of standards, by controlling key patents or platforms, they can entrench market power, deter entry, and slow the pace of innovation and technology diffusion.

Technology standards matter because they transform scientific discoveries into usable, interoperable products. For example, without shared protocols, mobile networks, internet services, and digital payment systems could not operate

globally. Standards ensure that a phone produced in one country connects to a tower in another, that a charger fits multiple devices, and that data move securely across platforms.¹⁰⁵

However, because technologies evolve rapidly, the setting of technology standards is increasingly contested. Competing firms, alliances, and governments seek to influence standards that define the rules of emerging industries, from artificial intelligence (AI) to electric vehicles. Standards are no longer seen as purely technical or commercial instruments, but as strategic assets linked to national security and competitiveness, central to what many now call “technological sovereignty.”¹⁰⁶ The term reflects governments’ desire to maintain autonomy in developing, deploying, and governing key technologies amid intensifying global competition.¹⁰⁷ Yet it is also a fluid concept, interpreted differently across countries. For developing countries, most of which remain technology *takers* rather than technology creators, the challenge lies in participating meaningfully in the processes affecting development of standards rather than merely adapting to standards set elsewhere.

In the digital economy, standards are particularly critical. The more users adopt a standard, the more valuable it becomes, reinforcing market dominance for early movers. But as standards increasingly intersect with industrial policy and geopolitical goals, the risk of “standards wars” has grown. Competing systems of standards—whether in telecommunications, semiconductors, or digital platforms—can slow the harmonization of international standards, fragment markets, and reduce innovation. Developing countries often face the hardest choices when standards are in competition with one another, compelled to align with one or another technological sphere before a clearly dominant standard emerges and sometimes locking themselves into systems that quickly become obsolete or incompatible. The global economy thus faces a recurring tension

between openness and control: coordination around common rules versus competition among rival technologies, each tied to a vision of technological sovereignty.

Types of technology standards

Whereas most standards discussed in this chapter thus far set minimum levels of quality, most technology standards instead involve interoperability (refer to chapter 2). Technology standards fall into two categories depending on how they are developed: those formally approved by a recognized body and those that emerge through market dominance or collective adoption, known as *de facto standards*. Both types influence innovation, market competition, and the diffusion of technology, but they do so through different mechanisms.

Formal processes of consensus for developing standards are led by national or international standards development organizations, such as ISO, the International Telecommunication Union (ITU), and the International Electrotechnical Commission (IEC). Standards that emerge through these organizations' processes provide stability and interoperability across borders. They are often designed through open participation involving governments, industry, and academia. Once adopted, they serve as reference points for regulation, trade, and investment. Examples include ISO/IEC 27001 on information security and IEC 61850 on automation of power utilities.

By contrast, *de facto* standards emerge from the marketplace when a particular technology achieves dominance through widespread adoption. Examples include early operating systems for computers, word processing formats, and technologies for video playback. In the case of such standards, compatibility and network effects drive diffusion faster than formal regulation can develop. However, market dominance can lead to lock-in, limiting competition and slowing innovation when the costs involved in switching

technologies are high or interoperability among technologies or the systems that depend on them is restricted. Examples of *de facto* standards include USB, originally promoted by Intel and Microsoft; PDF by Adobe; Ethernet before formal standardization by IEEE, 4G and 5G mobile broadband standards before formal codification by the 3rd Generation Partnership Project (3GPP), and web protocols like HTML before formal ratification by the World Wide Web Consortium (W3C); and the Bluetooth Special Interest Group (SIG) standard, developed collaboratively by a group of firms.

Increasingly, however, the distinction between these two types of standards is blurring. Many modern standards, especially in digital and communications technologies, are developed in hybrid settings that combine formal standardization with private initiative. Industry alliances, consortia, and specialized working groups collaborate under procedures they have mutually agreed upon to set technical specifications that standards bodies later recognize formally.

Influence of technology standards on technology adoption

Technology standards can be critical enablers of technology adoption in developing countries. By providing common technical frameworks, technology standards allow firms to integrate new technologies without the need for costly customization or proprietary interfaces.¹⁰⁸ This is particularly important for countries or firms that lack the capacity to develop or adapt technologies independently. For example, adherence to global telecommunications standards, such as those developed by 3GPP, has enabled many low- and middle-income countries to adopt mobile broadband technologies rapidly and at scale.¹⁰⁹ Furthermore, technology standards reduce market fragmentation and create economies of scale that lower the costs of imported technologies and equipment.¹¹⁰

Technology standards influence innovation at every stage of production. They lower coordination costs, reduce uncertainty regarding compatibility and market acceptance, and make it easier for different components and systems to work together. Upstream, in research and development, standards provide shared protocols and benchmarks that guide platform technologies and enable firms to build on common foundations rather than duplicating basic work.¹¹¹ Downstream, in firms and among users adopting technology, they reduce the costs of switching between products or service providers, build consumer trust, and facilitate regulatory compliance, while allowing local firms to develop new products and services.¹¹² Standards in blockchain and 5G technologies accelerate complementary innovations¹¹³ and mitigate technological and legal uncertainty, particularly in fragmented markets in developing countries.¹¹⁴ The Global System for Mobile Communications standard, for example, triggered rapid diffusion and network effects across Africa.¹¹⁵ The experience of China illustrates how countries can leverage technology standards strategically to coordinate innovation in their manufacturing sectors.¹¹⁶

Aside from that offered by some country case studies, the evidence linking the development of technology standards with innovation and the diffusion of technologies in developing countries is limited. Additionally, standards do not have automatic benefits in regard to innovation; these benefits depend on firms' capacity to absorb the related technologies, which connects upstream research and development with downstream diffusion. Without investments in this absorptive capacity, developing countries will struggle to realize the full potential of technology standards to drive innovation.

In this context, finding ways to accelerate the diffusion, adoption, and use of technologies in developing countries is critical for their economic growth. Although the speed of technology diffusion and adoption in developing countries has increased, with new technologies reaching early

adopters more quickly, it remains slow, leading to growing technology gaps among firms and among countries.¹¹⁷ Developing countries are also less likely than high-income countries to use advanced technologies intensively.¹¹⁸

Justifications for public involvement in setting technology standards

As part of the innovation process, firms may simultaneously develop competing technologies. In some cases, a standards war can ensue as each firm tries to establish its proprietary technology as the dominant one. Notable examples include VHS versus Betamax in video cassette recording, Blu-ray versus HD DVD, and more recently, rivalries in 5G infrastructure.

Recognizing the potential benefits of developing standards, industries set thousands of interoperability standards every year without any government involvement. An extensive literature explores when it is profitable for different actors in technology fields to participate in standard setting. Conflicts arise, however, when numerous actors participate, because they have vested interests, which is what motivates them to participate in setting common standards and bear the costs. Conflicts can be especially severe when potential standards incorporate patented intellectual property.¹¹⁹ Such conflict can delay finalization of standards and thus their harmonization and diminish the benefits from coordination,¹²⁰ but more generally, it generates *coordination failures*.

Beyond strategic and coordination concerns, there are two main reasons for public involvement in setting technology standards. First, interoperability standards can create powerful network effects. A digital payment system, for example, becomes more useful as more merchants and users join. But network effects can cut both ways: Without coordination, they can lead to under-adoption and fragmented markets; with excessive

concentration, they can lock in technologies and exclude merchants and users that are not in the network.¹²¹ Public action can help balance these opposing forces—through coordination across actors, investment in shared infrastructure, and use of mandates and incentives to ensure that network effects work for inclusion rather than market power (refer to spotlight 5).

Second, interoperability standards can function as a public good: part of what is often called “infrastructure.”¹²² This includes the systems for measurement, testing, and reference that provide the technical foundations for production and innovation. Infrastructure supports efficient research and development by making basic, nonproprietary knowledge widely available and reducing information gaps among firms.¹²³ In fast-moving sectors, it helps new technologies build on shared foundations rather than starting from scratch.¹²⁴ Governments can play a role in developing these foundations by promoting interoperability standards and open protocols that make knowledge accessible and usable across firms and industries.

Actions developing countries should take to leverage the potential impact of technology standards

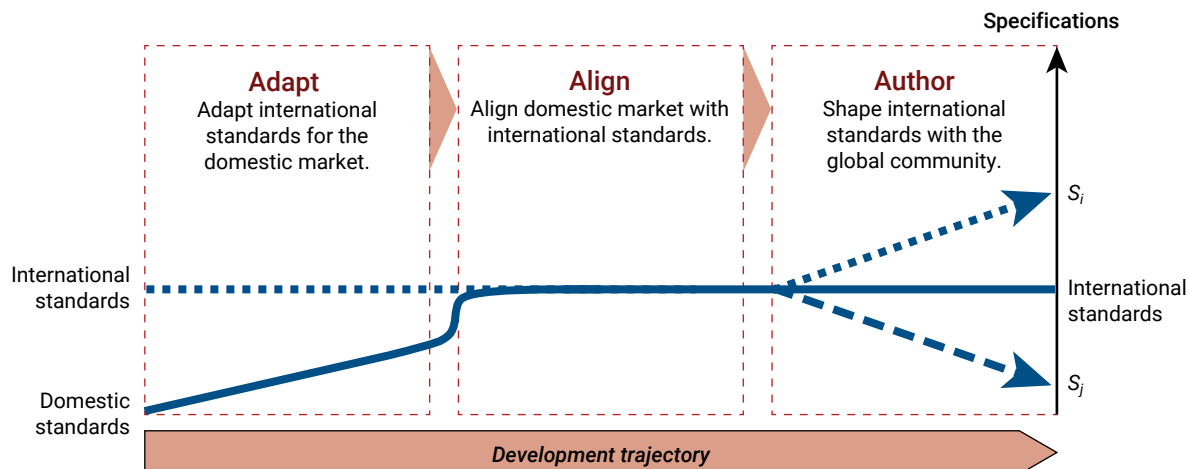
As mentioned earlier, most developing countries are standard takers rather than standard makers and have limited technical capacity and expertise to shape the standards they adopt or adapt. With this in mind, these countries should consider taking four actions in particular in regard to technology standards: increasing cooperation and expanding the number of technology standards that are agreed upon in common; ensuring access to existing standards; taking an active role in sectors with large network effects, sizable externalities, and high potential for inclusion of users; and participating in the development of standards for general-purpose technologies.

Increasing cooperation and expanding the number of technology standards that are agreed upon in common

Developing countries are particularly vulnerable when standards wars result in decoupling: the fragmentation of global technology systems into incompatible systems that reduce the number of internationally accepted standards. Because many firms in developing countries have limited technological capabilities, being forced to choose among rival, noninteroperable systems can discourage adoption, lock these countries into outdated technologies, widen technological gaps, and weaken productivity and competitiveness. Conversely, adopting widely accepted superior technologies can help speed up the development of technological applications in a country and accelerate technology diffusion, as for example with the widespread adoption of mobile phones and technologies that can be operated at low cost from mobile phones.

Figure 4.11 depicts the challenges facing a developing country, using the framework presented in chapter 2. Standards for interoperability must be adopted as they are; adapting them to local conditions will defeat their purpose, which is to lower transaction costs and enable innovation. With competing systems for interoperability (S_i and S_j in the figure), firms will likely struggle to integrate machines that use different systems. For example, multiple competing systems exist (such as those from Rockwell Automation and Siemens) for programmable logic controllers that establish control over machinery and processes in smart manufacturing. None of the systems are directly interoperable with the others, which makes investments in smart manufacturing conditional on the choice of system and can lead to technological lock-in. International or industry standards that ensure interoperability for systems of this kind are crucial for developing countries.

Figure 4.11 Developing countries, in particular, need common standards for technology



Source: WDR 2025 team.

Note: S_i and S_j refer to two different competing standards.

Ensuring access to existing standards

Access to standards matters as much as choice. Many interoperable technologies rely on *standard-essential patents*: patents covering technologies that must be used to comply with standards such as Wi-Fi, Bluetooth, or 5G. Using these technologies requires licenses, often from a small number of holders of major patents. Ensuring that technologies are licensed on *fair, reasonable, and nondiscriminatory* terms (refer to box 4.8) is key to lowering barriers to adoption. For developing countries, affordable access to licenses for standard-essential patents not only enables firms to adopt advanced technologies but also allows firms to design new products and applications that are built on these technologies. These patents can also reinforce market concentration (when a small number of firms hold a large share of a market), however, when the terms of the licenses for the underlying technologies are restrictive or prohibitively expensive.

Taking an active role in sectors with large network effects, sizable externalities, and high potential for inclusion of users

Certain sectors, such as those for digital payments or e-government services, have substantial network effects, involve significant externalities, lend themselves to inclusion or exclusion, or any combination of these. In such sectors, governments tend to take a more active role to ensure that systems are more open, can facilitate more interoperability, and maximize the number of connected users. Different models build upon international standards and use more open platforms to ensure large interoperability. These models normally have strong public governance, with one notable exception being M-PESA, a payment system in Kenya that is owned by a private company, although regulated by Kenya's central bank.

A key objective of these models is outreach and engaging as many beneficiaries as possible. In the case of digital payments specifically, a key objective is financial inclusion and financial

depth (that is, a greater spectrum of services offered and greater access to them), to generate as many additional services as possible (refer to spotlight 5).

Box 4.8 Standard-essential patents: Balancing innovation and access

In many technology sectors, especially information and communications technologies, some standards incorporate patented components; the patents for these components are known as *standard-essential patents*. Standard-essential patents protect inventions that must be used to comply with a standard. They sit at the intersection of two goals: Patents reward innovation through exclusivity, whereas standards seek openness and interoperability. Managing the tension between these two goals is critical to ensuring that standards promote rather than restrict technological diffusion.

To safeguard access to technologies that are critical for compliance with standards, standards development organizations require holders of patents for such technologies to disclose them to prospective users of the technology and commit to licensing them on *fair, reasonable, and nondiscriminatory* terms.^a The commitments these patent holders make, however, are voluntary and do not guarantee access. Licensing negotiations can be complex and costly, and when bargaining fails, litigation may follow. Holders of standard-essential patents may also exploit their position through *patent holdups*—refusing licenses or demanding excessive royalties once a standard is widely adopted—increasing input costs and discouraging innovation.^b

The distribution of standard-essential patents is highly concentrated. According to World Intellectual Property Organization (WIPO) data on declarations to the European Telecommunications Standards Institute (ETSI), the Institute of Electrical and Electronics Engineers (IEEE), and the International Telecommunication Union (ITU),^c more than 70 percent of such patents relate to two areas of communications technology: wireless networks and digital transmission. More than half are registered in Europe and North America, with China as the only developing country with a sizable share. A handful of firms from high-income countries and China account for most declared standard-essential patents; six firms alone hold more than 70 percent of the core patents for 5G.^d In Africa, virtually all such patents belong to foreign firms, and domestic ownership in Brazil and India remains limited.

(Box continues next page)

Box 4.8 Standard-essential patents: Balancing innovation and access (*continued*)

For developing countries, standard-essential patents present both opportunities and risks. On the one hand, these patents can provide access to advanced technologies that developing countries might otherwise find prohibitively expensive to develop internally. On the other hand, complex licensing processes and unequal bargaining power between licensees in developing countries and large holders of standard-essential patents can present a barrier to access and may blunt incentives for innovation among developers and manufacturers in developing countries. Smaller companies in developing countries often lack the resources to negotiate effectively with established holders of such patents or to build patent portfolios to use as leverage in negotiations. Although in many cases holders of standard-essential patents do not seek enforcement against infringement of their patents by smaller firms in developing countries, the uncertainty surrounding what patent holders will consider fair, reasonable, and nondiscriminatory licensing rates and processes can discourage innovation. As markets and firms in developing countries grow, cases involving patent infringement by firms in developing countries will be more likely to be brought forward. Litigation has started to emerge in developing countries and is also becoming more frequent as part of antitrust efforts,^e but representative data on fair, reasonable, and nondiscriminatory licensing and relevant litigation are largely unavailable. Models of brokerage and intermediation for licensing of standard-essential patents are being proposed to ensure reasonable licensing fees for small and medium enterprises; developing countries could adopt these models.

Source: WDR 2025 team.

- a. Swanson and Baumol (2005).
- b. Lemley and Simcoe (2019) build a data set of standard-essential patents and related litigation in the United States and find that the overwhelming majority of these patents in their sample (95 percent) were subject to a commitment to fair, reasonable, and nondiscriminatory access. For patent holders that litigate, the authors find no statistically significant differences between outcomes in such litigation and those in litigation that does not involve standard-essential patents. The authors conclude that standard-essential patents may not actually be that essential, because they are rarely infringed and when infringement is litigated, the outcomes are similar to those for cases involving patents that are not essential to standards.
- c. The database includes only standard-essential patents that are well defined and declared in standards and can be found in the patent pool. For a few standards, participants declare having a patent but do not provide full information about the patent; these instances are therefore excluded from the data set. Although it does not include data for other international standards development bodies, this data set is the most complete one that includes data about standard-essential patents.
- d. Hassan et al. (2021).
- e. Nyman and Begazo (2025).

Participating in development of standards for general-purpose technologies

General-purpose technologies, such as AI, shape entire economies and societies, driving successive waves of innovation.¹²⁵ The standards that guide their development influence how these technologies evolve and who benefits from them. Yet participating in setting such standards is technically demanding, and many developing countries lack the expertise or resources for it. The costs of staying out, however, are also high. When only advanced economies and large firms shape the rules, standards may reflect their priorities and overlook local contexts, as for example in the case of models for AI that fail to capture local languages or realities. Active participation by developing countries in the process of setting standards helps ensure that technologies are inclusive, relevant, and interoperable and allows them to align their own domestic approaches in areas such as ethics, fairness, and transparency with international ones.

How developing countries can leverage technology standards

Pushing for technology standards to be fully open

Open standards require no royalties and have no licensing restrictions. They reduce dependency on proprietary technologies, lower the total costs of owning firms, and foster local systems for innovation. Having fully open national and international standards could facilitate access to standards. For example, there is growing support for mandating openness in the foundational layers of digital public infrastructure, especially within government systems. Additionally, a number of countries and regional bodies, including Brazil, India, South Africa, and the European Union, have adopted policies favoring open standards in public procurement. India, for instance, requires that standards for e-governance entail no royalties and permit unrestricted use, partly in response to sovereignty

concerns over foreign patents. The Group of Twenty (G20) has also recognized the need for “networked open technology standards” to avoid vendor lock-in and promote interoperability in digital public infrastructure.¹²⁶ By signaling a commitment to open standards, governments encourage technology providers to align with requirements to have them, which helps countries build more inclusive and adaptable digital systems.

Despite the normative appeal of fully open standards and beyond digital payments (refer to spotlight 5), a rigid insistence on zero royalties or technologies that are free of standard-essential patents can be counterproductive. Openness in standards exists on a spectrum, rather than standards being either completely open or closed; it depends on factors such as network effects, the standard-setting process, or the strategic behavior of firms. Many standards, including those incorporating standard-essential patents, are developed through global consortia and are deeply embedded in global infrastructure. In many instances, it is impractical to circumvent them without incurring higher costs, reduced functionality, or system incompatibility.

The key policy trade-off involves balancing openness and sovereignty with performance, functionality, and global interoperability. As a result, many governments adopt a hybrid approach: mandating open standards for critical system interfaces and data formats, while permitting proprietary components as necessary. This strategy, sometimes summarized as “protocols over platforms,” ensures that core application programming interfaces, schemas, and interoperability layers remain open, so that other elements of systems that have proprietary sources can be replaced with versions available through open sources if needed.¹²⁷ For technologies other than digital public infrastructures, governments and standards development organizations can influence the degree of openness through their policies and standard-setting choices, encouraging innovation and competition without compromising quality or functionality.

Minimizing competition risks from standard-essential patents

The ambiguity over what constitutes “fair, reasonable, and nondiscriminatory” access poses challenges for developing countries and their laws dealing with competition. For emerging markets, strategies to address these challenges can range from promoting groups to negotiate licensing or pools for patents to leveraging regulatory measures that promote fairer practices in regard to standard-essential patents. Recent policy efforts, such as the European Commission’s 2023 proposal for a registry of such patents and support services for SMEs in dealing with them, as well as guidelines from Malaysia, Singapore, and Türkiye, highlight attempts to reduce barriers and ensure that such patents foster innovation rather than hindering market entry. Other proposals include the creation of independent intermediaries that can license standard-essential patents from patent holders at no cost and sublicense them to SMEs—but only for as long as they remain SMEs. The goal is to encourage smaller firms to adopt and build on standards in developing innovative products. To facilitate this, SMEs and standard-essential patent holders could negotiate on a “safe island” where both sides can engage without the threat of litigation or the risk of historic liabilities. In return, firms that grow beyond SME status would commit to mediation or arbitration for subsequent licensing arrangements. Technical assistance to enhance the capacity of policy makers and judges in developing countries regarding competition law and what constitutes fair, reasonable, and nondiscriminatory rates is also crucial.

Participating in international setting of standards for interoperability

Most developing countries are technology takers rather than creators. As such, they have a strong strategic interest in actively engaging in the development of interoperability standards to avoid dependency on norms set by advanced economies

and multinational firms that may not work well in the countries’ own contexts. When countries do not participate in developing standards, they lose the opportunity to raise concerns about the costs and feasibility of compliance, making it harder for domestic firms to meet the resulting standards. By contrast, participation in standards development enables governments to adapt standards to local realities, strengthen domestic capacity to comply, and enhance firms’ competitiveness by lowering compliance costs and facilitating their integration into global value chains. To maximize impact, developing countries should make it a priority to engage in the standardization of general-purpose technologies that are foundational for digital transformation, such as digital identity, e-payments, data exchange protocols, and AI, while promoting open and inclusive approaches that ensure affordability and flexibility. Aligning standardization efforts with national development strategies and focusing on high-impact sectors like health care, agriculture, and education can yield the greatest benefits, whereas regional collaboration through organizations such as the African Union or ASEAN can amplify developing countries’ influence and bargaining power in global standard-setting processes.

Creating an enabling environment for technological upgrading

Interoperability standards can deliver their benefits only if countries have the right foundations for developing and upgrading technology. Without an enabling environment that encourages investment, adoption of key digital technologies, and access to skills and equipment, standards alone cannot drive progress. High tariffs on inputs critical to developing technologies, restrictive regulations, or barriers that limit the entry of foreign technical experts and providers of technology services can all hold back innovation. Building countries’ and firms’ technological capabilities is therefore essential. Participation in setting standards helps only when countries also invest in the institutions, skills, and policies that allow firms to absorb, adapt, and create new technologies.

Notes

1. Krishna et al. (2023).
2. Data from the World Bank Enterprise Surveys suggest that sectors such as construction and retail have a development trajectory similar to that of tradable sectors. About 11 percent in low-income countries and 31 percent in high-income countries have adopted any internationally recognized standard in construction, whereas for retail and wholesale, 9 percent of low-income countries and 21 percent of high-income countries have done so. Refer to World Bank Enterprise Surveys (dashboard), World Bank, <https://www.enterprisesurveys.org/en/enterprisesurveys>.
3. Guasch et al. (2007); Verhoogen (2023).
4. Beyond these studies at the microeconomic level, literature at the macroeconomic level assesses the impact of standards on GDP growth. This literature tests whether standards substantially enable innovation and facilitate technological change. Many of the studies, however, rely on data from high-income countries and are conducted by national standards bodies, which may bias the reporting of the data in the studies if the national standards bodies have an interest in justifying government support. Although there are some concerns about methodology, this literature finds positive effects on economic growth and aggregate productivity (for example, refer to DTI 2005; Haimowitz and Warren 2007; Vennerød et al. 2023).
5. Escribano and Guasch (2005); Escribano et al. (2005).
6. Guasch et al. (2007).
7. Goedhuys and Sleuwaegen (2013).
8. For example, refer to Santos (2002) on Brazil.
9. Caloi et al. (2025).
10. Maskus et al. (2005).
11. de Roux et al. (2025).
12. Krishna et al. (2023).
13. For example, discussions by World Bank staff members with representatives of Lebanon's Ministry of Economy and Trade highlight that because of the limited number of laboratories in Lebanon that are accredited by the European Union, exporters in the country often send samples abroad for analysis, with costs typically ranging between US\$500 and US\$1,000 per product, excluding transport and delays.
14. Macedoni and Weinberger (2022).
15. Macedoni and Weinberger (2022).
16. Macedoni and Weinberger (2022) analyze these trade-offs and find that the welfare effects of stringency depend on factors such as the distribution of firm productivity, distortions in markets (that is, departures from norms that ensure competitiveness), costs of compliance, and externalities. In sectors with high externalities, such as food (safety) or industry (pollution), stringent regulations can raise average firm quality and reduce misallocation of resources, especially if market distortions are holding back more productive firms (Hsieh and Klenow 2009). However, gains from higher quality must be weighed against risks such as reduced competition, increased market power among a few firms, and excessive compliance costs. In Chile, regulations were found to lower firms' survival probability by 40 percent, with highly varied welfare outcomes across sectors.
17. OECD (2025).
18. World Bank (2024).
19. Dollar and Kraay (2004).
20. Specifically, adoption of standards increases exports by opening new markets, as Martincus et al. (2010) find for ISO 9001 and Blyde (2025) finds for ISO 14001. Regulations improve the quality of exported goods by reallocating market share toward high-quality firms (Macedoni and Weinberger 2022) or encouraging firms to upgrade the quality of their goods or services (Disdier et al. 2023). Shared standards facilitate trade between two countries through mutual recognition of standards (Chen and Mattoo 2008), harmonization of national standards (Moenius 2004), or adoption of international standards (Schmidt and Steingress 2022). These advantages can even extend to third countries by simplifying the requirements for market access (Reyes 2011).
21. Martincus et al. (2010).
22. Carrillo Labella et al. (2024).
23. Briscoe et al. (2005).
24. Henn et al. (2013). The index is calculated using export flows weighted by trade volumes. Because it is based on a country's exports, which reflect the country's comparative advantage, it suffers from a composition effect. For example, most exports from Africa are concentrated in agriculture and minerals, and the index reflects the quality of exports within these sectors, in which there is less differentiation among products.
25. For evidence, refer to Export Diversification and Quality (July 2017) (dashboard), International Monetary Fund, <https://www.imf.org/external/datamapper/datasets/SPRLU>. Because exported goods tend to be of higher quality than those produced for the domestic market in most developing countries, the measure of export quality available through the dashboard likely underestimates the quality gap in a country's production. For historical data from 1960 to 2014, refer to Henn et al. (2013).
26. The quality of the set of goods that a country produces and the country's productivity determine the country's level of income (Aghion and Howitt 2005; Hausmann et al. 2007; Hummels and Klenow 2005; Sutton and Trefler 2016).
27. *Nontariff barriers* are a subset of nontariff measures that have a protectionist intent. They result from nontariff measures that are discriminatory or that are simply poorly implemented. The dividing

- line between nontariff measures and nontariff barriers is not always clear, often requiring complex legal and economic analysis.
28. For more information, refer to UNCTAD (2019).
 29. Based on World Bank staff interviews conducted with a manufacturer of home textiles in Faisalabad, Pakistan, on March 6, 2025.
 30. The WTO Agreements on Technical Barriers to Trade and on the Application of Sanitary and Phytosanitary Measures aim at reducing unnecessary nontariff measures that act as obstacles to trade. They recognize that countries have legitimate reasons to establish technical regulations to protect human health, safety, and the environment, while encouraging the use of international standards as the basis for these regulations, if suitable. Regulations must be nondiscriminatory, transparent, and—in the case of sanitary and phytosanitary measures—based on scientific evidence. The agreements also include requirements for notifying the WTO about proposed regulations in these areas and for consultation among WTO members to resolve potential trade issues. Whereas the Agreement on Technical Barriers to Trade focuses on nontariff measures related to all manufactured goods, such as labeling requirements, the Agreement on the Application of Sanitary and Phytosanitary Measures specifically addresses a defined set of health regulations related to food safety (such as pesticide limits for agricultural commodities) and animal and plant health.
 31. ePing: SPS & TBT Platform, International Trade Centre, United Nations, and World Trade Organization, accessed October 15, 2025, <https://www.epingalert.org/en/FactsAndFigures/Notifications>.
 32. The sudden rise in nontariff measures in 2008–09 shown in panel a of figure 4.6 was driven by a wave of environmental standards in the European Union, as confirmed in panel b, including those for emissions from motor vehicles, organic agriculture, and chemicals. Refer to REACH Regulation [Regulation on the Registration, Evaluation, Authorization, and Restriction of Chemicals] (dashboard), European Commission, https://environment.ec.europa.eu/topics/chemicals/reach-regulation_en.
 33. Kee et al. (2009).
 34. Kee and Xie (2024).
 35. Kee and Nicita (2022).
 36. Fischer and Serra (2000).
 37. Haile and Musco (2025).
 38. This may explain the increasing share of Specific Trade Concerns on Technical Barriers to Trade raised at the WTO by developing countries (refer to WTO 2025).
 39. Fernandes et al. (2019).
 40. The analysis is based on calculations by Iodice and Reverdy using data from Iodice and Reverdy (2025).
 41. Borchert et al. (2020).
 42. Baiker et al. (2025).
 43. Henson and Humphrey (2010).
 44. Henson (2008).
 45. For example, a supplier for two large retail chains that require certification to different private food safety standards will need to employ a consultant to guide compliance with each standard, be audited separately for each standard (with the attendant costs for private auditors, staff time, and so on), and pay the owners of each standard for certification. For a larger supplier, the costs could be in the tens of thousands of dollars. Many of these costs are recurring because reauditing and recertification are often required annually.
 46. Dragusanu et al. (2014).
 47. de Janvry et al. (2015).
 48. Dragusanu et al. (2022) find benefits for smallholders in Costa Rica, whereas Oya et al. (2018) report modest results.
 49. Macchiavello and Miquel-Florensa (2019).
 50. Alfaro-Ureña, Faber, et al. (2022).
 51. Fiorini et al. (2019).
 52. Refer to State of Sustainable Markets, 2024 (dashboard), International Trade Centre, <https://standardsmap.org/en/trends>.
 53. Smith (2009).
 54. Masood and Brümmer (2014).
 55. Marx and Wouters (2014).
 56. The EUDR requires importers to conduct due diligence across their supply chains and confirm that regulated commodities do not originate from areas recently subject to deforestation and do not breach national laws regarding environmental protection, land ownership, and labor and human rights.
 57. Although the EUDR may succeed in raising standards involving sustainability, the costs of compliance vary significantly from country to country, disadvantaging developing countries with fragmented supply chains, limited access to the internet and technology tools, and limited land registries. In these countries, larger companies are more well equipped to bear the costs of compliance with the regulation, which could distort market competition. Though the regulation was announced in 2023, implementation has been delayed, highlighting the difficulty of applying uniform rules regarding sustainability worldwide and suggesting that regulations focusing on labor could face even greater challenges.
 58. Swann (2010).
 59. Blind (2001); Chen and Mattoo (2008); Grajek (2004); Moenius (2004); Reyes (2011).
 60. Baller (2007); Chen and Mattoo (2008); Czubala et al. (2009); Grajek (2004).
 61. Czubala et al. (2009).
 62. Chen and Mattoo (2008).
 63. Disdier et al. (2008); Fontagné et al. (2015); Kee and Xie (2024); Zavala et al. (2023).
 64. Fontagné et al. (2015); Zavala et al. (2023).
 65. Iodice and Reverdy (2025); Zavala et al. (2023).

66. Ghose et al. (2023).
67. Calì et al. (2022).
68. Hoekman and Nicita (2011); Kee and Xie (2024); Kee et al. (2009).
69. Essaji (2008); Iodice and Reverdy (2025); Murina and Nicita (2017).
70. Chen et al. (2008).
71. Beghin et al. (2015).
72. Zavala et al. (2023).
73. de Roux et al. (2025).
74. Dragusanu et al. (2022); Reverdy (2024).
75. Alfaro-Ureña, Manelici, et al. (2022).
76. Liu (2009); Prag et al. (2016).
77. Macchiavello and Miquel-Florensa (2019).
78. Fernandes Martins et al. (2022); Furumo et al. (2020); Liu (2009).
79. Oka et al. (2020).
80. Oya et al. (2018).
81. Bonneton (2025); Dragusanu et al. (2014).
82. Alfaro-Ureña, Manelici, et al. (2022).
83. One such tool is ePing, which provides regular updates on regulatory changes in export markets. Refer to ePing SPS [Sanitary and Phytosanitary] and TBT [Technical Barriers to Trade] Platform (dashboard), International Trade Centre, World Trade Organization, and United Nations, <https://eping.wto.org/>.
84. Developed countries generally benefit from pursuing harmonization agreements with other countries (Baller 2007; Chen and Mattoo 2008; Moenius 2004; Schmidt and Steingress 2022), whereas developing countries generally do not (Baller 2007; Disdier et al. 2015), unless standards are harmonized with international standards (Disdier et al. 2015).
85. Both types of mutual recognition agreements—those related to regulations and those related to procedures for assessing conformity—can facilitate trade among participating countries (Baller 2007; Chen and Mattoo 2008; Fernandes et al. 2021; Schmidt and Steingress 2022).
86. The WTO Trade Facilitation Agreement aims to expedite the movement, release, and clearance of goods across borders, including goods in transit. The agreement, which entered into force in 2017, requires countries to simplify and modernize opaque border procedures and embrace risk-based approaches to regulation. The World Bank's Trade Facilitation Support Program helps developing countries implement the agreement through targeted technical assistance, capacity building, and knowledge sharing. Refer to Trade Facilitation Support Program (TFSP) (dashboard), World Bank, <https://www.worldbank.org/en/programs/trade-facilitation-support-program>; Trade Facilitation (dashboard), World Trade Organization, https://www.wto.org/english/tratop_e/tradfa_e/tradfa_e.htm.
87. Garetto et al. (2025).
88. Dunning (1993).
89. Dean et al. (2009).
90. Duanmu (2014).
91. Santos and Forte (2021).
92. Based on a survey of 112 empirical studies published between 2000 and 2018, Islam and Beloucif (2024) find that the size of the host market is the most robust determinant, followed by trade openness, infrastructure quality, labor cost, macroeconomic stability, human capital, and the growth prospects of the host country.
93. Chaurey et al. (2024).
94. Brucal et al. (2019) find that in Indonesia, for example, domestic firms acquired by multinationals reduce energy intensity by about 30 percent as of two years after the acquisition, suggesting that foreign investors can help improve local practices and reduce ecological impact by applying more stringent environmental standards originating in their home countries.
95. Huang et al. (2023) show that in China, for example, opening the service sector to FDI has boosted energy efficiency through spillovers, indicating that superior environmental standards can diffuse beyond foreign affiliates to wholly owned domestic firms.
96. Farole and Winkler (2014). A survey of FDI and productivity spillovers in 31 developing countries (covering 69 empirical studies published in 1986–2013 with 1,450 spillover estimates) reveals that only one-third of the studies included in the survey found significant positive effects (Demena and van Bergeijk 2016).
97. Guasch et al. (2007).
98. World Bank (2025b).
99. Mistura and Thomsen (2017).
100. OECD (2024).
101. For example, Mistura and Roulet (2019).
102. Interviewed by Smith (2009).
103. Brucal et al. (2019).
104. Aghion and Howitt (1992); Romer (1990).
105. David and Greenstein (1990); Farrell and Saloner (1985).
106. Edler et al. (2020, 2) define the concept of technology “sovereignty” as “the ability of a state or a federation of states to provide the technologies it deems critical for its welfare, competitiveness, and ability to act, and to be able to develop these or source them from other economic areas without one-sided structural dependency.”
107. Edler et al. (2023) suggest that, in a world characterized by intensified competition based on global technology and mounting geopolitical tensions, there is an increasing demand for states to preserve their ability to act strategically and autonomously.
108. Blind (2004); David and Greenstein (1990).
109. ITU (2022).
110. Tassey (2008).
111. Blind (2004); Tassey (2010).
112. Dutz et al. (2011); Swann (2000).
113. Wen et al. (2022).
114. ITU (2022).
115. Aker and Mbiti (2010).

116. Zoo et al. (2017).
117. For example, refer to Comin and Mestieri (2018).
118. Cirera et al. (2022).
119. Farrell and Klemperer (2007).
120. Simcoe (2012).
121. Farrell and Saloner (1985); Katz and Shapiro (1986).
122. Tassej (2008, 2010).
123. Link and Scott (2001).
124. Link and Tassej (1988).
125. Bresnahan (2010).
126. G20 (2023), annexure 1.
127. Sankritik and Shetty (2025).

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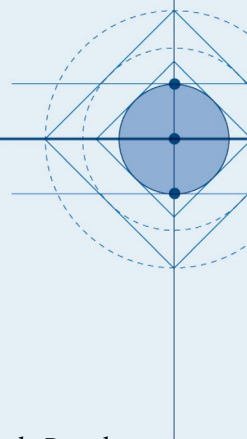
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SPOTLIGHT 4

Standards in Finance

Financial standards lay the foundation for effective financial systems, promoting trust, stability, interoperability, and inclusion. From those that form the basis for accounting rules that enable transparent financial reporting to those embedded in regulatory frameworks that oversee bank risk and fight financial crime, these standards help preserve the integrity and resilience of financial systems. They also play a key role in expanding access to financial services. Although there is a broad ecosystem of financial standards,¹ for brevity, this spotlight examines how four examples shape financial development and inclusion: the International Financial Reporting Standards (IFRS), the standards embodied in the Basel Framework, Financial Action Task Force (FATF) standards, and standardization in securities markets. These examples also illustrate the benefits and challenges of tiered approaches to the development of standards.

Accounting standards: The International Financial Reporting Standards

Reliable, comparable financial statements are prerequisites for effective prudential regulation, market-based finance, and the operations of securities markets. Accounting standards provide that foundation for financial markets.

The IFRS require companies to disclose relevant information clearly and consistently. Issued in 2003

by the International Accounting Standards Board (IASB), the IFRS are intended for private sector entities that are accountable to the public, such as financial institutions, insurers, state-owned enterprises, and companies listed on a stock exchange. Because smaller firms found the IFRS complex and burdensome, in 2009, the board issued the IFRS for small and medium enterprises (SMEs), meant for entities that are not accountable to the public but are nonetheless required by law to prepare financial statements. Although more than 140 jurisdictions have adopted the full IFRS, only about 80 use the IFRS for SMEs.² For many small firms in developing countries, implementing even the IFRS for SMEs may still be too costly. Some jurisdictions instead use them as a reference for developing their own set of accounting standards for SMEs.

Adopting accounting standards makes firms and countries more appealing to investors by enhancing financial transparency and decreasing the asymmetry between information available to firms and that available to potential investors in those firms. For example, adoption of the IFRS has increased foreign ownership of shares in mutual funds³ and boosted inflows of foreign direct investment to developing countries.⁴

Standards for regulating bank capital: The Basel Framework

Once standards for accounting and financial statements are in place, prudential regulation of bank

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capital builds on the foundations these statements provide in order to ensure solvency, soundness, and resilience in banking systems. Bank capital, which mostly includes shareholders' equity and retained earnings, provides a cushion for absorbing losses during times of distress, thus contributing to financial stability. Higher levels of capital can also curb risk taking among banks because they put more of bank shareholders' skin in the game, since the latter could lose their equity if the bank fails. However, banks may not hold enough capital to remain solvent in episodes of financial stress if they expect to rely on safety nets, such as deposit insurance and bailouts, during times of crisis.⁵ Bank failures also impose high social costs that bank managers and shareholders do not internalize.⁶ Regulators thus use capital requirements to give banks incentives to ensure adequate management of risks.⁷

The primary developer of global standards for the prudential regulation of banks is the Basel Committee on Banking Supervision (BCBS). Countries that are committee members agree to fully implement BCBS standards for their internationally active banks; currently, 45 regulatory institutions from 28 jurisdictions are members. Nonmembers may adopt these standards voluntarily.

In 1988, the BCBS published its first set of minimum capital requirements for banks, now known as the Basel I accord or simply Basel I, in response to an international debt crisis that originated in Latin America. Basel I categorized assets according to four levels of credit risk and assigned each level a weight: 0 percent, 20 percent, 50 percent, or 100 percent, with the weights increasing according to the riskiness of the underlying assets. (Cash, for example, carried a risk weight of 0 percent, whereas commercial loans—the balances of which banks include as assets on their balance sheets—were assigned the highest risk weight, 100 percent.) Banks use these weights to calculate their *risk-weighted assets* (as opposed

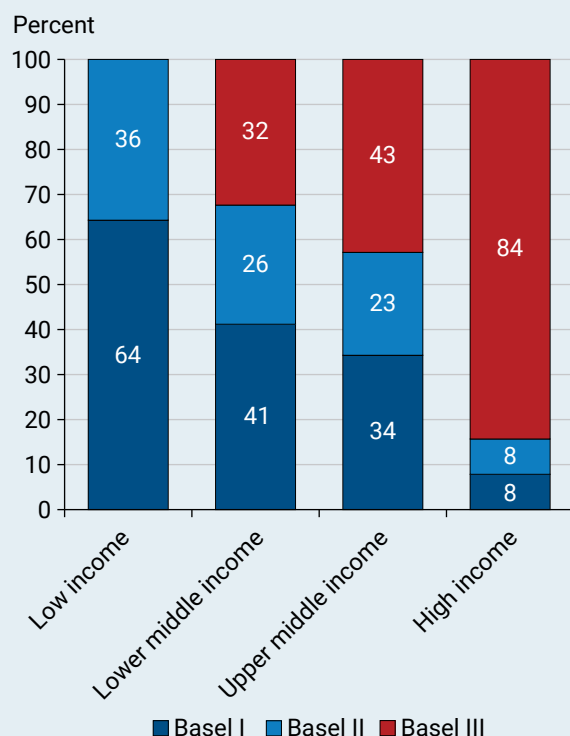
to simply their total assets, which had proven an inadequate metric for capturing banks' level of risk). Basel I required banks to hold minimum amounts of capital equal to 8 percent of their risk-weighted assets; this meant that banks had to hold more capital if they had higher levels of risky assets and that two banks with nearly identical levels of total assets could theoretically be subject to very different capital requirements. Most regulators worldwide ended up adopting Basel I,⁸ helping to ensure that supervisory effectiveness would be adequate and consistent across member jurisdictions.

Basel I's four categories of risk proved to be too simple, limiting its effectiveness.⁹ In practice, loans assigned the same risk weight under Basel I could have very different risk levels. For example, Basel I assigned all commercial loans a risk weight of 100 percent, but loans to small firms are often riskier than loans to large firms. In 2004, the BCBS therefore introduced Basel II, which included a more granular formula for measuring risk-weighted assets. It even allowed some banks to use their own models to calculate the credit risk their asset mixes posed.

The global financial crisis exposed weaknesses in Basel II as well, prompting the BCBS to propose Basel III in 2009. Basel II, as it turned out, did not require banks to hold enough high-quality capital, and the complexity of calculating risk-weighted assets made it difficult to monitor banks' risk exposures. Among other changes, Basel III (1) restricts what bank holdings qualify to be considered capital; (2) includes two capital buffers, which are extra amounts of capital that banks are required to have on hand during times of financial distress or economic downturns; (3) revokes, for certain risks, the use of internal models that was permitted under Basel II; and (4) adds a requirement regarding banks' leverage ratios, specifically, that banks' capital needs to equal at least 3 percent of their total assets, which is easier to measure and monitor than risk-weighted assets.

All 134 countries responding to the World Bank's most recent Bank Regulation and Supervision Survey, conducted in 2016, reported using one of the Basel regimes, but many were still using Basel I or Basel II (refer to figure S4.1). The adoption of Basel III is related to country income level. As of 2016, 84 percent of high-income countries had adopted Basel III, followed by 43 percent of upper-middle-income countries and about one-third of lower-middle-income countries. By contrast, no low-income countries reported using Basel III, and almost two-thirds still used Basel I.

Figure S4.1 Many developing countries are still using Basel I or Basel II bank capital requirement regimes



Source: Bank Regulation and Supervision Survey (dashboard), World Bank, <https://www.worldbank.org/en/research/brief/BRSS>.

Note: The Basel accords outline minimum capital requirements for banks. Basel I dates from 1988, Basel II from 2004, and Basel III from 2009. The sample includes 134 countries. Constituent percentages in each bar may not sum to exactly 100 percent because of rounding.

As noted earlier, regulators from countries that are not members of the BCBS may still adopt Basel standards to strengthen the resilience of their banking systems. Additionally, adoption of Basel II or III can signal sophistication and advanced standards, which can help attract foreign direct investment and improve the international competitiveness of countries' domestic banks. It can also facilitate coordination between home and host country supervisors of international banks.¹⁰ However, in lower-capacity environments, regulators may choose to stick with the simpler requirements of the Basel I accord and make building up supervisory capacity their priority instead.

More recently, the BCBS has published considerations regarding simplified standardized approaches to Basel III that are based on proportionality. Countries can develop such approaches and apply them to smaller, non-internationally-active banks that are not able to implement the more resource-intensive approaches the accord requires, and some jurisdictions with simpler banking systems could adopt such approaches for their entire banking sectors.¹¹ However, using a proportional approach also poses challenges for a country's regulators. In a joint survey of 90 jurisdictions conducted by the World Bank and the Bank for International Settlements (BIS), respondents mentioned challenges they encountered during the design phase of such approaches, such as how to define which banks can follow a simplified approach and how to avoid regulatory arbitrage, in which banks adjust their characteristics or location to become eligible for simplified standards, as well as challenges after countries implement proportionality, including how to ensure that financial positions are still comparable across banks.¹²

Capital requirements have different effects on financial development in the short and long terms. Increased capital requirements tend to reduce bank lending in the short term,¹³ particularly among banks that are less capitalized relative to other banks before the requirements

go into effect.¹⁴ This reduction in lending primarily affects SMEs that previously had no loans with any bank.¹⁵ However, in the long term, banks that have more capital increase their lending relative to other banks,¹⁶ perhaps because holding extra capital lowers banks' costs of debt and equity.¹⁷ Evidence from Spain shows that capital requirements smooth banks' credit supply and, in bad times, support the performance of firms receiving bank loans, increasing employment and firm survival.¹⁸ Although higher capital requirements impose some short-term costs, the benefits of reduced probability and impact of banking crises tend to more than offset these costs.¹⁹

Fighting financial crime and promoting financial inclusion: FATF standards

Countries across the globe have begun cooperating over the past few decades in response to crime and related financial flows that cross national borders, with key elements of such cooperation embodied in several United Nations (UN) conventions that create binding obligations for ratifying parties. In 1989, the FATF was established as a technical intergovernmental body responsible for providing the necessary technical details for and supporting the implementation of instruments facilitating this cooperation, which are typically high level, and setting international anti-money laundering standards and standards for combating the financing of terrorism as well as the financing of proliferation of weapons of mass destruction.²⁰

The FATF currently has 40 member jurisdictions representing major economies and financial hubs. It maintains a framework of measures known as FATF Recommendations,²¹ which more than 200 countries and jurisdictions have committed to implementing. With the help of nine associate member organizations and other global partners like the International Monetary Fund (IMF) and the World Bank, the FATF monitors these countries and jurisdictions to ensure, through a continuous process of peer evaluation, that they implement these measures. Failure to implement them effectively can result in public warnings to noncompliant countries, which in turn create pressure on these countries to address any compliance issues to maintain their access to the global financial system (refer to box S4.1).

The FATF recommendation most directly relevant to financial inclusion is that regarding customer due diligence, which includes customer identification and verification, often referred to as *know-your-customer* procedures. Strict rules regarding customer due diligence can cause banks to exclude customers or potential customers if they lack ID or other documents the banks require for identification purposes.²² Some 1.3 billion adults worldwide do not have a financial account, often because of documentation requirements, according to the World Bank's Global Findex Database.²³ In Sub-Saharan Africa, 44 percent of adults without such accounts and without ID cite lack of documentation as a barrier to having a mobile money account, compared with 19 percent of adults without an account but with ID (refer to figure S4.2).

Box S4.1 Promoting correspondent banking relationships and international standards on fighting financial crime in Pacific Island countries

When a bank in one country (the *correspondent bank*) provides banking services to a second bank in another country (the *respondent bank*), the two banks are engaging in a cross-border *correspondent banking relationship*. Correspondent banking relationships are at the core of the global system for international payments, enabling cross-border transactions that facilitate international trade, tourism, and remittances, as well as disaster relief and humanitarian financial flows.

Correspondent banking relationships in which the respondent banks are located in certain emerging market and developing countries have declined over the past decade.^a Globally, these relationships declined by about 30 percent between 2011 and 2022. Some of the largest declines, averaging about 60 percent, have been in Pacific Island countries. These countries are especially vulnerable to the withdrawal of correspondent banking relationships given the countries' heavy reliance on trade, tourism, and remittances—often equivalent to more than 40 percent of GDP—as well as disaster relief and humanitarian financial flows.

Correspondent banking relationships in Pacific Island countries have declined mainly for two reasons. First, international correspondent banks increasingly consider such relationships a high-risk, low-return business because they require a certain transaction volume to make them sufficiently profitable to justify correspondent banks engaging in them, and individual Pacific Island countries tend to have low volumes of transactions. Second, some Pacific Island countries do not fully comply with anti-money laundering standards and those related to combating the financing of terrorism.^b

To address the threat of a continuing decline in or even loss of correspondent banking relationships involving respondent banks in Pacific Island countries, the World Bank in 2024 approved a project covering the economies of Fiji, Kiribati, the Marshall Islands, Samoa, Tonga, Tuvalu, and Vanuatu.^c The project aims to enable continuous access to services in these economies that are typically provided through correspondent banking relationships. First, it will provide temporary access through the recruitment of a service provider that will serve eligible countries facing loss of such relationships in key currencies. Second, it will support increased compliance with anti-money laundering standards and those related to combating the financing of terrorism standards and improved oversight of payment systems, as well as regional regulatory harmonization to facilitate economies of scale.

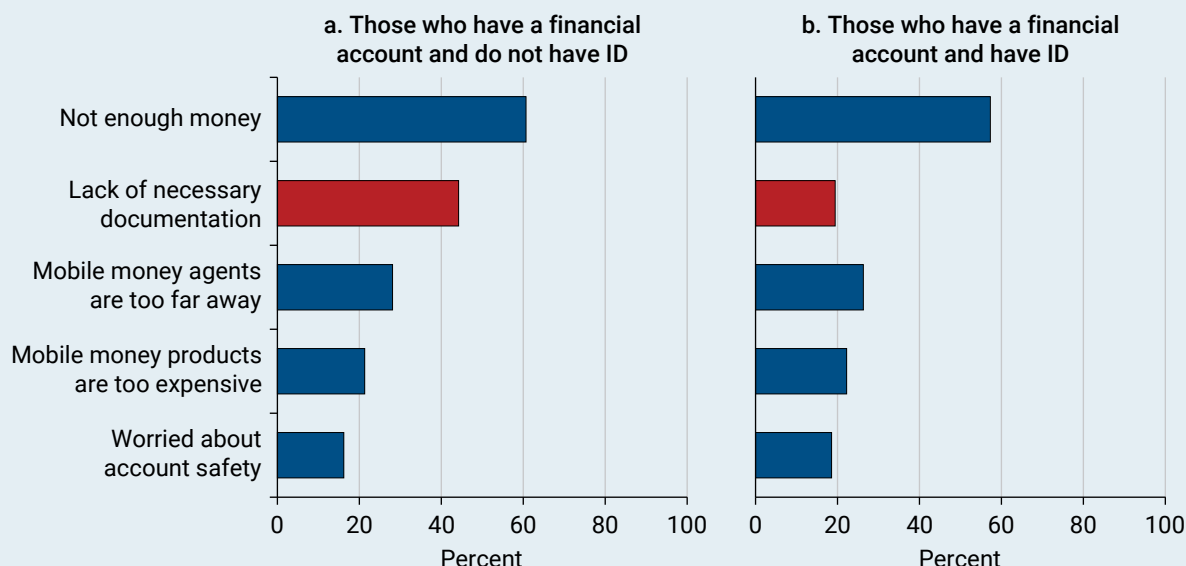
Sources: Pacific Islands Forum 2023; World Bank 2024.

a. The withdrawal of correspondent banking relationships in response to concerns regarding anti-money laundering and combating the financing of terrorism is also known as *derisking*. A broader term for the withdrawal of such relationships that encompasses other concerns is *debanking*.

b. Pacific Islands Forum (2023).

c. World Bank (2024).

Figure S4.2 Barriers to ownership of mobile money accounts in Sub-Saharan Africa



Sources: WDR 2025 team, based on data from Global Findex Database, World Bank, <https://www.worldbank.org/en/publication/globalfindex/download-data>; Identification for Development, World Bank, <https://id4d.worldbank.org/>; Klapper et al. 2025.

Note: Respondents to the Global Findex 2025 could choose more than one reason. Adults without accounts in Chad and Liberia are excluded because of lack of ID data. The red bars highlight that in Sub-Saharan Africa, the share of adults without an account and without an ID who cited lack of documentation as a barrier to having a mobile money account is more than twice as large as the share of adults without an account but with an ID. All other barriers are cited by about equal shares of adults in both subsamples.

In 2012, the FATF adopted a mandatory risk-based approach to anti-money laundering and combating the financing of terrorism that applies more scrutiny to high-risk customers while allowing simplified measures for lower-risk ones. This approach includes, for example, tiered customer due diligence, which enables financial institutions to provide basic, lower-risk financial services to customers with minimal identification and verification and additional services with further identification and verification. By replacing its previous rules-based standards, the FATF partly responded to evidence that its standards could lead to financial exclusion.²⁴ According to a 2023 World Bank survey of authorities in the financial sector, about half of the responding jurisdictions had implemented standards that permit tiered customer due diligence among commercial banks and nonbank issuers of electronic money.²⁵

Mexico, for instance, approved a successful tiered scheme for opening deposit accounts in 2011.²⁶ In the two years following the introduction of an account with simplified requirements for customer due diligence, 9.1 million accounts were opened (of which 77 percent were with simplified requirements), and 2.9 million prepaid cards issued for government programs were replaced with such accounts.

However, a risk-based approach to customer due diligence may fail to apply proportionality and underestimate the impact that financial exclusion has on risks to financial integrity.²⁷ Using proportionality requires regulatory capabilities that are often lacking in economies most in need of increasing financial inclusion. As a result, countries underuse simplifications and exceptions in this area.

In addition to the adoption of risk-based customer due diligence, investments and innovation in ID systems can ease constraints on financial inclusion imposed by requirements related to customer due diligence. Technology-enabled solutions, such as biometric identification,²⁸ can significantly lower the compliance costs associated with customer identification and verification.²⁹ For example, India's rapid growth in account ownership over the past decade has been in part due to a government policy launched in 2014 that leveraged biometric identification cards to boost account ownership among the unbanked.³⁰

Standardization in securities markets

Beyond banking, standardization also plays a foundational role in the development of securities markets. By harmonizing terms of securities contracts (such as maturity dates, contract sizes, and settlement conventions), standardization reduces transaction costs, improves price discovery,³¹ and lowers barriers for new participants in securities markets. This is particularly important for maintaining market liquidity, as standardized instruments are easier to trade, compare, and value.³²

A classic example of the power of standardization in securities markets comes from the evolution of the Chicago Mercantile Exchange (CME). In 1964, the CME introduced live cattle futures contracts with precise, uniform specifications: fixed quantities (40,000 pounds), quality grades defined by the US Department of Agriculture (USDA), and designated delivery points. This transformed an opaque, bilateral market into a centralized one with transparent pricing and reliable settlement.³³ The use of standardized contracts enabled CME's clearinghouse to scale efficiently, build trust, and accommodate a growing investor base.³⁴ As a result, participation in trading of cattle futures and the volume traded grew explosively.

For developing countries seeking to deepen their securities markets, the experience of organized exchanges such as the CME offers several lessons. First, governments often devote significant effort to building sovereign yield curves, issuing bonds at different maturities that serve as reference prices for other securities. Concentrating issuance around a few standardized bonds with fixed maturities and regular calendars for issuance can strengthen this process by channeling liquidity into specific instruments and helping establish a clear benchmark yield curve.³⁵ Second, early investment in centralized infrastructure for clearing trades can enhance counterparty confidence and reduce reliance on bilateral trading relationships. Finally, simplifying contract terms can attract institutional investors, including foreign participants that face higher costs related to due diligence in opaque markets.

Conclusion

Financial standards are essential for building stable, transparent, and inclusive financial systems. IFRS improve transparency in accounting and attract investment, whereas the Basel Framework enhances banking resilience through requirements regarding bank capital. Similarly, FATF standards strengthen financial integrity but can inadvertently limit financial inclusion; adopting risk-based approaches and digital ID systems helps mitigate these effects.

A common theme in financial standards is that one size may not fit all. To reap the benefits of such standards while maintaining access and inclusion for smaller and lower-capacity market participants, standards development organizations typically implement tiered approaches to application of the standards they develop.

Standardization also supports the development of securities markets by reducing the costs associated with transactions conducted in those markets and improving the markets' liquidity.

Overall, well-designed standards not only safeguard financial systems but also promote broader access to and investment in them, as well as market development, particularly when the standards are adapted to local capacities and needs.

Financial standards offer valuable lessons for current debates on digital assets like stablecoins and cryptocurrencies. The key lesson from IFRS is that transparency and comparability are essential for building trust: Disclosure frameworks for digital assets must reduce opacity in regard to reserves, governance, and risk. From the Basel Framework, the lesson is that prudential safeguards and proportionality are key: Just as rules regarding capital requirements balance resilience with capacity, rules for digital assets must adjust requirements regarding reserves, liquidity, and leverage based on the risks posed by different actors while remaining manageable across jurisdictions.

The FATF's experience shows that integrity standards can foster trust but also pose the risk of exclusion: designing know-your-customer and anti-money laundering procedures for digital assets should incorporate proportionality and technology-enabled solutions for identification to avoid excluding those who most need financial access. And the history of standardization in securities markets teaches us that interoperability and uniformity lower costs and increase liquidity: Standards and settlement protocols for tokens could serve the same purpose for digital finance.

Overall, the main takeaway of the discussion in this spotlight is that standards for digital assets should evolve through adaptation, alignment, and eventual authoring—balancing ambition with compliance capacity—to ensure they protect stability while encouraging innovation. Achieving this will require strong international cooperation.

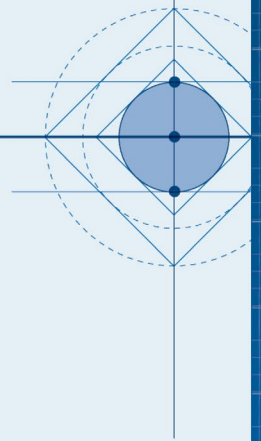
Notes

1. Refer to FSB (2025).
2. Perera (2024).
3. DeFond et al. (2011).
4. Akpomi and Nnadi (2017); Gordon et al. (2012); Lungu et al. (2017).
5. Calomiris (2012).
6. Aiyar et al. (2015).
7. World Bank (2012, 2020).
8. Goodhart (2011).
9. Ferguson (2003).
10. Jones et al. (2018).
11. BCBS (2022b).
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13. Refer to Behn et al. (2016) on Germany; Fang et al. (2022) on Peru.
14. FSB (2019).
15. Fišera et al. (2025).
16. Gambacorta and Shin (2018).
17. BCBS (2022a).
18. Jiménez et al. (2017).
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20. For an overview of the history of the current international framework for addressing financial crimes, refer to de Koker and Goldbarsht (2024).
21. FATF (2003).
22. Refer to World Bank (2023) for information about a World Bank survey of documentation requirements among financial authorities around the world.
23. Klapper et al. (2025).
24. Jenik et al. (2024).
25. World Bank (2023).
26. AFI (2011).
27. FATF (2021).
28. Meagher (2019).
29. D'Silva et al. (2019).
30. Demirgüç-Kunt et al. (2022); Sankritik and Shetty (2025).
31. "Price discovery" refers to how trading activity reveals the fair value of securities.
32. Diamond and Verrecchia (1991); Loon and Zhong (2014).
33. Lambert (2010); Paulson (2024).
34. Central clearing of contracts increases the liquidity of the markets for those contracts only when the contracts are sufficiently uniform to allow for opposing positions across counterparties to be more easily offset, thus reducing counterparty risk (Duffie and Zhu 2011).
35. "Bond yield curves" refer to the relationship between bond yields and maturities.

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SPOTLIGHT 5

Standards and Digital Public Infrastructures

Digital technologies have the potential to foster development in a wide range of areas, from boosting economic growth to enhancing public services.¹ The digital economy depends on digital public infrastructure, the digital systems and platforms (such as digital systems for identification and for payment and platforms for data exchange) that enable essential services to be delivered on a large scale.² Sector-specific digital platforms, like those in health care, education, and transportation, often support digital public infrastructure. Digital infrastructures create open channels on which both public and private actors can develop solutions, similar to the way physical infrastructure, such as roads and electricity, does. Standards act as the “rails” for the digital economy, especially in building digital public infrastructure, shaping who can participate, innovate, and benefit from the digital economy.

The *public* nature of digital *public* infrastructure does not mean that the government necessarily is, or should necessarily be, involved in the development and management of the infrastructure; many successful digital public infrastructures are entirely managed by private institutions. Rather, it refers to the fact that digital public infrastructure is inherently a public good, supporting both governance and market innovation. Such infrastructure also aims to fulfill critical objectives in the realm of public policy like enhancing competition, expanding access to services, and fostering inclusion. Accordingly,

governments can take the lead in the adoption of digital public infrastructure, whether by convening stakeholders, mandating standards, or even directly building the infrastructure.

Open versus proprietary standards: The hourglass model of standardization

The model used to set standards for some notable digital public infrastructures, like India Stack, can be visualized as an hourglass.³ In the middle is a slim set of common standards (a “thin waist”) covering areas such as digital authentication of identification, payment protocols, and the protocols for software connecting computers and programs (that is, the application programming interface) and for data consent. At the bottom of the hourglass is a wide range of technologies. At the top is a wide range of applications. The core standards in the thin waist at the middle of the system interconnect with the base of technologies below and support the range of applications above.

There is a strong case for requiring openness of standards for digital public infrastructure, especially for the core layers (that is, the thin waist). Because public infrastructure serves the public interest, it should not be limited by restrictions on private intellectual property or technologies that dominate the market. Therefore, standards for such infrastructure should be open, meaning

generally accessible to all potential users without restrictions, rather than being controlled by a single company or consortium that may impose licensing fees or usage constraints. “Open standards policies” are based on the idea that core government systems, such as platforms for identification, payments, and data exchange, should not depend on proprietary software or require licensing fees for interoperability. However, enforcing a strict mandate that components of digital public infrastructure use only fully open standards can be difficult, especially because in some technology areas, the most advanced standards may involve patents. The emerging consensus is for governments to adopt a hybrid, principles-based approach: Use open standards whenever possible, especially for interfaces, but consider proprietary technology if it is in the public interest, ensuring that no proprietary element compromises the overall openness of the system.

Building on the hourglass model for digital public infrastructure, openness in the thin waist—the critical connectors and data definitions—ensures that the system can expand to additional users and remain competitive. Flexible options, including proprietary offerings, can be implemented above the waist (applications) and below it (infrastructure), provided they remain compatible with the open core. A balanced approach of this type recognizes that, at its core, public infrastructure should incorporate open standards by design, while also leveraging the best available technologies (open or proprietary) for providing services, as long as those technologies do not create silos.

There is also an argument for having a minimalistic set of core standards. Maintaining a small number of standards for an open core can foster more innovative services such as financial technology applications, e-commerce solutions, and digital health services without requiring separate agreements for each integration. Such a model can also allow for rapid scale-up. In India, for example, hundreds of banks and dozens of payment

applications began interoperating on the country’s digital public infrastructure within a few years of one another, without the government’s needing to develop every application itself. The government also prevented a monopoly by ensuring no single vendor owned the standard for core digital public infrastructure, which kept barriers to entry low.

Another recurring feature of successful digital infrastructures is interoperability across platforms and providers. A key consideration at every level of digital public infrastructures should be how easy it would be to replace a component. Designing for replaceability hedges against both technological obsolescence and vendor opportunism. As a principle, it leads to modularity: the practice of building systems from modular components connected using standard interfaces (again in line with the hourglass model). In the area of payments, the clearest success stories are intentionally built around common rails for clearing and settlement (networks for instant payment with shared rules), with strong competition in consumer-facing products. In the area of data exchange, although arrangements are newer, the same philosophy is gaining traction. Countries are identifying key common standards—data formats, exchange protocols, security methods, and consent rules—that form the thin waist of the hourglass. When such standards are established at a national level, they enable a wide range of data-sharing uses.

Digital public infrastructure has impact: The case of digital payments

Digital public infrastructure can have impacts in areas ranging widely, from health care to agriculture and from financial services to government payments.⁴ Instant and interoperable digital payments often represent the most advanced level of digital public infrastructure in developing countries. Globally, 93 countries have active, real-time retail payment systems managed by operators

functioning in the public interest. The interoperability of these payment systems has become an unofficial standard. Examples of real-time payment schemes in developing countries that allow instant fund transfers include the UPI (Unified Payments Interface) in India, Pix in Brazil, SPEI (Sistema de Pagos Electrónicos Interbancarios) and CoDi (Cobro Digital) in Mexico, the Internet Banking Payment System in China, and Fonların Anlık Sistemde Transferi (Instant and Continuous Transfer of Funds) in Türkiye. Recent growth in the number of real-time payment schemes means the number now surpasses what was available a decade ago, when the infrastructure required to support them was limited to a few advanced economies. In fact, many emerging markets have surpassed their more developed counterparts in the volume of transactions these systems process.

Lowering transaction costs related to digital payments can boost financial inclusion. Users of India's UPI, for example, are nearly three times more likely to save in formal accounts without reducing their informal savings.⁵ In Brazil, adoption of Pix facilitates new banking relationships: a 1 percent increase in active Pix users results in a 0.25 percent rise in relationships with new banks and a 0.8 percent increase in first-time openings of bank accounts.⁶ Interoperable payment systems also significantly influence competition and innovation in the payment sector and, more broadly, in the banking industry.⁷

The effects extend beyond financial outcomes. By lowering transaction costs and reducing information asymmetries, efficient methods for payment can improve outcomes in the real economy. For example, in India, households in districts with a higher share of banks participating in UPI experienced a 2 percent greater increase in business ownership and an 8 percent greater rise in income between 2018 and 2022, compared with households in districts with lower shares of banks participating in UPI.⁸ Increased borrowing capacity mainly drove this growth in household income

and entrepreneurial activity, indicating that histories of transactions through digital payment systems can serve as collateral for loans. Having open and interoperable data is crucial to unlocking this potential. Thanks to UPI, data on customers' financial transactions can be shared among providers of financial services, promoting competition and innovation and leading to an expansion of credit, primarily for underbanked and marginalized borrowers.⁹

Beyond technology standards: The need for complementary policies

Technology standards alone cannot ensure a thriving, competitive digital ecosystem; supportive policies are also required. If a government mandates an open standard for, say, mobile payments, it must also be prepared to monitor the market and prevent anticompetitive behavior. Policy makers need to oversee market concentration even after open standards have been adopted.¹⁰ Therefore, competition policy, data governance (ensuring fair sharing of data), and consumer protection (preventing proprietary lock-in through application stores or devices) all come into play.¹¹ Effective exchange of data in digital public infrastructure requires both technical standards (such as common protocols, formats, and application programming interfaces for interoperability) and legal frameworks (such as those including policies on privacy, security, and data management). Achieving scalable nationwide exchange of data is difficult and requires addressing rising concerns regarding data privacy.

In addition, technology choices alone do not ensure success; institutional and policy frameworks are the foundation that makes digital public infrastructure effective for development. Emerging market and developing economies must carefully sequence legal and regulatory steps as they implement digital public infrastructure. Countries should be free to adopt approaches

that suit their specific contexts and should consider limitations in their capacities. Implementing digital public infrastructure requires coordination across multiple sectors (finance, telecommunications, social welfare, and so on), so having a clear institutional home or coordination body is essential. In lower-income countries, international partners may initially support such high-level coordination to build capacity, but it is crucial that local ownership be established (perhaps through a permanent e-government unit or information and communications technology ministry).

There is no one-size-fits-all blueprint for digital public infrastructure, but the hourglass logic presented in this spotlight can act as a guiding principle. Policy makers should first evaluate which

elements of the infrastructure, if standardized, will generate the greatest network effects and public benefits. These likely belong in the thin waist of the hourglass and include things such as a national format for identification, a scheme for interoperability of payment systems, and a data-sharing consent system. Then, policy makers should identify areas in which diversity and competition are more valuable than uniformity. These areas are better at the edges and can include things like user-facing applications and sector-specific business processes. By making distinctions of the type discussed here, governments can avoid both extremes: chaos from failing to standardize essential elements and stifling uniformity by imposing too many standards in areas better suited for local innovation.

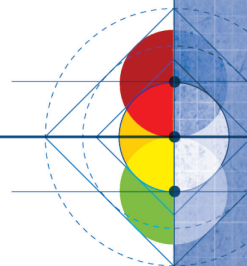
Notes

1. World Bank (2016).
2. Clark et al. (2025).
3. Sankritik and Shetty (2025).
4. For a comprehensive set of case studies, refer to Clark et al. (2025).
5. Greenlend and Toth (2023).
6. Sampaio and Ornelas (2024).
7. Refer to Bianchi and Garz (2024) for more details.
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5 Standards for Better Human Capital

Main messages

- Quality standards are the backbone of delivery of services in health care and education. Without them, investments leak away in poor implementation. In health care, 60 percent of deaths in low- and middle-income countries stem from conditions that could be prevented or treated with high-quality care. Compliance with standards in areas from supply chains to staffing depends on strong quality infrastructure.
- Early standards shape lifelong success. The first thousand days of life set the foundation for a child's learning and health. Every US\$1 invested in nutrition and stimulation in early childhood yields up to US\$13 in later returns, through better school performance and higher productivity. Standards for prenatal care, early learning, and teacher-pupil ratios lock in these gains.
- Countries should start where they are, then raise the bar. Setting overly ambitious standards too soon can exclude poor people. When their standards match their capacity to enforce them, countries expand coverage faster and learn by doing. As countries' capacity to comply with them grows, standards can—and should—rise. This adaptive path explains how Viet Nam moved from performing below the average for Organisation for Economic Co-operation and Development (OECD) member countries regarding scores on the OECD's Programme for International Student Assessment (PISA) to the top PISA performance in less than a decade.
- Process standards save lives. Simple checklists for hospitals to follow reduced mortality by 47 percent. Standardized clinical guidelines and monitoring tools boost equity and innovation, especially in systems in which poor people are most at risk from low-quality care.
- Teachers are the most powerful standard in education. When teaching quality is raised, learning follows. In Brazil's state of Ceará, clear standards for teacher practice and literacy benchmarks helped nearly every child read by grade 2, lifting the state's scores on Brazil's National Education Quality Index from 3.2 to 7.7 in less than two decades.
- What gets measured gets improved. Global learning assessments like PISA have jolted countries into action—from Germany, where reforms after its 2000 "PISA shock" lifted student scores above the OECD average, to Peru, where a similar wake-up call spurred sweeping reforms to programs for teacher development and to curriculums.

The link between policies and standards for health care and education

Health and education are essential for human development and inclusive growth.¹ The foundation of human capital is established during early childhood, when most of the brain's neural connections are formed. Missing out on investments in early childhood is very difficult and costly to compensate for later in childhood or adolescence.² The return on investment in human capital is greatest in a child's early years.³ Such early investment starts with health, through prenatal care, cognitive stimulation, and nutrition, which are crucial for brain development and future learning. Standards in early childhood lay a key foundation for success in school and later life. Although human capital also develops through work, this Report does not address standards in labor markets.⁴

Governments in developing countries face the immense challenge of providing their large populations with access to health care and schooling. Given these countries' limited institutional capacity and financial resources, the key trade-off is between high standards and low levels of access or low standards and high levels of access. At low levels of income, giving villagers access to even bare-minimum services in health and education has high marginal returns. On the other hand, certain interventions cannot be downgraded if they are to have the expected impact. For instance, immunization must reach a critical minimum coverage in a population to achieve or maintain control of infectious diseases. Similarly, as patient volumes increase, so does treatment quality in hospitals, to such a degree that this relationship has led to standards on minimum patient volumes.⁵

There are important links between policies and standards in both health and education. Interventions to improve children's health can improve their educational outcomes effectively

and vice versa. For instance, a deworming program in Kenya significantly increased school attendance.⁶ More generally, health interventions such as those related to nutrition and sanitation directly increase children's ability to learn and therefore improve educational outcomes. School nutrition programs, such as the Tawana Pakistan Project,⁷ not only address malnutrition but also increase school enrollment as well as improve children's ability to pay attention in school. Relatedly, education leads to better health. School feeding programs promote healthy eating habits among children. Educating children about handwashing reduces the incidence of disease.

The world's unfinished agenda for human capital development

While progress in both health and education reached unprecedented levels in the late twentieth century, it remains incomplete and unevenly shared. Thanks to improvements in medicine and public health, life expectancy in low-income countries today is much higher than it was in Organisation for Economic Co-operation and Development (OECD) member countries when they were at similar levels of GDP per capita.⁸ Nonetheless, while life expectancy in high-income countries reached 80 years in 2023, in low-income countries it is only 65 years.⁹ Poor and rural households in low- and middle-income countries continue to face high rates of infectious disease; reproductive, maternal, infant, and child health disorders; and malnutrition, which translate into a high burden of disease.¹⁰

Access to education has expanded widely, with primary school enrollment in low-income and lower-middle-income countries having reached 81 percent and 87 percent, respectively.¹¹ Yet learning outcomes remain a challenge, with many children failing to meet minimum standards of

proficiency in reading and mathematics. The share of children unable to read a simple text by age 10 (so-called learning poverty) stands at 91 percent in low-income countries and 60 percent in lower-middle-income countries. In upper-middle-income countries and high-income countries, learning outcomes remain unsatisfactory, with indexes of learning poverty in the two country groups at 29 percent and 8 percent, respectively.¹²

Improvements in health have been more apparent in mortality rates than in morbidity rates, while improvements in education have been much more significant in regard to enrollment rates than in regard to learning outcomes.

Standards for health and education

Standards can be used to enhance outcomes related to human capital, such as reducing morbidity and mortality, ensuring proper physical growth of children, and improving reading skills. These outcomes rely on quality inputs (such as supplies, infrastructure, and staffing) and processes (such as clinical protocols and teaching methods). Countries can choose to adopt, adapt, or align with international standards developed by organizations like the World Health Organization (WHO) and the United Nations Educational, Scientific and Cultural Organization (UNESCO) to fit their local contexts. International standards for best practices carry more influence in health care than in education, for which it is more important to adapt to local circumstances.

The importance of standards related to human capital is clear in regulations such as caps on class size, measurement systems like standardized tests, and protocols like checklists for surgical procedures used daily worldwide. Standards set acceptable levels of quality and practice in licensing teachers and medical professionals; accrediting

schools, diagnostic laboratories, and hospitals; and establishing quality requirements for learning or medicines. Standardized measures are crucial for monitoring performance, benchmarking best practices, and enabling comparative analysis.

Most standards for inputs into and processes for human capital are examples of minimum quality standards (such as teacher or doctor qualifications or minimum requirements for staffing). Others are compatibility standards, including certification credentials. Measurement standards include disability-adjusted life years (DALYs) in health and learning-adjusted years of schooling¹³ in education, which serve as benchmarks for evaluating improvements in outcomes.

This Report posits that countries reach desired human capital outcomes when standards for individual countries are set based on those countries' ability to comply with them. As a country's capacity grows, standards should be updated, as discussed in chapter 2. Compliance with standards for health and education services builds trust in the systems associated with those standards, which then increases demand for both types of services.

The importance of complementary policies

Standards are just one tool, however, in the policy toolbox. To achieve desired outcomes, interventions may sometimes require other policy instruments, such as incentives and training. Standards ensure that interventions are implemented as designed, but the wrong set of interventions will fail to produce desired outcomes even when the right standards are used.

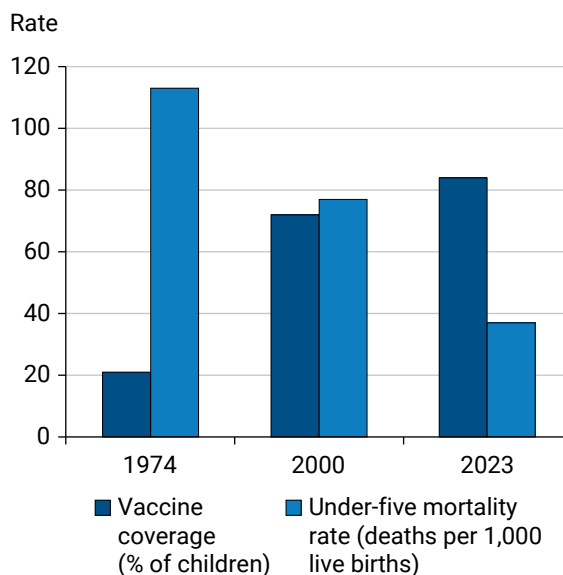
The WHO Essential Programme on Immunization illustrates how standards can achieve desired outcomes.¹⁴ Vaccination coverage—that is, the percentage of a population that needs to be vaccinated to achieve herd immunity—varies by disease

(for example, it is 95 percent for measles and 80 percent for polio).¹⁵ This minimum share of the population that must be vaccinated to achieve herd immunity is a standard, and so are quality standards to ensure that vaccines are effective. While vaccination campaigns can save lives, adherence to standards ensures that enough people get immunized during a campaign and that quality vaccines and vaccination methods are used.

The Essential Programme on Immunization, which initially focused on six major infectious diseases, has expanded its reach and integrated newer vaccines, supported since 2000 by Gavi, the Vaccine Alliance. Expanded vaccination coverage has led to a decline in deaths of very young children (refer to figure 5.1). Some have estimated that the program has contributed to a 40 percent decline in the death rate of children under the age of five.¹⁶ In the case of this program, compliance with standards led to a successful implementation of the intervention, which in turn reduced mortality, the intended outcome.

A recent study of teacher qualifications in Pakistan offers a contrasting example.¹⁷ In 2016, Pakistan changed its practices for recruiting teachers for the public sector by introducing nationwide standardized testing and requiring a passing score for candidates for teaching positions, aiming to promote merit-based hiring. The change in hiring practices resulted in new teachers being more qualified (refer to figure 5.2, panel a). Teachers hired after the reform were significantly more likely to hold postgraduate degrees, with female teachers more likely to have majored in science. However, despite the hiring of more qualified teachers, classroom practices and outcomes of student learning did not improve and, in fact, actually declined (refer to figure 5.2, panel b).

Figure 5.1 Expanded vaccination coverage has led to a decline in deaths of very young children

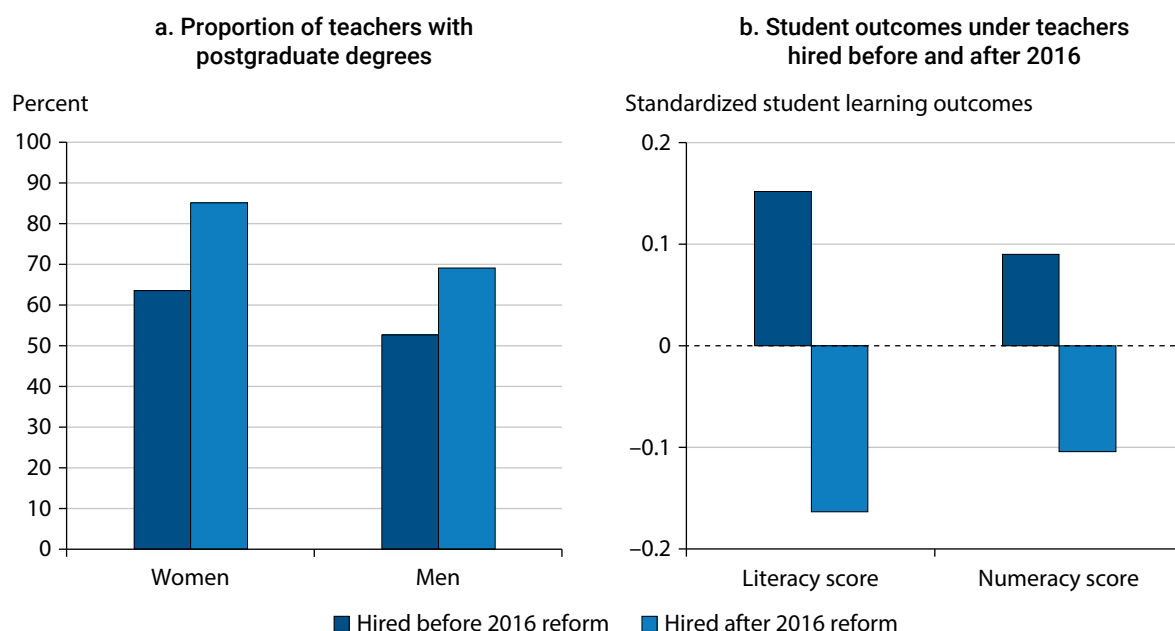


Sources: WDR 2025 team estimate using data from Mirza et al. 2025 for vaccine coverage in 1974. Data on vaccine coverage for 2000 and 2023, as well as data on the under-five mortality rate for 1974, 2000, and 2023, are from WDI (World Development Indicators) (dashboard), World Bank, Washington, DC, <https://datatopics.worldbank.org/world-development-indicators/>.

Note: “Vaccine coverage” is the percentage of children receiving the vaccine for diphtheria, pertussis, and tetanus, which is a good proxy for the percentage of children receiving a wider range of vaccines. “Under-five mortality rate” is the number of children younger than five that died per 1,000 live births.

These findings highlight the limitations of using standards. While changing hiring practices improved teacher qualifications as intended, higher hiring standards alone were insufficient to improve the overall quality of education. What was missing were complementary efforts to improve how teachers teach and ensure they teach effectively.

Figure 5.2 Raising teacher qualifications is not enough to improve student outcomes: Evaluating standards for hiring teachers in Pakistan



Source: Asad and Fatima 2025.

Note: Panel a reports the percentage of teachers with postgraduate degrees before and after a 2016 policy change (refer to chapter text). Panel b reports outcomes of student learning as measured by standardized test scores in the areas of literacy and numeracy before and after the policy change. A standardized test score of zero is equal to the average.

Adopting standards to improve quality in the health sector

The medical community adopts standards to ensure the quality of medical services provided and build trust between medical personnel and patients, which is essential for increasing demand for public or private health services. Reliable public enforcement of these standards can lead to expanded health coverage and better health outcomes. The discussion that follows explores the use of standards in selected examples from the field of health care, highlighting the difference between the quality of inputs and processes and their impact on outcomes.

Quality standards for health inputs

Inputs into health care include physical facilities (such as hospitals, clinics, and health centers), other physical support (such as equipment, medicines, and vaccinations), and certified medical providers (such as doctors and nurses).

Standards for a country's supply of medicine: Essential Medicines Lists

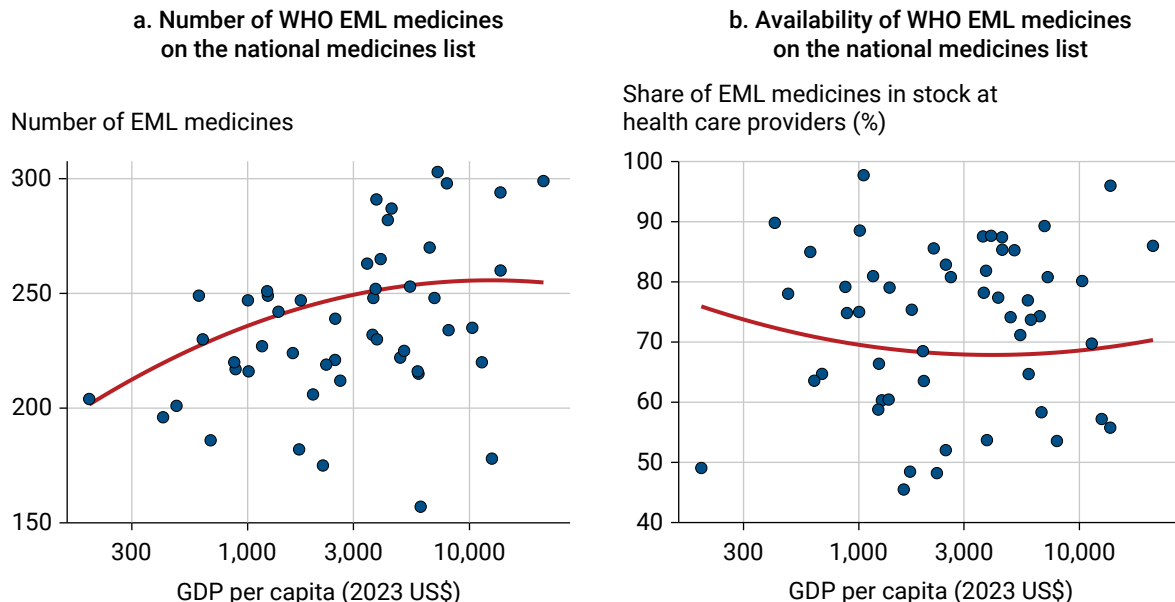
To guide countries in deciding which medicines to make a priority in regard to their health care needs, WHO has published and regularly updated a Model List of Essential Medicines (EML) since 1977.¹⁸ From 186 medicines in the first list, the number had expanded to 502 medicines by 2023.

WHO chooses medicines for inclusion on the list based on their safety, effectiveness, and cost. Updating the list is a continuous process, in keeping with changes in epidemiological conditions and pharmaceutical progress.

The EML has been instrumental in improving access to essential medicines and has shaped national health policies by encouraging many low- and middle-income countries to develop their own national medicines lists (NMLs). More than 150 countries, mostly lower income, have developed NMLs, based on the EML, to reflect their specific health priorities and resource availability. By developing an NML, a country commits to procuring the medicines on the list and ensuring that they will be available in its health care facilities.

Figure 5.3 tests whether NMLs follow the conceptual framework discussed in chapter 2 (refer to figure 2.5). According to the framework, countries should adapt NMLs not only based on their health needs, but also on their capacities to enforce them. As the ability to procure the medicines included on NMLs increases—that is, as countries' compliance capacity (proxied by income per capita) increases—countries should include more medicines from the EML on their NMLs. This is precisely what panel a of figure 5.3 shows is happening. As countries' income per capita increases, the number of medicines from the EML on countries' NMLs also increases (refer to figure 5.3, panel a). Furthermore, the overall number of medicines (both from the EML and others) on a country's NML increases as the country's income

Figure 5.3 Countries create national medicines lists according to their compliance capacity



Sources: Panel a: WDR 2025 team using data from Global Essential Medicines (dashboard), World Health Organization, <https://global.essentialmeds.org/dashboard/countries>; Persaud et al. 2019. Panel b: Oldfield et al. 2025; World Health Organization/Health Action International Project on Medicine Prices and Availability (portal), World Health Organization, <https://www.who.int/teams/health-product-and-policy-standards/medicines-selection-ip-and-affordability/who-hai-project-medicine-prices-and-availability>.

Note: Panel a shows the number of medicines from the World Health Organization (WHO) Essential Medicines List (EML) that are included on countries' national medicines lists. Panel b shows the share of those medicines in stock at countries' health care providers.

per capita increases.¹⁹ The NML is adapted in such a way as to minimize the compliance gap, that is, the difference between full and actual availability of medicines listed on the NML. As shown in panel b of figure 5.3, the compliance gap is consistent across countries of different income levels.

Medicines listed on a country's NML should be available and affordable to all patients in that country who need them.²⁰ Medicines on NMLs tend to be more available, on average, than medicines not on NMLs.²¹ Even so, availability of medicines on NMLs remains suboptimal.²² Left to its own devices, the market for medicines would not provide enough affordable drugs to meet public health needs. Narrow profit margins discourage manufacturers from producing essential drugs in quantities sufficient to meet those needs, while nonessential drugs for symptomatic relief of trivial conditions have high profit margins. NMLs thus assure markets for essential drugs and thereby provide the pharmaceutical industry with incentives to increase production of those drugs while accepting a lower price in exchange for a wider consumer base.

Minimum standards for qualifications for doctors and nurses

Countries and others often use the doctor-to-population ratio as a standard at the national, regional, and local levels to measure ease of access to health care services among various populations, whether urban or rural, affluent or poor. One important aspect the ratio misses, however, is the qualifications of medical personnel (including doctors, nurses, pharmacists, and laboratory technicians).²³ National accreditation agencies set national quality standards to validate the credentials of medical personnel. WHO plays a key role by creating global standards for medical education at the undergraduate, postgraduate, and continuing professional development levels and by

certifying national accreditation agencies through the World Federation for Medical Education (WFME) Recognition Programme.

International recognition of skills is essential for medical schools and graduates seeking both national and international certification, and it can help rebalance the global labor market. High- and upper-middle-income countries require migrants with skills appropriate for meeting the demands of the health care market.²⁴ Indeed, global demand for health care workers is projected to rise significantly by 2030, potentially causing a shortage of millions.²⁵ Meanwhile, low- and lower-middle-income countries have excess health care workers. But merely shifting workers from lower- to higher-income countries will not resolve the issue, because those workers may not have the necessary skills or certifications.²⁶

Global Skill Partnerships (GSPs) are a promising policy tool for addressing this problem.²⁷ In these partnerships, firms and governments in workers' destination and origin countries jointly implement training programs and share the costs of worker training and mobility. Training mainly occurs in origin countries, with a portion of graduates emigrating to destination countries through formal channels and the rest entering domestic labor markets. This dual-track model allows countries on both sides of the exchange to share the economic gains from training and mobility. To date, most existing GSPs have been small-scale pilots, with a few exceptions. Australia-Pacific Technical College has trained and certified more than 20,000 students since 2007 from 14 Pacific Island countries in five main sectors, with 8 percent of graduates migrating to Australia.²⁸ A skill mobility program similar to GSPs is Germany's Triple Win program, established in 2013. Since its launch, the program has placed more than 6,000 registered nurses in Germany from different countries.²⁹

Minimum quality standards for medicines and vaccinations

One of WHO's functions is to develop standards for medicines and vaccines to ensure they are safe and effective and meet quality requirements. The process for fulfilling this function includes many elements, such as prequalification, quality assurance, guidelines for inspecting pharmaceutical manufacturing facilities, and monitoring for counterfeit or substandard products and medicines.³⁰

Developing countries have complex issues involving drug safety. Given differences between

developed and developing countries in health systems, disease patterns, and marketed drugs, health authorities in the latter cannot simply adopt and implement standards from the former.³¹ It is essential that developing countries have a functioning quality infrastructure to monitor their pharmaceutical supply chains and enforce standards. Pharmaceutical standards and regulatory systems across the developing world remain fragile, uneven, and highly dependent on aid and technical support from international donors.³² The trade and consumption of substandard medicines remain too common (refer to box 5.1).

Box 5.1 The high cost of substandard medicines and missing quality infrastructure

Cough syrup contaminated with diethylene glycol is a recurring hazard. The first mass poisoning from diethylene glycol occurred in the United States in 1937, when the compound was used as a solvent in cough syrup at a time when toxicity testing was not mandatory. The result: 105 deaths, including 34 children. The tragedy catalyzed sweeping reforms to the 1938 Federal Food, Drug, and Cosmetic Act, with a strong emphasis on safety. The United States has not since experienced another mass poisoning from diethylene glycol.^a

But the problem persists in developing countries. In 2022, 66 child deaths in The Gambia led the World Health Organization (WHO) to issue a global alert^b and flag 20 contaminated cough syrups.^c The deaths were traced to an Indian manufacturer. Indian authorities halted production, investigated the plant involved, and found serious violations of the country's Good Manufacturing Practices.^d The government's position was that the incident reflected a single firm's compliance failure, not a systemic weakness in regulation. Nevertheless, it quickly introduced safeguards—ensuring that plants in India meet standards recommended by WHO and requiring mandatory preexport testing and certification from accredited laboratories—to strengthen quality assurance for medicines bound for international markets. Smaller firms were given more time to comply with the safeguards, but after 24 people died in India in 2025

(Box continues next page)

Box 5.1 The high cost of substandard medicines and missing quality infrastructure (*continued*)

as a result of consuming locally produced cough syrup contaminated with diethylene glycol, India refused drugmakers' requests to extend the deadline, requiring them to upgrade their manufacturing facilities to international standards by the year's end.^e

Preventing additional occurrences of such incidents requires robust national quality infrastructure: accredited upstream and downstream laboratories for quality control, postmarketing surveillance, and meaningful penalties for quality failures.^f In the absence of global compulsory enforcement, countries must enforce their own standards. Developing countries like The Gambia need external technical and financial support to build verification capacity.

Source: WDR 2025 team.

a. Thakur and Reddy Thikkavarapu (2022).

b. Saied et al. (2023).

c. Dutt (2023).

d. Saied et al. (2023).

e. Eglovitch (2025).

f. Nallathambi and Cadwallader (2024).

Gender gaps in standards for medicines and vaccinations

Standard setting for medicines and vaccinations is also addressing a long-standing gender gap in health. Standard dosages in medicine have long failed to take gender differences into account.³³ Many medicines and vaccines are administered in gender-neutral doses even though women and men are biologically different. For example, the influenza vaccine has one dose for both genders, even though women develop higher levels of antibodies³⁴ and are more likely than men to experience adverse drug reactions.³⁵

Historically, women have been underrepresented in medical trials for developing drugs and vaccines,

which has implications for the safety and efficacy of the drugs and vaccines developed. Cardiovascular disease has been the leading cause of death among women in the United States since 1989. Yet women represented only 25 percent of participants in 31 landmark trials for drugs treating congestive heart failure between 1987 and 2012. Risk prediction models developed for men often miss warning signs of the risk of heart attacks in women. Preventive measures that reduce the risk of heart attack developed for men may be less effective for women. For example, while aspirin has been found to be effective in preventing a first heart attack, studies have found that it may be ineffective or even harmful in women.³⁶ In the United States, 80 percent of the drugs withdrawn from the

market by the US Food and Drug Administration (FDA) were banned because they were found to have had adverse effects on women.³⁷

In recent years, progress has been made in Australia, the United States, and the European Union. For example, in 2016, the US National Institutes of Health (NIH) required that data from studies it funded be disaggregated and analyzed by sex, unless there was a compelling reason not to do so.³⁸ As of 2021, women accounted for about half of all clinical research supported by the NIH, expanding consideration of sex in research designs, analysis, and reporting from preclinical studies to clinical interventions.³⁹ Between 2016 and 2024, the share of adverse events in the United States reported by women fell by 1 percentage point.⁴⁰

Standards for health care processes

High-quality health care is the right care delivered at the right time, in a coordinated way, in response to the needs and preferences of patients, while minimizing harm and resource waste. Unfortunately, there is substantial evidence that the quality of care in many lower-middle-income countries is low, especially for those who are poor.⁴¹ Applying process standards can help push provision of health care to higher levels of quality.

The checklist: Process standard for treating patients

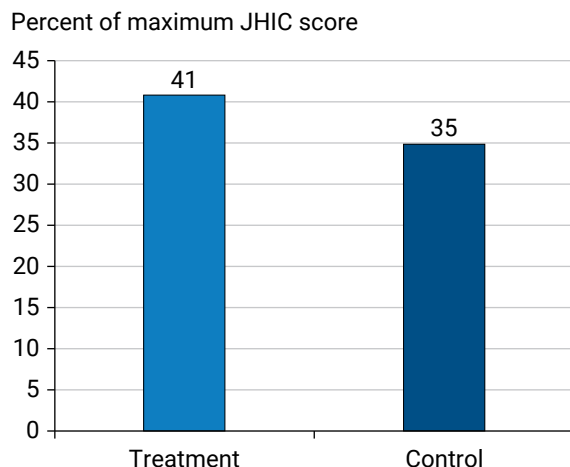
One notable example of a process standard that reduces medical errors is the use of checklists to ensure that health personnel follow vital steps during complicated medical processes. Adherence to standards of this type has been associated with improved patient outcomes across a wide range of diseases, including heart failure, breast cancer, and pneumonia.⁴² Standardizing treatment of childhood illnesses in communities and health facilities through an approach known as Integrated

Management of Childhood Illness, which includes clinical algorithms, is associated with reduced childhood mortality when used at scale.⁴³

Inspired by air pilots' checklists, WHO and a team of researchers developed the Safe Surgery Checklist to address common lapses in safety during surgery and prepare for uncommon complications.⁴⁴ The checklist is not intended to be comprehensive and is meant to be adapted to local conditions for health care. It was tested in 2008 in eight hospitals around the world.⁴⁵ Assessment results showed that in hospitals that introduced the checklist, the rate of complications fell by 36 percent and deaths fell by 47 percent.⁴⁶ WHO recommends the use of surgical safety checklists, requiring that hospital teams make certain that a patient's known allergies are checked before surgical procedures and that instruments, needles, and sponges are counted after procedures to make sure none are left inside patients.⁴⁷ Studies have shown that such checklists have reduced the rate of surgical complications, including mortality.⁴⁸

In Kenya, between 2013 and 2015, the World Bank and the Ministry of Health developed a new regulatory mechanism for both public and private providers of health care. This was coupled with an impact evaluation to assess the effects of the new mechanism, involving a randomized controlled trial of 1,348 health facilities across three Kenyan counties, categorized into 273 distinct health markets. The project implemented a standardized inspection protocol, the Joint Health Inspection Checklist, for evaluating a facility's compliance with safety protocols. The health markets were randomly assigned to high-probability inspections with enforcement of safety standards (treated) and low-probability inspections (control).⁴⁹ Enforcement of standards successfully increased compliance with measures for patient safety in both public and private facilities, increased trust in public health care and patient safety, and

Figure 5.4 Process standards such as checklists improve health care quality



Source: Bedoya et al. 2023.

Note: The figure shows the estimated increase in patient safety (that is, compliance with safety protocols) in Kenya after implementation of the Joint Health Inspection Checklist (JHIC) to measure compliance with safety protocols. “Treatment” refers to health care markets that were randomly selected to be inspected. “Control” refers to health care markets that were not. The difference between scores among the treatment and control groups is statistically significant at the 1 percent level.

improved delivery of health care while maintaining access to care. Treated facilities scored on average 41 percent of the maximum score, compared with 35 percent in control facilities (refer to figure 5.4).

Standards for accountability and monitoring systems in health care

WHO provides countries with frameworks and tools for developing their national quality infrastructures covering various aspects of service delivery of health care, such as those related to staffing, equipment, and clinical protocols. It also gives countries guidance for developing frameworks that ensure safety, quality, and efficacy of medical devices and medicines.⁵⁰ For example, it publishes guides such as *Global Standards for*

Quality Health-Care Services for Adolescents (2015)⁵¹ and *Standards for Improving Quality of Maternal and Newborn Care in Health Facilities* (2016).⁵²

The International Organization for Standardization (ISO) issues standards for the quality of medical devices and laboratories. For example, ISO 13485 specifies requirements for medical devices, ensuring consistent design, development, production, and delivery. Many countries require compliance with this standard as a prerequisite for regulatory approval.⁵³ ISO 15189 specifies requirements for quality and competence of medical laboratories.⁵⁴ At the country level, national regulatory agencies help enforce ISO standards. For example, in the United States, the FDA approves and regulates medical devices.⁵⁵

Standards for best practice established by WHO are voluntary. Countries that adopt or adapt them must find ways to enforce them, working with their medical communities. For example, although WHO sets quality standards for drugs, the countries where the drugs are produced are responsible for enforcing these standards. This requires capacity in importing countries to verify drug quality. Because most low-income countries import their medicines and have limited verification capacity, it behooves producer countries to enforce quality standards to ensure safety.

Viet Nam’s strategy for setting up a quality infrastructure for medicine provides a good example. In 2009, the country launched a National Center of Drug Information and Adverse Drug Reactions Monitoring (in its Ministry of Health), responsible for pharmacovigilance. The center collects, analyzes, and evaluates reports on adverse events received from health care professionals, national public health programs, and pharmaceutical companies (which are required to submit Periodic Safety Update Reports); updates the country’s pharmacovigilance database; and assesses and

communicates drug-related risks. External technical assistance has helped the country develop a strong and comprehensive pharmacovigilance system and detect problems with drug quality. The system has largely met the minimum WHO requirements for a functional pharmacovigilance center.⁵⁶

Standards for measuring health

Together with incentives, quality standards—when enforced—can lead to better health outcomes. Collection of data on health outcomes is essential for measuring the actual impact of increased quality throughout a country's health system. Given the focus of this Report on early childhood development, one especially important outcome metric is WHO's standards for child growth, which pediatricians around the world use to measure children's early physical growth against a sample of children. This metric allows health care workers to assess whether a child's growth is on track. Detecting faltering growth early on is of vital importance to reversing any tendency toward stunting by providing remedial nutrition in time.

The WHO Global Health Estimates present comprehensive and comparable time series data from 2000 onward on health-related outcomes, including life expectancy, healthy life expectancy, mortality, and morbidity, as well as burdens of diseases at the global, regional, and country levels, disaggregated by age, sex, and cause.⁵⁷ The calculation of these indicators is made possible by the 11th version of the International Classification of Diseases (ICD-11), which standardizes, by means of codes, the diagnosis of diseases and causes of death globally. The coding of diseases and treatments across hospitals has helped improve diagnosis and treatment. ICD-11 also allows data on disease morbidity and mortality to be compared across different regions and countries and across time. The disease statistics it generates are

fundamental to global health, including research on health services, health payment systems, and health planning.⁵⁸

Focusing on mortality rates alone does not adequately capture the burden of disease. The DALY is a measurement standard that combines healthy life years lost because of premature mortality resulting from particular diseases with those lost because of disability.⁵⁹ DALYs help policy makers identify priority health issues by quantifying the burden imposed by different diseases. For example, in low-income countries infectious diseases such as malaria and tuberculosis cause major loss of health, so focusing resources on these is particularly cost-effective.⁶⁰ Also, the use of DALYs has been critical in showing that some tropical diseases and mental health conditions are highly disabling even if they are not a major cause of premature mortality.

The applicability of the DALY has been criticized, however.⁶¹ One concern, acknowledged by its creators, is the lack of representativeness of the weights used for various diseases, owing to survey limitations.⁶² Nonetheless, the DALY remains the dominant summary measure of health used by key global health actors including WHO, the *Lancet* family of journals, and the Gates Foundation, which makes funding decisions based on the DALY.⁶³

Transitioning to higher health care standards: The case of “barefoot doctors” in China

By ensuring the quality of and building trust in medical services, standards are a useful tool for improving health care outcomes. For standards to be most effective, however, the setting of standards in each country should follow the conceptual framework presented in chapter 2. In addition, standards need to be used in a flexible way and updated over time as economies develop and situations change.

Consider the case of the “barefoot doctors” in China, an adaptive, phased approach to standard setting that allowed a country’s health care system to grow. Between 1950 and 1985, China reduced mortality far more than did other developing countries with comparable levels of income.⁶⁴ Before 1949, the prevalence of infectious diseases, such as typhoid fever, cholera, and tuberculosis, and premature deaths in China was high, as were mortality rates (the crude death rate was 30–40 per thousand people, and infant mortality was 200 per thousand live births), and life expectancy was 32 years.⁶⁵ By 1978, at the beginning of China’s reform and opening-up process, although its GDP per capita was US\$156, its life expectancy had already increased to 63 years, exceeding the average level in lower-middle-income countries by 10 years.⁶⁶

In the mid-1960s, China had 730 million people, with 80 percent of the populace living in rural areas. Meanwhile, only 31 percent of health care professionals resided in rural areas; the rest lived in urban areas.⁶⁷ Recognizing that it had far too few conventionally trained medical personnel to serve its enormous rural population, in 1965 China shifted its health policy to focus decisively on rural areas.⁶⁸ Resources were reallocated to train and provide a paramedic—popularly called a “barefoot doctor”—in each village. Meanwhile, all Chinese universities, including medical schools, discontinued enrollment of full-time students.⁶⁹

The term “barefoot doctor” is really a misnomer, because the medical personnel trained under the program were neither barefoot nor doctors, but rather (as noted) paramedics: local farmers given short, intensive training to provide basic care and public health services in their own communities.⁷⁰ The name “barefoot” originated from farmers’ treasuring their sole pair of shoes too much to wear them in the muddy fields where

they worked. Because these medically trained peasants split their time between working in the fields and caring for patients, they were often running between one and the other with muddy feet.⁷¹ At the program’s height, in 1975, there were approximately 1.6 million barefoot doctors.⁷²

Instead of receiving the standard instruction in anatomy, physiology, biochemistry, and pharmacology, the barefoot doctors relied on a manual that was practical and results oriented. It focused on disease prevention, diagnosis of common symptoms, disease treatment, traditional Chinese herbal medicine, acupuncture, family planning and birth attendance, women’s and children’s diseases, and first aid. Barefoot doctors carried a medical box containing a syringe, a stethoscope, a few gauze pads, and a few medicine tablets to use in providing their fellow peasants with primary health care.⁷³ At the time, WHO praised the model for providing the greatest benefits with the least investment.⁷⁴

It is difficult to assess how much of China’s health improvement during the program’s existence can be attributed to the barefoot doctors. On the one hand, the trend in the country toward improvements in health predated the launch of the training and deployment of barefoot doctors.⁷⁵ On the other hand, the program rebalanced resources and thereby helped close the gap between urban and rural areas in access to health care.⁷⁶

As China’s system matured, the country gradually raised its standards, in 1984 requiring barefoot doctors to pass a new set of professional tests to become “village doctors.” In 1985, about 1.25 million barefoot doctors took the nationwide tests; 50 percent passed and received formal certificates as village doctors. Recent records suggest that there are about 910,000 certified village doctors in China.⁷⁷

Adopting standards to improve quality in the education sector

Standards for public education articulate the essential knowledge, skills, and abilities students should acquire as a result of the education they receive. Although student learning is a core goal of education, the success of an education system depends upon the adherence to quality standards in two critical areas: inputs (infrastructure, teachers, curriculum) and processes (pedagogy, leadership, accountability). Effective standard setting in these areas increases the chance of delivering higher-quality education services, facilitates comparability across time and space, and enables coherent policy making and targeted improvements in the education sector. If complied with, standards also create trust in the sector and increase demand for education services, increasing school attendance and improving learning outcomes.

In contrast to what is the case in the health sector, international standards play less of a role in education. Notwithstanding some universal minimum standards in education (minimum proficiency in reading and mathematics), local context largely determines what children need to learn. The main agency tasked with setting and enforcing international standards in education is UNESCO. To date, UNESCO's standard-setting instruments have included 43 conventions defining rules, 37 recommendations to influence the development of national laws and practices, and 14 declarations of universal principles.⁷⁸ For example, as part of Sustainable Development Goal 4.1.1, UNESCO monitors the percentage of children and youth achieving minimum proficiency in reading and mathematics at three stages (grades 2–3, the end of primary school, and the end of lower-secondary school).

Bolivia's 2010 educational reform (Law 70, "Avelino Siñani–Elizardo Pérez," named after two historic

Bolivian educators) well illustrates how curriculums can be adapted to local contexts. The reform built on earlier reforms in 1988 and 1994 designed to promote intercultural and bilingual education. It replaced the country's traditional curriculum, which often marginalized indigenous knowledge, with one that incorporated local cultural knowledge and practices and reinforced the involvement of communities and local authorities in school management and educational decision-making.⁷⁹ Since being implemented, the reform has led to increased access to education, particularly among indigenous children, and higher attendance rates among students.⁸⁰

Quality standards for educational inputs

Educational inputs encompass all foundational resources required for delivering quality education, including elements of the physical learning environment, teacher qualifications, and curriculum.

Standards for infrastructure and the physical learning environment

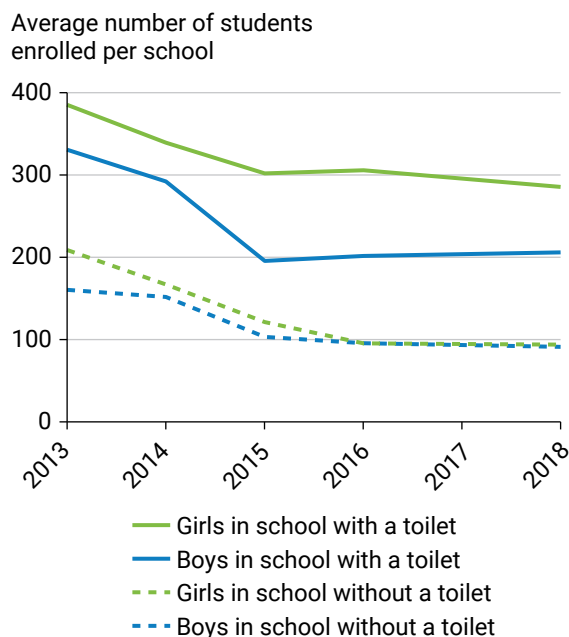
Physical learning environments such as buildings⁸¹ and classrooms are essential for effective education. They directly influence students' safety, comfort, and ability to learn.⁸² Ensuring that schools meet minimum standards for infrastructure is vital for reducing inequalities and providing students with safe, supportive learning spaces.⁸³

As is the case with curriculums, international standards for physical facilities need to be adapted to local conditions. Traditional buildings may suit the local climate best, although some minimum standards are necessary. For example, the availability of hygienic toilets is critical for encouraging attendance, particularly among girls. The lack of sanitation facilities for girls is known to discourage their school attendance. School latrine

construction significantly increases enrollment of pubescent girls, especially when sex-specific latrines are provided.⁸⁴ Yet worldwide, 28 percent of schools lack basic sanitation services, affecting 539 million children.⁸⁵

Interventions to improve sanitation clearly affect student learning. For example, in 1999, India launched the School Sanitation and Hygiene Education program to set standards for sanitation facilities in the country's schools. In 2003, India's government increased financial support for the standards, which led to a significant rise in the construction of school latrines.⁸⁶ From 2006 to 2023, the proportion of schools in India with basic sanitation services (improved, usable, single-sex toilets) nearly doubled, from 44 percent to 84 percent.⁸⁷ Similarly, in Pakistan, enrollment is higher in schools with toilets (refer to figure 5.5).

Figure 5.5 In Pakistan, enrollment is higher in schools with toilets



Source: Adapted from Gillani 2021.

Standards for teacher qualifications

Teachers are the most important input into school learning.⁸⁸ Standards for teaching staff focus on three interconnected areas: attendance, qualifications (discussed here), and pedagogic skills (discussed in “Standards for educational processes” later in the chapter).

Qualification standards guide teacher recruitment. Examples include formal credentials for teaching (as mandated in Chile, Jamaica, and Panama); standardized testing for teacher selection (as performed in Brazil and Colombia);⁸⁹ teacher certification and performance assessment (as in the United States);⁹⁰ and comprehensive initial training coupled with rigorous selection (as in Singapore). Africa, through the African Continental Teacher Qualification Framework, promotes harmonization of qualifications across countries,⁹¹ an important step; implementation, however, will require external support and resources (for further information on hiring standards in the public sector, refer to chapter 7).

Although necessary, teacher qualifications alone are not sufficient to guarantee student learning. Standards in regard to teaching methods and expectations for instructional quality are essential to achieve learning, and policies regarding teachers' salaries and benefits are crucial to motivate and attract teachers.

Standards set by curriculums

School curriculums outline learning objectives and minimum competencies students should reach at each stage of their education. They are crucial for coordinating instructional materials, teacher practices, professional development, and assessment. They also guide the selection of standards and targets. Education policy often ignores noncognitive skills. Curriculums should cover both cognitive as well as noncognitive skills.

Countries worldwide use curriculum standards to improve their education systems. In France, for example, these standards define grade-level benchmarks. In Singapore, curriculum reforms are paired with in-service training. The national curriculum in Viet Nam emphasizes grade-level competencies rather than rote memorization. In countries with decentralized education systems, such as Brazil and India, national standards enable localities to adapt curriculums to reflect linguistic and cultural diversity.

In many developing countries, curriculums are out of sync with the actual learning taking place. When the pace of instruction set by a curriculum outpaces their pace of learning, students cannot

keep up.⁹² Learning is cumulative. Failing to master foundational skills, such as reading, early on will cause children to fall behind and struggle to catch up.⁹³

Interventions aimed at narrowing the gap between curriculums and student achievements have generally produced positive outcomes. In India, “learning camps” have resulted in higher language scores (refer to box 5.2). Similar programs have led to significant improvements in student outcomes across various settings, including Chile⁹⁴ and the United States,⁹⁵ prompting the adoption of similar interventions that have reached at least one million students across 12 African countries.⁹⁶

Box 5.2 Setting the right level of curriculum standards in India and Sub-Saharan Africa

India’s national assessment program is designed to reflect grade-level learning outcomes from the national curriculum framework. Findings from national assessments often reveal a disconnect between intended and attained learning, pointing to gaps in implementation of the framework, such as uneven teacher preparation or limited instructional time.

Teaching at the Right Level (TaRL), developed by Pratham, a nongovernmental organization in India, aims to build foundational skills in mathematics and reading among all children before the end of primary school. The idea is to meet children where they are and teach them at their level, regardless of age or grade. Focusing on gaps in children’s learning, rather than following an overly ambitious uniform curriculum, has led to significant learning gains. Notably, six randomized evaluations in seven Indian states have shown that the TaRL approach is consistently effective when implemented systematically and has led to some of the largest gains in learning, rigorously measured, in the education literature.^a “Learning camps” in Uttar Pradesh doubled the number of children who could read a paragraph or story.^b TaRL in Haryana resulted in a significant increase in language scores, but not in mathematics scores.^c TaRL has been extended to 16 countries in Sub-Saharan Africa.^d More than 60 million students in Africa and India have benefited.^e

Source: WDR 2025 team.

a. Banerjee et al. (2007, 2010, 2016); J-PAL (2022).

b. Banerjee et al. (2016); J-PAL (2022).

c. Banerjee et al. (2016).

d. For more information, refer to TaRL (Teaching at the Right Level) Africa (dashboard), <https://teachingattherightlevel.org/>.

e. J-PAL (2022).

Other reforms should accompany reforms to curriculums. In India, Pakistan, and Tanzania, school improvement programs did not accompany reforms of curriculum standards, resulting in a continuation of low levels of achievement.⁹⁷

Like national education policy, curriculums have tended to overlook the importance of noncognitive skills (such as motivation, perseverance, and self-regulation).⁹⁸ Multiple studies have shown that cognitive and noncognitive skills are mutually reinforcing and that both boost academic performance.⁹⁹ International assessments such as PISA are increasingly looking at noncognitive outcomes, thus helping governments pay attention to this relatively new area of focus.

Standards for educational processes

Educational processes involve the methods and practices used to deliver and evaluate education, such as teaching methods and monitoring systems.

Pedagogical standards and teacher professionalism

The most effective interventions to improve student learning depend on teachers. Therefore, more attention should be given not only to what teachers know, but also to what they do in the classroom.¹⁰⁰ Pedagogical knowledge involves skills in implementing instructional strategies, planning lessons, using student-focused teaching methods, and techniques for classroom management. Standards establish clear expectations for teachers in these areas. Although data on pedagogy are limited, the existing information reveals concerning gaps. In studies in Kenya and Tanzania, for instance, fewer than two-thirds of teachers could answer questions related to pedagogy, and

in Mozambique, only 15 percent could. A study conducted in Bihar, India, found that many teachers with sufficient knowledge of the content they were teaching nonetheless struggled to explain concepts clearly. Teaching often requires, among other things, breaking tasks into steps for learners. Yet in another study, whereas nearly 80 percent of teachers could correctly solve a long division problem, only 11 percent could perform all the steps correctly.¹⁰¹ Standard-driven interventions, such as structured programs in pedagogy—including detailed lesson plans, training, and coaching for teachers—have been estimated to improve student language and mathematics scores by the equivalent of nine months and six months of learning, respectively.¹⁰²

Standards for accountability and monitoring systems in education

Various countries are implementing mechanisms for monitoring and evaluation to assess compliance with standards and guide continuous improvement. These mechanisms vary in structure and scope but share a common purpose: to promote transparency, inform decision-making, and ensure that students receive quality education.¹⁰³

Ireland's accountability and monitoring system, for instance, focuses on a self-evaluation framework for schools that serves as both a quality assurance tool and a mechanism for improvement. Schools gather and analyze data, such as student achievement scores, classroom observations, and stakeholder feedback, and then publish reports and develop improvement plans for addressing identified priorities. External inspectors evaluate the quality of the self-evaluation process itself, thereby reinforcing accountability. This reciprocal relationship ensures that schools receive support while also being held responsible for meeting national standards.¹⁰⁴

Rwanda has established an accountability and monitoring system that creates a feedback loop among data, standards, and improvement planning. The Rwanda Basic Education Board (REB) regularly conducts school audits in partnership with education officials in school districts, evaluating key areas of school performance, including teacher deployment, classroom conditions, and student achievement. As part of this effort, Rwanda has developed an education management information system to collect school-level data across various indicators aligned with the country's strategic plans and quality standards for the education sector. Schools identified as underperforming or not meeting minimum standards may be made a priority for teacher redeployment, investment in infrastructure, or targeted capacity-building initiatives. The board also offers technical guidance and support to schools and districts in using data from the education management information system for local planning and efforts to improve schools, further fostering a culture of data use.¹⁰⁵

Standards for measuring education outcomes

Monitoring outcomes of student learning (through learning assessments) is essential for understanding how well education systems meet their goals. Measuring results related to education processes, including student enrollment, attendance, learning achievements, and development of cognitive and noncognitive skills, is key to knowing where things stand, where they are headed, and what actions can make a difference. Measuring learning outcomes reveals the extent and nature of learning challenges, helping countries plan more effectively, including setting realistic objectives with feasible strategies and allocations.¹⁰⁶

PISA offers a salient example of a global educational measurement standard. Because it does not rely on any single national curriculum, PISA serves as a strong diagnostic tool for assessing whether countries' education systems develop

the skills needed for participation in modern economies and societies. Since its launch in 2000, PISA has been conducted in 102 countries about every three years. It has proven to be an effective metric for comparing education systems across countries, a task that was previously thought to be impossible.¹⁰⁷ In many countries, PISA results have catalyzed review and updating of education standards across several areas, not only in curriculum content, but also in professional development for teachers, frameworks for student assessment, and system-level accountability (refer to box 5.3).

Other international assessments, such as the Trends in International Mathematics and Science Study (TIMSS) and the Progress in International Reading Literacy Study (PIRLS), are more explicitly aligned with curriculum-based learning and provide insight into how well students have mastered content typically taught in school. Since 1995, TIMSS has assessed mathematics and science in grades 4 and 8 every five years, covering 64 countries in 2023. PIRLS, initiated in 2001 and implemented in 57 countries in 2021, focuses on reading comprehension in grade 4 and is administered every four years. Assessments of this type have proven useful around the world for monitoring learning outcomes and for informing processes for curriculum review, revisions to textbooks, and instructional guidance for teachers.

A variety of regional assessment programs have emerged to complement global assessments and provide context-sensitive measures of student learning. In Latin America, the UNESCO-led Regional Comparative and Explanatory Study assesses foundational skills using regionally developed benchmarks, and its findings have informed curriculum alignment and equity discussions in the region. In Sub-Saharan Africa, assessments such as those under the Programme d'analyse des systèmes éducatifs de la CONFEMEN [Conférence des Ministres de l'Éducation des États et Gouvernements de

Box 5.3 Educational reforms spurred by PISA shocks

A “PISA shock” occurs when disappointing PISA results in a country generate outrage in the media and lead to subsequent educational reform. PISA—the Programme for International Student Assessment—offers an international test that measures 15-year-old students’ ability to apply knowledge and skills in reading, mathematics, and science to real-world contexts.^a

The first PISA results in 2000 showed that students in Germany had performed below the average for member countries of the Organisation for Economic Co-operation and Development (OECD), sparking public debate and leading to pressure for educational reforms. Further scrutiny of the results revealed that socioeconomic status and social background were largely related to educational success or failure in German schools.^b Following educational reforms to address these factors, German students’ scores in reading, mathematics, and science significantly increased, surpassing the OECD average, and by 2015, the impact of socioeconomic background on student scores had decreased.^c

Peru experienced its own PISA shock in 2012, when front-page news announced that the country’s PISA results had ranked it last among countries completing the assessment. The country’s low test scores led the government to recognize Peru’s immense learning challenge, and it embarked on a course of educational investment and reforms. The reforms had three pillars: (1) meritocratic reform of teachers’ careers, including coaching; (2) revising the curriculum; and (3) use of data from learning assessments for school planning.^d The reforms had a sizable impact on the country’s PISA scores.

Conversely, in 2012, Viet Nam drew worldwide attention with its strong showing on PISA. Among PISA participants from low- and middle-income countries, those from Viet Nam outperformed those from many high-income countries. The country’s 2012 PISA scores in mathematics and reading (511 and 508, respectively) were one standard deviation higher than those in neighboring—and wealthier—Indonesia (which scored 375 and 396, respectively).^e Possible explanations include the large Vietnamese population that is out of school (inflating the relative performance of students who participate in the assessment), coaching of students, and possibly greater motivation among students. Analysis by Dang et al. (2023), however, suggests that these factors explain at most 30 percent of Viet Nam’s strong PISA performance. In 2015, 2018, and 2022, Viet Nam’s scores were again comparable with the OECD average.

PISA is controversial and is frequently criticized. Assessment at 15 years of age is perceived by some to be late, and PISA measures educational accomplishment only among children who are in school, thereby not capturing the full extent of a country’s education challenge. More than 100 academics around the world called for a moratorium on PISA in 2014.^f Although Finland initially scored high in mathematics, it later discovered that its students were entering college unprepared in the subject, calling into question the validity of the country’s PISA

(Box continues next page)

Box 5.3 Educational reforms spurred by PISA shocks (*continued*)

results.^g Despite these perceived weaknesses, PISA remains valuable as a global metric of learning outcomes.

Between 2000 and 2012, most countries' PISA scores improved. Since 2012, however, test scores have trended downward in most countries, especially high-income countries, a situation aggravated by the COVID-19 pandemic.^h The drop has been noted as coinciding with the arrival of smartphones and social media in teenagers' lives.ⁱ Test scores in the United Kingdom increased by 6.4 percent after the vast majority of schools in that country banned phones.^j

Source: WDR 2025 team.

- a. OECD (2024).
- b. Woldow (2009).
- c. Davoli and Entorf (2018).
- d. Saavedra and Gutierrez (2020).
- e. Dang et al. (2023).
- f. Strauss (2019).
- g. Loveless (2013).
- h. OECD (2022).
- i. OECD (2024).
- j. Beland and Murphy (2016). Although the United Kingdom does not yet have a national ban, more than 90 percent of its schools have banned mobile phones, and there is a call for a nationwide statute (Adams 2025).

la Francophonie] (Education Systems Analysis Program of the Conference of Ministries of Education of French-Speaking States and Governments) and the Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ) offer valuable information on literacy and numeracy in primary education, and assessment results have been used to raise awareness about foundational learning and factors linked to student learning. In Asia and the Pacific, the Southeast Asia Primary Learning Metrics and the Pacific Islands Literacy and Numeracy Assessment support cross-country benchmarking and help align national frameworks with shared regional learning goals.¹⁰⁸ These regional assessments add more locally relevant content than PISA while preserving comparability within and across countries in the region.

Transitioning to better education standards: The case of Ceará, Brazil

A country seeking to raise its education standards may ponder where to begin. Pritchett and colleagues (2022) suggest five actions to accelerate progress in learning: (1) commit to universal, early foundational learning; (2) measure learning regularly, reliably, and relevantly; (3) align systems around learning commitments; (4) support teaching; and (5) adapt what you adopt as you implement.¹⁰⁹ The last piece of guidance resonates with the conceptual framework in chapter 2 and is especially relevant in regard to setting flexible standards in education that are raised periodically as countries progress toward better-quality services.

The state of Ceará in Brazil demonstrates how systemwide standards, benchmarks, and monitoring

of outcomes of student learning can lead to significant improvements in education. The first phase of education reforms in the state (1997–2000) successfully increased school enrollment but did not improve learning. In response, Ceará’s education authorities launched a reform strategy based on clear standards for foundational learning. The state established benchmarks requiring all students to be literate by the end of grade 2, aligning this goal with curriculum standards and expectations for teachers. These learning benchmarks have become performance targets for municipalities, supported by legal measures and funding mechanisms.

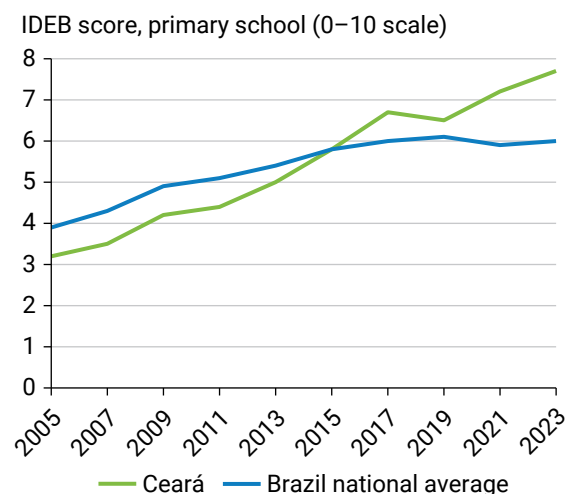
Ceará integrated the goals of its education reforms with updates to systemwide standards, including curricular reforms that focused on basic literacy and numeracy, professional development for teachers aligned with new instructional methods, and regular state-level assessments to track student progress. Municipalities both received autonomy and were subject to accountability. Although the reforms promoted local adaptation of implementation strategies, meeting state benchmarks for literacy and numeracy became a requirement for accessing additional state funds available through an incentive scheme based on tax transfers.

Monitoring of results was thorough and systematic. Ceará implemented a statewide program of large-scale assessments (Sistema Permanente de Avaliação da Educação Básica do Ceará [Permanent Evaluation System of Ceará Basic Education], or SPAECE), conducted annually, to evaluate student performance against the standards that the state’s education authorities had established. Results were published, enabling public recognition of progress and peer comparison across municipalities. High-performing municipalities received financial rewards and public acknowledgment, generating strong positive incentives for ongoing improvement. SPAECE releases an educational quality score (Índice de Desenvolvimento da Educação Básica

[National Education Quality Index], or IDEB) that allows authorities to monitor progress.

The reforms have had a lasting impact. Over two decades, Ceará achieved nearly universal literacy by the end of grade 2, surpassing national averages and becoming a model for other Brazilian states. Its IDEB score rose from 3.2 in 2005 to 7.7 in 2023 (refer to figure 5.6). Ceará’s success can be credited to consistent alignment among its standards (defining what students must learn), benchmarks (measurable goals and targets), and guidelines (technical support offered to municipalities and recommended teaching strategies backed by evidence).¹¹⁰ Its experience highlights the importance of clear learning standards, ongoing monitoring, and targeted support in fostering improvements in foundational learning, especially in decentralized systems.

Figure 5.6 Reform of education policy in Ceará, Brazil, successfully boosted the quality of education in the state



Source: WDR 2025 team elaboration using data from Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira [Anísio Teixeira National Institute of Educational Studies and Research], <http://ideb.inep.gov.br/resultado/home.seam?cid=321762>.

Note: The figure reports IDEB scores among primary school children in Ceará and in Brazil (including Ceará) as a whole. IDEB = Índice de Desenvolvimento da Educação Básica [National Education Quality Index] (a measure of education quality).

Recommendations for better standards related to human capital

Standards regarding human capital, when carefully set and systematically enforced, help build trust in service delivery. Their effectiveness depends on how they are designed, implemented, monitored, and maintained. Developing countries should set standards for health and education practically, aligned with their needs and resources, making access for the widest population the initial priority, then improving standards on inputs and processes. In environments with limited resources, high standards may not be achievable at scale; instead they might be rationed to benefit only the privileged.

No matter how high a country's standards are, they will not be effective without proper compliance and supportive policies, especially incentives to motivate those personnel directly responsible for meeting the standards. The most well-equipped hospitals and schools staffed with highly qualified personnel will still struggle to achieve high-quality outcomes if doctors and teachers fail to show up.

Recommendations for health policy

National health standards adapted from WHO global standards need to be set realistically, according to each country's resources and enforcement capacity, and adjusted periodically. A phased approach to setting health standards, beginning with modest targets and adjusting those targets as the health system expands, has proven to be cost-effective, as global vaccination campaigns have demonstrated. In particular, if lower standards can boost access to medical services on a large scale, they tend to enhance the overall welfare of a country's population more than higher standards that only a select few can meet, as China's experience with "barefoot doctors" illustrates.

Enforcement is of the highest priority in the health sector on account of the significant and even tragic consequences of compliance failures. Pharmaceutical standards and regulatory systems across the world remain fragile, inconsistent, and heavily reliant on aid and technical support from international donors.¹¹¹ The risk of compliance failure in the production, distribution, and trade of drugs and medical equipment remains all too high. Countries need to invest in quality infrastructure for medicines, as shown by the strategy Viet Nam pursued. Regional agreements could help offset the costs of infrastructure investments. Alternatively, countries could choose to import only from manufacturers certified by WHO or trusted drug regulators, such as those in the European Union and the United States.

Monitoring the availability and quality of health services at the local level is critical to enforcing health standards countrywide. Simple basic monitoring systems that do not require extensive administrative work should be implemented, ideally integrated into digital platforms for near-real-time monitoring and analysis. Kenya, for example, is adopting standardized protocols for inspection aimed at evaluating facilities' compliance with safety standards. The African Development Bank developed the Strategy for Quality Health Infrastructure in Africa 2022–2030, including assistance to enhance connectivity of information and communications technology and to strengthen national health information systems (as well as to support innovations in delivery of health services).¹¹²

Recommendations for education policy

Strong political commitment at the highest level is essential to ensure that standards-based education reforms lead to successful learning outcomes. Sustained political support ensures resources adequate to support reforms and can motivate a country's education system to act on reforms. Regular reporting of and broad dissemination of

information on progress are crucial for maintaining public support and motivating teachers and school authorities. As discussed in the chapter, both Germany and Peru initiated investments in and reforms of education following widely circulated PISA results that revealed relatively poor performance.

Think globally, act locally. Although global standards offer useful reference points, local adaptation is critical for relevance, legitimacy, and equity. When adapting standards, it is important to recognize the diverse starting points and learning needs of different populations. Creating space for adaptation while using global benchmarks as scaffolding can help national educational systems stay both ambitious and realistic. This involves aligning international benchmarks with national curriculums and adjusting standards to fit classroom realities, modifying learning targets as needed. It also means ensuring that equity and inclusion are integrated into standards, by, for example, incorporating meeting students at their level, as exemplified by India's TaRL program. Including culturally relevant content in curriculums, providing materials in multiple languages, making accommodations for disabilities, and improving gender-sensitive infrastructure and teaching practices are also essential. For example, Bolivia's 2010 educational reform promoted intercultural

and bilingual education, replacing the traditional curriculum with one that incorporates indigenous knowledge and practices.

Standards should be revised periodically and refined through feedback loops. Accountability systems monitor adherence to educational standards and provide feedback at various levels of education systems for ongoing improvement, as demonstrated by steps taken by Ireland and Rwanda. Effective frameworks for monitoring and quality assurance are essential for aligning educational inputs, processes, and outcomes with policy goals. By systematically collecting and analyzing data on factors such as school infrastructure, teacher deployment, instructional quality, and outcomes of student learning, such frameworks help identify gaps, guide resource allocation, and support evidence-based decision-making.

Standards alone are not enough; they need to be embedded within a broader framework for implementation, as exemplified by reforms in Ceará, Brazil, over the last few decades. Programs should encompass teacher training, curriculum-linked materials, sustained opportunities for professional development, targeted funding, and testing and monitoring. Notably, financial support should be structured to reflect both the costs of achieving basic educational conditions and the incentives needed to motivate continuous improvement.

Notes

1. Filmer et al. (2022); Sen (1999).
2. Cunha and Heckman (2007).
3. Heckman (2008).
4. For more on labor market standards, refer to chapter 8 of the 2013 *World Development Report* on jobs (World Bank 2012).
5. For example, refer to the Leapfrog Group's standards for hospitals (Leapfrog Group 2020).
6. Miguel and Kremer (2004).
7. Badruddin et al. (2008).
8. Deaton (2013).
9. Based on 2019 data from World Development Indicators (dashboard), World Bank, <https://datatopics.worldbank.org/world-development-indicators/>.
10. Based on estimates of disease burden by cause, age, sex, country, and region, 2000–21. Refer to Global Health Estimates (dashboard), World Health Organization, <https://www.who.int/data/global-health-estimates>.
11. Based on the data for the most recent year available (2018 for low-income countries and lower-middle-income countries) from World Development Indicators (dashboard), World Bank, <https://datatopics.worldbank.org/world-development-indicators/>.
12. Refer to World Bank (2021). Percentages are based on 2019 data from World Development Indicators (dashboard), World Bank, <https://datatopics.worldbank.org/world-development-indicators/>.
13. Angrist et al. (2020).

14. The Essential Programme on Immunization was launched in 1974, building on the global momentum of countries' efforts to eradicate smallpox. It was then known as the Expanded Programme on Immunization. Refer to Essential Programme on Immunization (dashboard), World Health Organization, <https://www.who.int/teams/immunization-vaccines-and-biologicals/essential-programme-on-immunization/>.
15. WHO (2020).
16. Mirza et al. (2025).
17. Asad and Fatima (2025).
18. WHO (1977).
19. Based on data from Global Essential Medicines (dashboard), World Health Organization, <https://global.essentialmeds.org/dashboard/countries>; Persaud et al. (2019). Refer to GlobalEssentialMedicinesDatabase.xlsx dataset, Figshare, March 7, 2019, <https://figshare.com/articles/dataset/GlobalEssentialMedicinesDatabase.xlsx/7814246?file=14541080>.
20. Hogerzeil (2004).
21. Based on data from Oldfield et al. (2025); WHO/Health Action International Project on Medicine Prices and Availability (portal), WHO, <https://www.who.int/teams/health-product-and-policy-standards/medicines-selection-ip-and-affordability/who-hai-project-medicine-prices-and-availability>.
22. Mean availability of the lowest-price generic drug at public health care clinics is estimated at 46.1 percent in low-income countries, 47.4 percent in lower-middle-income countries, and 40.4 percent in upper-middle-income countries. Availability is relatively better in the private sector, at 71.4 percent, 64.4 percent, and 65.8 percent, respectively (Oldfield et al. 2025).
23. The other quality variable is clinical practice standards, discussed later in the chapter.
24. World Bank (2023b).
25. Liu et al. (2017).
26. Acosta et al. (2025).
27. Acosta et al. (2025).
28. Acosta et al. (2025).
29. Acosta et al. (2025).
30. Bharali et al. (2025).
31. Nguyen et al. (2018).
32. Pezzola and Sweet (2016).
33. Criado Perez (2019).
34. Klein and Pekosz (2014).
35. Criado Perez (2019).
36. Criado Perez (2019).
37. GAO (2001). Between 2004 and 2024, more than 14 million adverse drug reactions were recorded in the United States among women compared with 9 million among men, according to data from FDA Adverse Event Reporting System (FAERS) (public dashboard), Food and Drug Administration, United States, <https://fis.fda.gov/sense/app/95239e26-e0be-42d9-a960-9a5f7f1c25ee/sheet/7a47a261-d58b-4203-a8aa-6d3021737452/state/analysis>. The FAERS database includes information on adverse-event and medical-error reports submitted to the FDA.
38. Criado Perez (2019).
39. ORWH (2021).
40. Data according to FDA Adverse Event Reporting System (public dashboard), Food and Drug Administration, United States, <https://fis.fda.gov/sense/app/95239e26-e0be-42d9-a960-9a5f7f1c25ee/sheet/7a47a261-d58b-4203-a8aa-6d3021737452/state/analysis>.
41. de Walque et al. (2022); Kruk et al. (2018).
42. Grimshaw and Russell (1993); Murad (2017).
43. Gera et al. (2016).
44. For example, refer to WHO (2009).
45. Four hospitals were in developing countries: Prince Hamza Hospital (Amman, Jordan), St. Stephen's Hospital (New Delhi), Philippines General Hospital (Manila), and St. Francis Designated District Hospital (Ifakara, Tanzania). Four were in high-income countries: Toronto General Hospital (Canada), Auckland City Hospital (New Zealand), St. Mary's Hospital (London), and University of Washington Medical Center (Seattle) (Gawande 2010).
46. Gawande (2010).
47. Sullenberger and Zaslow (2009).
48. Haynes et al. (2009); Qaiser et al. (2024).
49. Technically, there were two different treated groups, one for which inspection results were disclosed publicly and one for which they were not. For details refer to Bedoya et al. (2023).
50. For more information, refer to Medical Devices (dashboard), Health Topics, World Health Organization, https://www.who.int/health-topics/medical-devices#tab=tab_1.
51. WHO (2015).
52. WHO (2016).
53. For more information, refer to ISO (2020).
54. For more information, refer to ISO (2022).
55. For more information, refer to FDA (2024).
56. Nguyen et al. (2018).
57. Global Health Estimates (dashboard), World Health Organization, <https://www.who.int/data/global-health-estimates>.
58. Harrison et al. (2021).
59. World Bank (1993).
60. Lee (2025).
61. Parks (2014).
62. Salomon et al. (2012).
63. Mundel (2018).
64. Prescott and Jamison (1985).
65. World Bank (1984).
66. World Bank, World Development Indicators (dashboard), <https://datatopics.worldbank.org/world-development-indicators/>.
67. Fu (2025).
68. Mao's "June 26 Directive" in 1965 stated, "In medical and health work, put the stress on the rural areas" (World Bank 1984).
69. Fu (2025).
70. Pickowicz (1971).
71. Chang (1993).
72. World Bank (1984).
73. Fu (2025).
74. Fu (2025).
75. Filmer et al. (2000); Jack and Lewis (2009).

76. Fu (2025).
77. Fu (2025); Yiwen (2017).
78. Legal Affairs: Standard-Setting (dashboard), Office of International Standards and Legal Affairs, United Nations Educational, Scientific and Cultural Organization, <https://www.unesco.org/en/legal-affairs/standard-setting?hub=66535>.
79. UIL (2023).
80. Fonseca (2024). Data from the 2021 National Voluntary Report show that between 2015 and 2019, the attendance rate of the school-age population (ages 4–17) rose from 86.0 percent to 90.8 percent (Fonseca 2024).
81. For building standards, refer to chapter 6.
82. Barret et al. (2019).
83. Cuesta et al. (2016); Espinosa Andrada et al. (2024).
84. Adukia (2017).
85. JMP (2022).
86. Adukia (2017).
87. JMP (2022).
88. Schleicher (2018).
89. Mateo-Berganza Díaz and Lim (2022).
90. Fischer et al. (2022).
91. AUC (2019).
92. Pritchett and Beatty (2015).
93. World Bank (2018).
94. Cabezas et al. (2011).
95. Nickow et al. (2020).
96. J-PAL (2022).
97. GEEAP (2023); World Bank (2023a).
98. García (2014).
99. Malanchini et al. (2024).
100. World Bank (2018).
101. Béteille and Evans (2021).
102. Béteille and Evans (2021). This estimate is based on a meta-analysis of language arts outcomes from 18 studies of programs in Cambodia, Costa Rica, India, Kenya, Liberia, Mali, the Philippines, South Africa, and Uganda. For details, refer to Snilstveit et al. (2015).
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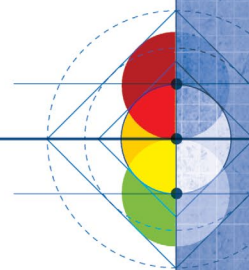
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6 Standards for a Better Environment



Main messages

- Environmental standards can power green development, but only if the transitions needed to comply with the standards are affordable and inclusive. Nearly 99 percent of people worldwide breathe air that is dirtier than World Health Organization (WHO) guidelines, costing lives and productivity. Meeting WHO's guideline for atmospheric levels of particulate matter with a diameter of 2.5 micrometers or less (PM_{2.5}) could add almost two years to global life expectancy, but the costs of compliance can hit poor households hardest. Balancing ambition with affordability is key to a just green transition.
- Countries cannot manage what they cannot measure. In most low- and middle-income countries, pollution and disaster monitoring remain dangerously thin: Only 4 percent of African governments and 7 percent of governments in Asia provide reliable data on air quality. Investing in monitoring infrastructure—from sensors to satellites—turns invisible threats into actionable information.
- One-size-fits-all standards do not fit anyone well. Blindly copying international norms for pollution can impose crippling costs, whereas fragmented standards cause pollution leakage, as when tighter US battery rules in 2009 pushed recycling to Mexico, raising local rates of low birth weight there by 21 percent. Coordinated or tiered approaches, backed by complementary policies, can curb leakage and share the burden more fairly.
- Strong enforcement turns standards from paper promises into cleaner air and safer water. Where capacity grows, compliance follows: China's nationwide reform of its system for monitoring pollution cut atmospheric levels of PM_{2.5} by 40 percent in five years, saving thousands of lives. Building capacity for enforcing standards, through local institutions, technology, and transparency makes every dollar spent on environmental standards count.
- Environmental standards work best when designed with other goals in mind. Trade-offs are real: A third of global waste is still openly dumped or burned, and adaptation to climate change gets just 5 percent of global financing. Integrating environmental, social, and economic objectives ensures standards raise overall welfare instead of shifting burdens from one country to another.

Worldwide environmental challenges

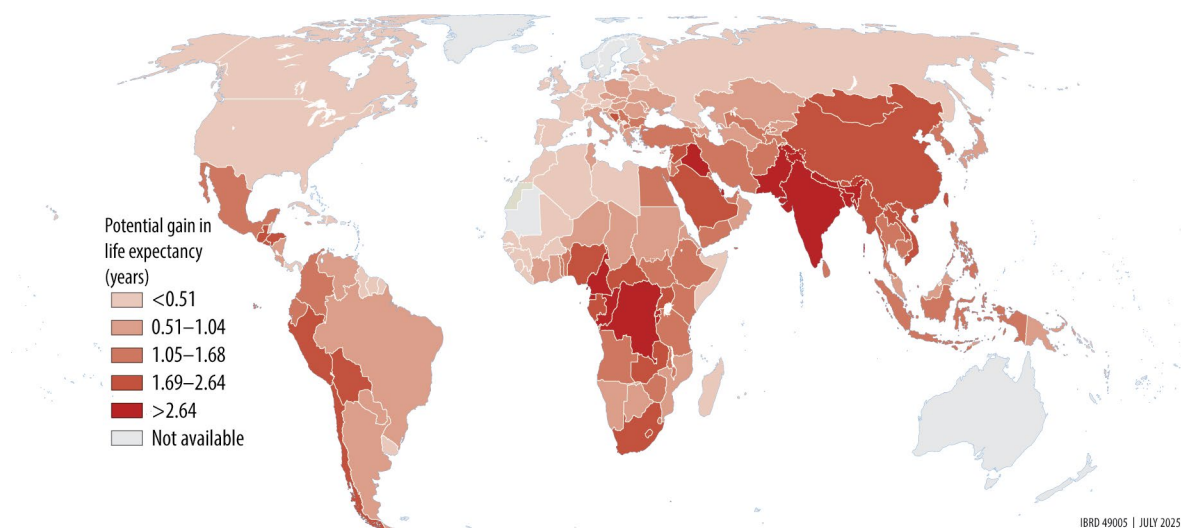
Human and economic activities inevitably generate waste and disruption, leading to a variety of environmental issues ranging from localized air pollution to water and soil contamination to land degradation and dispersed global emissions of greenhouse gases. These issues not only pose serious risks to human health¹ but also impose significant economic costs by reducing labor productivity, eroding human capital,² and increasing the frequency and severity of extreme heat, droughts, floods, and biodiversity loss.³ Low- and middle-income countries urgently need to take steps to both mitigate pollution and adapt to climate change.

For instance, 99 percent of the world's population lives in areas in which pollution exceeds WHO Air Quality Guidelines, with the highest levels—and the fastest increases—concentrated

in low- and middle-income countries.⁴ Particulate matter, particularly PM_{2.5} from combustion of fossil fuel, poses the greatest health risk among air pollutants. Meeting WHO's guideline for PM_{2.5} levels of 5 micrograms per cubic meter (µg/m³) could increase average life expectancy globally by 1.9 years, estimates indicate, as map 6.1 illustrates.⁵

Although environmental damage caused by human and economic activities imposes significant costs on others, market prices often do not reflect negative effects of this type, known as externalities. Moreover, effective adaptation to climate change often depends on public goods, such as resilient infrastructure and timely information about risks posed by climate change and strategies for adaptation to it, which are likely to be underprovided without proper incentives. Such market failures emphasize the crucial role of public policies in tackling environmental challenges more effectively.

Map 6.1 People in low- and middle-income countries, in particular, could gain years of life if air quality were improved



Source: Air Quality Life Index, EPIC Clean Air Program, Energy Policy Institute, University of Chicago, <https://aqli.epic.uchicago.edu/>.

Note: The map shows the potential gain in life expectancy (in years), as of 2022, from meeting the World Health Organization's guideline for atmospheric concentrations of particulate matter with a diameter of 2.5 micrometers or less (PM_{2.5}).

A natural case for environmental standards

Both market-based tools, such as pollution taxes and subsidies for climate-resilient technologies, and environmental standards can address environmental challenges by aligning private decisions with social costs. Market-based tools influence the prices of behaviors that either increase environmental challenges (actively or not) or help countries mitigate or adapt to them, whereas environmental standards require firms or individuals to follow established rules that reduce pollution, lessen damage, disclose emissions to the public or regulators, and facilitate climate change adaptation.

When are environmental standards most effective compared with alternative market-based policies such as taxes and emissions trading? A good starting point for answering this question is the work by economist Martin Weitzman,⁶ which compares price-based and quantity-based regulations. It finds that emissions standards that set maximum thresholds for emissions can be more efficient when it is critical to reduce emissions to a specific level, such as keeping local pollution below thresholds found to impair health. In contrast, when the priority is to minimize high and uncertain costs of abating pollution, emissions pricing is preferable in theory because it offers firms the flexibility to cut emissions at the lowest possible cost. For example, a study in India found that pollution markets requiring firms to pay for emissions beyond allocated allowances decreased firms' costs of compliance by an average of 11 percent compared with traditional standards

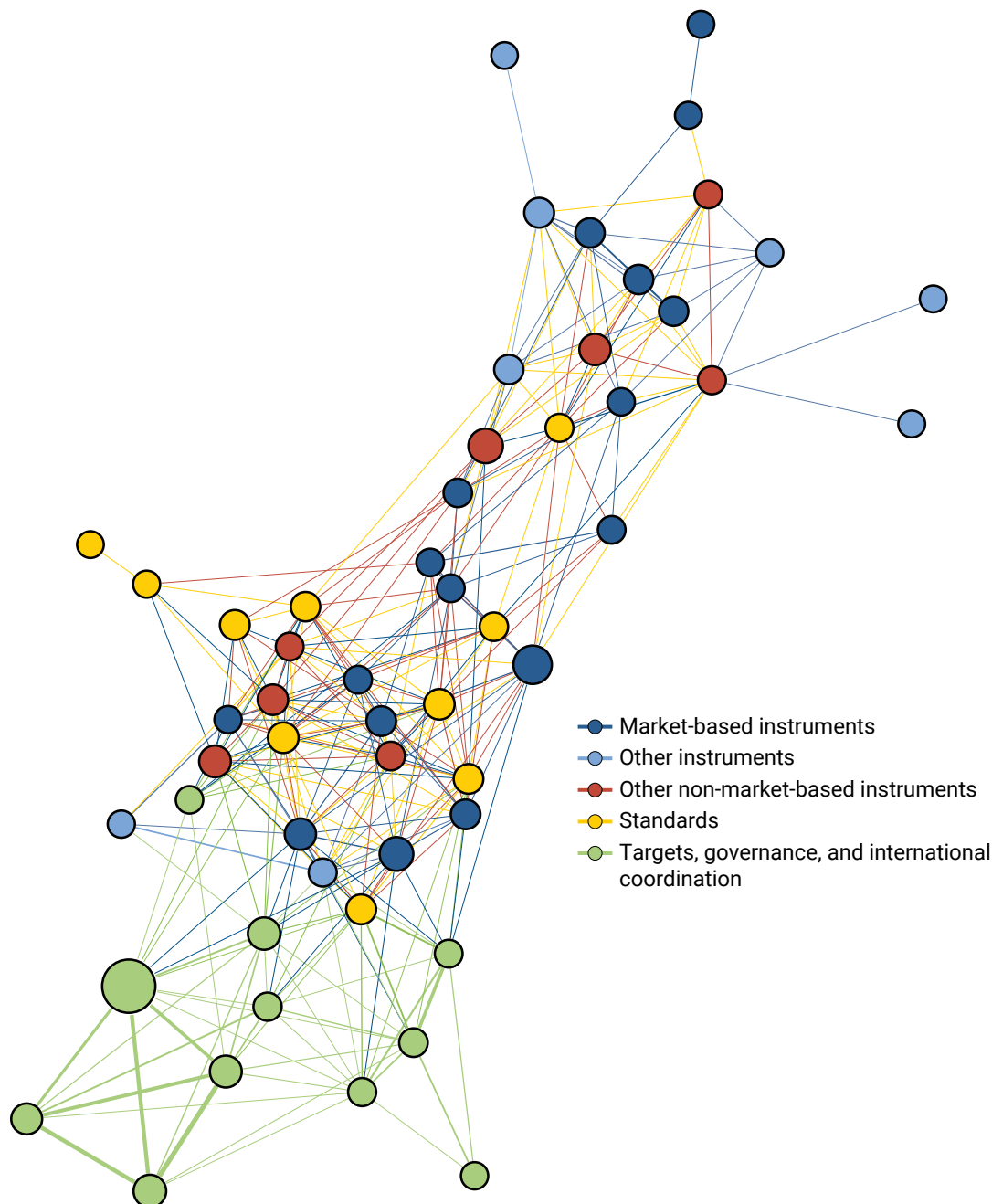
for emissions, while accomplishing the required reductions in emissions.⁷

However, in practice, emissions pricing often faces political resistance and has limited public support, making standards a more viable alternative in many cases. Additionally, it can be very difficult, if not impossible, to measure emissions for pricing purposes. For instance, directly pricing emissions from vehicles requires very costly real-time monitoring of emissions from individual cars.⁸ In contrast, standards for fuel economy that mandate minimum levels of fuel efficiency are less visible to consumers and more politically acceptable and have been more widely adopted.⁹ Even when pricing instruments are implemented, standards in measurement and reporting requirements can play a critical complementary role by ensuring transparency and consistency in enforcement.

In addition, standards rarely operate in isolation; they are typically part of a broader policy mix. For instance, they are often complemented by subsidies and investments in enhancing infrastructure for monitoring and by fostering green technologies and economic growth. Market-based instruments such as trading systems and taxes are also frequently implemented to achieve standards (refer to figure 6.1). This highlights the potential for combining standards with other policy tools to increase both compliance and overall effectiveness.

This chapter analyzes systematically when standards are effective tools for addressing environmental challenges, their limitations, and how thoughtful policy design and better enforcement can enhance their impact.

Figure 6.1 Environmental standards and other policies often coexist



Source: WDR 2025 team elaboration, based on 2021 data from Climate Policy Database, NewClimate Institute, <https://newclimate.org/resources/tools/climate-policy-database>.

Note: The climate policy space network depicted in the figure illustrates instruments for climate policy as nodes linked together based on their tendency to occur together in countries' mixes of climate policy (refer to Mealy et al. 2025). The size of the nodes reflects the number of times a given policy has been adopted across countries. The figure colors policy instruments according to broad policy categories. Standards (including those relating to products, sectors, vehicles, building codes, and performance labels) tend to occur together in policy mixes alongside other non-market-based instruments (such as auditing, monitoring, and reporting schemes) and market-based instruments (such as feed-in tariffs, carbon taxes, and schemes for trading emissions).

Setting and enforcing environmental standards in practice

The overall objective of environmental standards is to maximize the benefits of addressing environmental issues while minimizing the costs to individuals and organizations complying with those standards, taking into account the enforcement capacity. Because benefits, costs, and enforcement capacity can all vary by local context, a one-size-fits-all standard may not be appropriate.

How countries set and enforce environmental standards

A top-down approach: Stronger standards to mitigate local pollution, driven by economic growth, along with the resulting pollution and improved capacity to manage local environmental issues

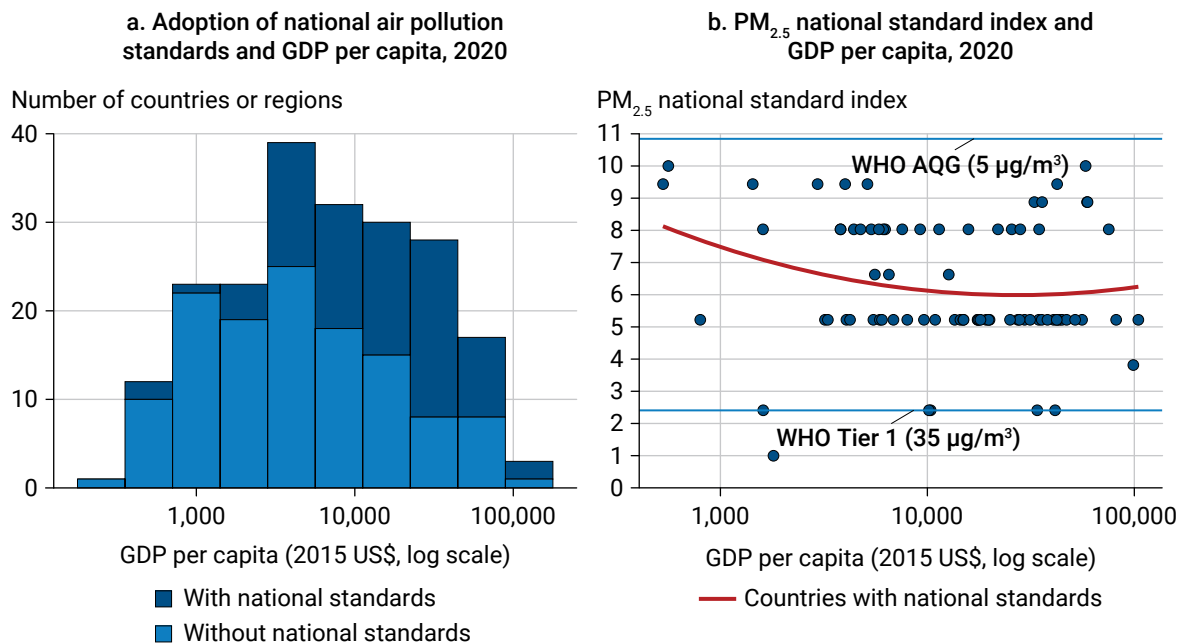
When do countries choose to adopt environmental standards? For local pollutants, countries tend to adopt more stringent standards as their economies grow, which contributes to increased air quality (refer to figure 6.2, panel a). Despite the significant health and economic costs of pollution and climate change, countries often do not make environmental issues a priority, especially those countries facing conflict or struggling to meet basic security needs.

However, a different pattern emerges for air quality when countries that have adopted national PM_{2.5} standards are considered. Among such

countries, both lower-income and higher-income countries tend to adopt relatively stringent standards, whereas middle-income countries adopt the least stringent ones (refer to figure 6.2, panel b). It appears that when setting pollution standards, countries do not follow the framework depicted in figure 2.5 in chapter 2, balancing the stringency of standards with countries' ability to comply with them. Instead, lower-income and higher-income countries adopt similarly stringent standards, although their enforcement capacity varies. Higher-income countries are more effective at implementing and enforcing standards, resulting in lower pollution levels. In contrast, lower-income countries often struggle with enforcing compliance, and pollution levels remain high, resulting in a compliance gap. The compliance gap—in this case, the failure to meet national standards—is more pronounced in lower-income countries.

In the case of dispersed global emissions of greenhouse gases, per capita emissions of carbon dioxide are higher in high-income countries than in low- and middle-income countries (refer to figure 6.3). This is because economic growth relies heavily on energy, often produced with fossil fuels. Also, countries have relatively weaker incentives to address global emissions compared with those for tackling local pollution. That is, whereas climate change mitigation has global benefits, the costs are borne locally. To encourage broader participation in efforts to address global emissions, it is important to emphasize local cobenefits, such as improved health and air quality, and to develop mechanisms that help monetize benefits to the global climate.

Figure 6.2 Higher-income countries are more likely to adopt standards for air pollution and to improve their air quality



Source: WDR 2025 team, based on Air Quality Life Index, EPIC Clean Air Program, Energy Policy Institute, University of Chicago, <https://aqli.epic.uchicago.edu/>; World Bank data.

Note: In panel b, the national standard index for particulate matter with a diameter of 2.5 micrometers or less (PM_{2.5}) is constructed by standardizing each country's actual national standards for PM_{2.5}. A value of 10 represents the most stringent standard, whereas a value of 1 represents the least stringent, and a value of 0 indicates no national standard has been adopted. Data on national standards are sourced from the Air Quality Life Index (AQLI), and air pollution concentrations and GDP per capita are obtained from the World Bank. The World Health Organization (WHO) has set an annual average PM_{2.5} concentration of 5 micrograms per cubic meter (µg/m³) as its Air Quality Guideline (AQG) and 35 µg/m³ as the Tier 1 interim target.

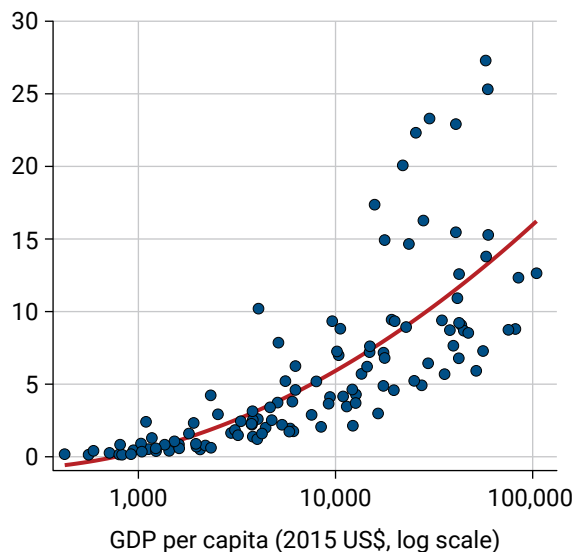
A bottom-up approach: Demand and enforcement of standards driven by public awareness

In addition to rising levels of pollution and a perceived need to enhance capacity to tackle local environmental problems caused by economic growth, public awareness and citizen complaints can also boost the demand for and enforcement of environmental regulations. One study found that after US embassies installed air quality monitors

at US diplomatic sites and publicly shared real-time data on air pollution, concentrations of fine particulates dropped by 2 µg/m³ to 4 µg/m³, especially in countries with limited infrastructure for monitoring such pollution. Increased government efforts to reduce pollution likely caused the decline.¹⁰ In China, public complaints submitted via social media have also proven effective in prompting more rigorous local inspections that help reduce violations of emissions standards and improve air quality.¹¹

Figure 6.3 Emissions of carbon dioxide per capita often continue to rise as countries grow richer

Consumption-based emissions of carbon dioxide per capita, 2020 (metric tonnes)



Source: WDR 2025 team, based on 2020 data from Global Carbon Project, Future Earth, <https://www.globalcarbonproject.org/>.

Note: The red line represents the fitted values based on observations from countries and regions in 2020.

The importance of robust enforcement: The problem of the compliance gap

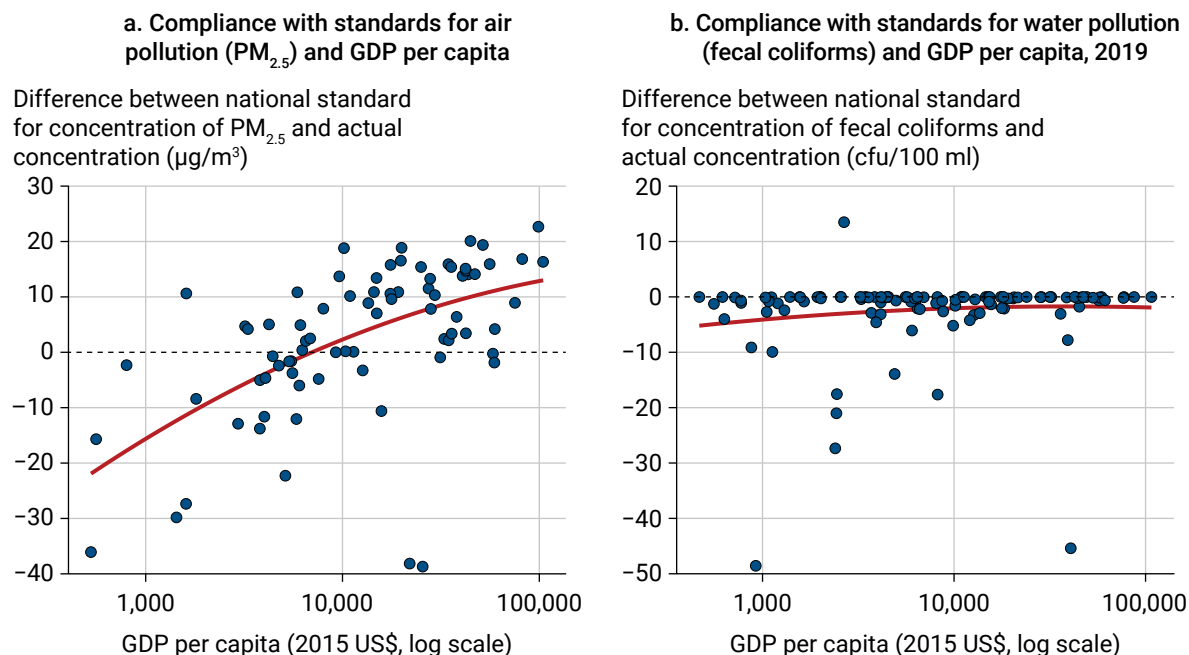
Effective environmental standards rely not only on proper design, but also on strong enforcement, which depends on adequate capacity for compliance. In practice, compliance with regulations regarding air pollution—the difference between *de jure* standards and actual pollution levels—increases as a country's income rises, indicating that lower-income countries tend to set pollution standards but fail to enforce compliance with them (refer to figure 6.4, panel a). Consistent with the framework described in chapter 2, standards greater than a country's compliance capacity can generate inefficiencies. Using the same data as in

figure 6.4, panel a, yields the result that countries with larger compliance gaps in regard to standards for air pollution in 2010 reduced pollution less by 2020, even compared with peers at similar levels of development and pollution. In addition, corruption has been reported in various contexts in which inspectors were bribed to falsify results to enable responsible entities to appear compliant with environmental standards.¹² Also, it has been documented that enforcement of standards for water pollution has been strategically focused on firms located upstream of monitoring stations, resulting in unequal regulatory treatment and economic distortions.¹³

On average, countries with higher incomes, which are also correlated with greater state capacity, are more likely to enforce compliance with standards related to air and water quality (refer to figure 6.4).¹⁴ This is partly because national standards rely on local inspectors to monitor compliance and enforce regulations, and enforcement can be compromised at the local level when state capacity is weak. When weak state capacity results from limited resources for local inspections, targeted inspections have been found to be more effective at reducing emissions than randomly assigned ones, as shown in a study conducted in Gujarat, India.¹⁵ In addition, emerging satellite-based measures of pollution can also serve as an independent source for cross-checking the credibility of self-reported data on pollution, which are subject to data manipulation (refer to box 6.1).

However, even with strong state capacity, effective local enforcement can face challenges when the incentives of local regulators do not align with those of the national government. As a result, complementary policies and efforts are required to expand capacity for enforcing compliance. For instance, water pollution travels across jurisdictional boundaries. Local officials may be less concerned about pollution that flows

Figure 6.4 Compliance with environmental standards increases as countries develop



Sources: Air Quality Life Index, EPIC Clean Air Program, Energy Policy Institute, University of Chicago, <https://aqli.epic.uchicago.edu/>; Jones et al. 2023; WHO 2021.

Note: Data on national PM_{2.5} standards for 78 countries and regions are collected through the Air Quality Life Index based on gazetted documents or official government press releases. National standards for drinking water quality for 125 countries and regions are collected from a 2021 survey by the World Health Organization (WHO 2021). Data on concentrations of fecal coliforms are from Jones et al. (2023). The red line represents the fitted values based on observations from countries and regions. The area below the zero line indicates noncompliance, and that above the zero line indicates compliance. cfu/ml = colony-forming units per milliliter; µg/m³ = micrograms per cubic meter; PM_{2.5} = particulate matter with a diameter of 2.5 micrometers or less.

downstream, beyond their area of responsibility. Research in Brazil found that redrawing of county borders, which altered the distance to downstream boundaries, altered levels of water pollution. For every kilometer a river moves closer to a downstream border on a redrawn map, the concentration of bacteria—as measured

by biochemical oxygen demand (a key indicator for organic pollution in water that quantifies the amount of oxygen that microorganisms require to decompose organic matter)—was found to increase by 1.5–3.0 percent, because standards become progressively more lax as the river moves downstream and across borders.¹⁶

Box 6.1 Nowhere to hide: Emerging satellite-based measures of pollution

Despite robust networks for monitoring exposure to pollution in many high-income countries, the majority of the world's population lives in areas for which high-quality data on such exposure are lacking. Only 3.7 percent of governments in Africa, 6.8 percent in Asia, and 19 percent in Latin America provide reliable data on air quality.^a

Emerging technologies are beginning to fill the gaps in such coverage. Machine learning applied to satellite imagery now enables pollution levels to be estimated in greater detail. This includes levels of air pollution, water quality indicators, and emissions of greenhouse gases. Satellites detect pollution by using advanced sensors to measure how various substances absorb or reflect sunlight at specific wavelengths. This allows scientists to estimate concentrations of pollutants like nitrogen dioxide, particulate matter with a diameter of 2.5 micrometers or less, methane, and chlorophyll (a proxy for excessive nutrient enrichment and thus a sign that water quality has degraded) from space at fine spatial resolutions, such as less than one kilometer.^b

However, given current technology, satellite data are best viewed as a supplement to, rather than a substitute for, ground-based monitoring. Factors like cloud cover and limited vertical resolution can influence the accuracy of satellite data at ground level, which is essential for evaluating human exposure. Therefore, it is important to account for prediction errors in satellite-based estimates. Additionally, satellite data generally cannot offer both high temporal and spatial resolution to the same degree as continuous ground-based monitoring. Combining satellite measurements with those provided by ground-based infrastructure can significantly and effectively lower the costs of monitoring air quality.^c

Source: WDR 2025 team.

a. Hasenkopf et al. (2023).

b. Di et al. (2016); Fowlie et al. (2019); van Donkelaar et al. (2019).

c. Hoffmann and Milusheva (2024).

The evolution of standards as compliance capacity and pollution levels change

Expanding compliance capacity

To address the compliance gap stemming from limited state capacity and misalignment of local incentives with those of national regulators, many countries have worked to expand their capabilities for enforcing environmental standards in line with the ambition of these standards. In particular,

advancements in technologies for monitoring pollution and institutional reforms have proven effective in strengthening capacity for enforcing compliance. For example, in China, automated systems for monitoring levels of particulate matter with a diameter of 10 micrometers or less (PM₁₀), installed starting in 2013 and centrally managed by 2015, increased reported levels of PM₁₀ by 35 percent, indicating reduced local underreporting,¹⁷ and led to greater enforcement and lower pollution.¹⁸ Additionally, public access to monitoring data can increase awareness, encourage

adaptive behavior, and increase accountability.¹⁹ Transparent, reliable systems for monitoring levels of pollution are thus critical for effective enforcement and pollution reduction.

Transparent data on pollution alone, however, may be insufficient to address the misalignment of the incentives of local regulators and those of central governments. For instance, regulators may respond strategically to data from pollution monitors by concentrating their enforcement efforts near those monitors rather than reducing pollution citywide.²⁰ In contrast, institutional reforms have been shown to effectively align the behavior of local regulators with national environmental goals. One strategy is to link outcomes of local enforcement to career incentives, for instance, by making promotions contingent on meeting national environmental targets²¹ or by granting higher-level agencies for environmental protection direct authority over the promotion of local regulators.²²

Regional and international institutions can also play a vital role in fostering cooperation on environmental challenges that cross national boundaries. For example, the United Nations Economic Commission for Europe's Convention on the Protection and Use of Transboundary Watercourses and International Lakes provides an international legal framework and platform for promoting the sustainable management of shared water resources. However, implementation remains limited. Only 43 of 153 countries with shared water resources have operational arrangements that cover at least 90 percent of their transboundary rivers, lakes, and aquifers.²³

Finally, not all environmental standards are mandatory; voluntary standards can help ease resistance from industry by allowing firms to opt into compliance.²⁴ When credible and well enforced—for instance, through third-party verification—they can potentially encourage compliance, normalize responsible practices, and

open access to sustainability-oriented markets. For example, certification under International Organization for Standardization (ISO) 14001 may offer economic benefits such as access to regulated markets and lower capital costs and appeal to environmentally conscious employees.²⁵ However, evidence on the environmental impact of voluntary standards is mixed, reflecting wide variation in both standards and baseline practices. Some studies find gains in forest habitat, climate change mitigation, and biodiversity;²⁶ others report only limited improvements.²⁷ Thus, voluntary standards should be adopted with caution and strengthened through transparency and third-party verification.

Adopting and upgrading standards

After adoption, environmental standards are often updated to reflect changes in pollution levels and enforcement capacity. Thailand, for instance, tightened its national standard for PM_{2.5} levels in 2023 to better align it with observed declines in pollution, though PM_{2.5} levels in the country still exceed the WHO Air Quality Guideline of 5 µg/m³. Dhaka, Bangladesh, consistently recorded extremely high concentrations of PM_{2.5}, and it relaxed its national standard—previously more stringent than WHO's Tier 1 interim target of 35 µg/m³—to match actual levels in the country, possibly reflecting persistent noncompliance with the stricter standard.

Numerous studies have documented that when standards are effectively implemented, they can significantly improve environmental outcomes in both high- and low- and middle-income countries.²⁸ For example, in the United States, the 1970 Clean Air Act, which set county-level limits on total amounts of suspended particulates in the air, led to a 10 percent reduction in these particulates within three years in counties that exceeded the thresholds.²⁹ The 1990 amendments to the act, which added PM₁₀ as a targeted pollutant, reduced PM₁₀ concentrations by 11–14 percent

(7–9 $\mu\text{g}/\text{m}^3$) between 1990 and 2005 in noncompliant counties.³⁰ In 2014, China launched its “war on pollution,” introducing national standards, annually adjusted, for $\text{PM}_{2.5}$ levels and strengthening air monitoring, data disclosure, and official accountability. By 2018, $\text{PM}_{2.5}$ levels in the country had fallen by 40 percent, levels of sulfur dioxide by 65 percent, and levels of carbon monoxide by 33 percent. Compliance with the standard for $\text{PM}_{2.5}$ levels rose from 20 percent of cities (13 percent of the population) in 2013 to 41 percent of cities (29 percent of the population) by 2018.³¹

Fully understanding the benefits and associated economic costs of environmental improvements

Using well-designed environmental standards to spur competitiveness and positive effects in the economy

A major concern for countries considering the adoption or strengthening of environmental standards is that such standards can increase compliance costs for polluting firms, potentially reducing their competitiveness with firms elsewhere, which may not be subject to the same standards.³² Firms may be required to invest in abatement technologies or change production processes, increasing their operational costs. Abatement costs have been widely documented and quantified across various polluting sectors.³³ Importantly, such costs can vary significantly depending on factors like firm size, technological capacity, and market structure.³⁴

However, more stringent regulations do not always diminish competitiveness in the long term.³⁵ According to the Porter hypothesis,³⁶ well-designed environmental policies have the potential to spur improvements in efficiency, overcome inertia in organizations, lower long-term costs, and promote innovation. Whether these positive effects are realized depends heavily on context, policy designs, and implementation.³⁷

Developing countries may have the opportunity to leapfrog older technologies that cause more pollution and to facilitate green growth, particularly in sectors such as energy and transportation, by combining environmental standards with green industrial policies.³⁸ Such an approach can be especially effective when transitioning directly to cleaner technologies is more cost-effective in the long term and better aligned with a country’s comparative advantage than retrofitting or cleaning up existing systems. For example, China’s large-scale efforts to promote the production and adoption of electric vehicles not only have reduced local air pollution and emissions of greenhouse gases³⁹ but also have enabled the country to leapfrog technologies for internal combustion engines that were traditionally dominated by Germany, Japan, and the United States. As a result, China accounted for nearly 70 percent of global sales of electric vehicles in 2023.⁴⁰

Reductions in pollution offer benefits beyond health improvements. They can enhance workers’ productivity⁴¹ and boost human capital, as reflected in standardized test scores⁴² and labor market outcomes such as earnings;⁴³ increase housing values through better environmental amenities;⁴⁴ and make regions more attractive to skilled workers.⁴⁵ These benefits vary depending on factors such as population density, demographics, economic structure, and baseline levels of pollution. For instance, high-density urban areas may experience greater health gains per unit of pollution reduced than do sparsely populated regions.

Therefore, it is important to understand the benefits of environmental improvements and the associated economic costs. Environmental issues, especially mitigation of climate change, which imposes global costs rather than only local costs, are not realistically a top priority for low-income countries still struggling with poverty. Putting a priority on adaptation to climate change is more important for these countries, as climate change can lead to significant local economic

losses. Many middle-income countries, on the other hand, could achieve economic benefits by addressing environmental issues. The challenge is to fully understand the costs and benefits and to carefully design environmental policies that fit local contexts, rather than treating these issues as isolated concerns. Tailoring these policies to the local context is also consistent with the principle of Common but Differentiated Responsibilities and Respective Capabilities established in the 1992 United Nations Framework Convention on Climate Change at the Rio Earth Summit. This principle recognizes that countries share responsibility for addressing climate change, but responsibilities and capacities differ, with high-income countries expected to take the lead.

Addressing the issue of emissions leakage through coordination across jurisdictions

Setting standards at different levels across regions can help the standards reflect local variations in the costs and benefits of pollution reduction. However, such an approach introduces emissions leakage, in which polluting activities or products shift to jurisdictions with weaker standards. When emissions leakage worsens environmental outcomes, it reduces the overall effectiveness of efforts to reduce pollution. Additionally, low- and middle-income countries—often with less stringent environmental regulations—risk becoming “pollution havens,” which can exacerbate global inequalities in environmental quality. These concerns highlight the need for coordination across jurisdictions to ensure both the effectiveness and the fairness of environmental standards.

For example, huge volumes of plastic waste are traded globally (6.66 million tonnes in 2022 alone),⁴⁶ often shipped from high-income countries to lower-income ones for recycling or disposal. The prices paid for this waste typically do not reflect its full social and environmental costs, partly because the receiving countries lack adequate environmental standards for waste

management. As a result, these countries disproportionately bear the environmental burden of waste generated elsewhere without fair compensation.

Complementary policies can help reduce emissions leakage, a topic later sections examine in more detail. Furthermore, as countries that import emissions develop, they may no longer remain passive recipients. Instead, emissions leakage could prompt them to adopt stricter environmental regulations and thus reduce the leakage.⁴⁷

Importantly, not all leakage results in worse environmental outcomes. The context is key. For example, used vehicles exported from the United States to Mexico are often cleaner to operate than Mexico’s domestic fleet, which lowers the country’s average emissions per mile. However, because these vehicles tend to stay in use longer in Mexico, their lifetime emissions can increase.⁴⁸ Similarly, location mandates that require polluting industries to relocate from densely populated areas to less crowded ones can increase the quality of local air at or near the industries’ original sites, although firms may incur higher costs in their new locations.⁴⁹

Standards for localized air pollution, solid waste, emissions of greenhouse gases, and adaptation to climate change

There are multiple types of environmental standards, and each type addresses environmental challenges in a distinct way, making certain types more suitable and effective depending on the context. *Measurement standards* can provide information as a public good. *National targets*, such as national air quality standards, set overarching goals that guide policy development and regulatory action. *Technology standards*, such as bans or phase-outs of fossil-fuel-based equipment, directly promote

the adoption of cleaner technologies. In contrast, *performance standards*, including energy efficiency requirements or emissions standards, regulate environmental outcomes while allowing flexibility in how those outcomes are achieved. This section examines specific environmental standards aimed at addressing challenges ranging from localized air and water pollution, to solid waste that causes both localized and dispersed pollution, to emissions of greenhouse gases that are highly dispersed. It also explores the role of standards in enabling adaptation to climate change. The discussion focuses on the specific impacts of these standards, outlines the contexts in which they are most effectively applied, and provides policy recommendations for their practical implementation.

Standards for localized air pollution

Setting overarching goals: Place-based quality standards for ambient air

Governments can set quality standards for ambient air as a basis for broader environmental regulations, often informed by WHO guidelines but adapted to take into account local costs and benefits. These standards target overall environmental outcomes without mandating specific technologies, offering local flexibility. For instance, Brazil's 2024 National Air Quality Policy sets pollution limits nationwide under Federal Law No. 14,850/2024. However, without strong local enforcement, outcomes can vary, so quality standards for ambient air are often combined with other measures.

Nonetheless, place-based standards can also cause emissions leakage, as regions with stricter standards may lose production to less regulated ones. In China, such leakage offset up to 60 percent of reductions in local emissions achieved using place-based standards.⁵⁰ Similarly, tighter US standards for lead disposal in 2009 led to increased exports of batteries to Mexico and a 21 percent increase in low birth weight near recycling plants.⁵¹

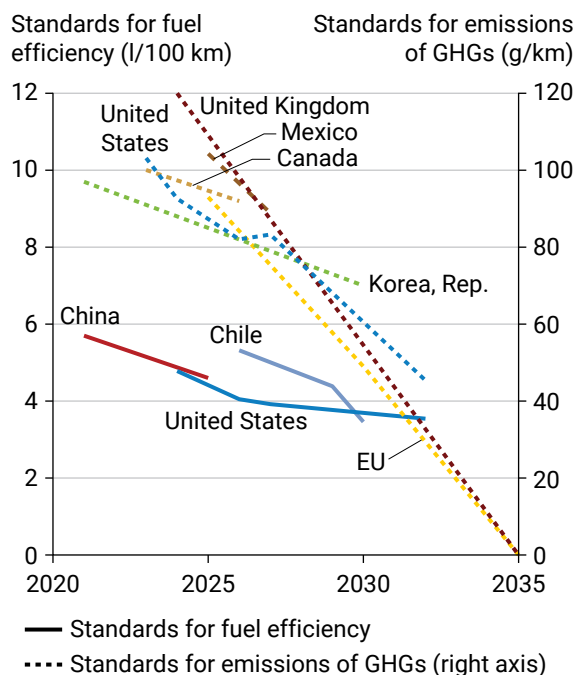
Moreover, when pollution levels are hard to measure, setting air quality standards can be challenging. For example, indoor air pollution is seldom regulated because monitoring it is difficult. However, it disproportionately harms women in countries like Ethiopia and Uganda where highly polluting forms of cooking fuel are used.⁵² In such cases, promoting clean fuels and reducing barriers to adoption of standards may be more effective.⁵³

Designing enforceable standards based on compliance capacity: Technology standards versus performance standards

National air quality standards set broad targets but are often accompanied by more practical tools like technology or performance standards. Technology standards mandate or prohibit the use of specific technologies (such as catalytic converters or coal), making enforcement easier when proven solutions are available. Manipulation of emissions data also affects this type of standard less.⁵⁴ Performance standards, by contrast, set emissions or efficiency thresholds, allowing firms flexibility in how they comply with them.

For example, the US Clean Air Act required catalytic converters on cars manufactured after 1975, cutting emissions by 50–99 percent per mile.⁵⁵ In India, similar mandates for catalytic converters have been shown to lower rates of infant mortality, whereas general air quality standards have had little effect on these rates.⁵⁶ When companies can choose among several technologies for pollution abatement, performance standards can be more effective. Standards for fuel economy set minimum thresholds for miles traveled per gallon of fuel instead of specifying engine design, and both high- and low- and middle-income countries have adopted them (refer to figure 6.5). Standards for industrial emissions often measure pollution per unit of output, allowing companies to choose the most cost-effective ways to meet the requirements.

Figure 6.5 Countries around the world have adopted standards for fuel economy



Source: ICCT 2023, table 4.

Note: EU = European Union; g = grams; GHGs = greenhouse gases; km = kilometers; l = liters.

Countries often decide on the stringency of performance standards using cost-benefit analysis, comparing the costs of compliance (such as increased expenses related to vehicle production or ownership) with potential benefits like fuel savings and environmental improvements. However, uniform standards for performance may not suit all countries, because they overlook differences in economic conditions and technological readiness. Additionally, when compliance costs are uncertain, fixed standards for performance can be too strict in contexts with high costs.⁵⁷

When effectively designed and enforced, however, performance standards can substantially reduce emissions.⁵⁸ In China, stricter limits on sulfur dioxide cut diseases related to air pollution by 39 percent between 1998 and 2010, and Jakarta's

2018 adoption of Euro 4 emissions standards, which set stricter standards for vehicle emissions of various pollutants, led to 58 percent and 49 percent drops in emissions of nitrous oxides and carbon monoxide, respectively.⁵⁹ Performance standards also spur innovation, driving growth in patents for pollution abatement technologies and adoption of such technologies in middle- and high-income countries.⁶⁰

In the design of technology or performance standards, it is critical to take a dynamic perspective, especially when the standards apply to long-lived assets. For instance, coal-fired power plants can remain in operation for 30–50 years, creating lock-in effects that delay the transition to cleaner alternatives. In such cases, if retrofitting is more expensive than building new facilities, early decisions regarding investment can have long-lasting consequences. Forward-looking mandates concerning technology can help steer investment toward cleaner options from the outset. Additionally, reducing uncertainty about the adoption and enforcement of performance standards before long-term investments are made can significantly influence technology choices and related outcomes for pollution.⁶¹

Both technology and performance standards, however, come with economic costs. In some cases, they can raise product prices, reduce firm productivity, and disrupt labor markets, requiring careful evaluation. For instance, electricity prices in the United States rose 11 percent after standards regarding renewable portfolios were put in place,⁶² and pollution controls in Indian coal plants may increase generation costs by 9–25 percent.⁶³ Stricter standards reduced productivity by 4.8 percent in polluting plants in the United States⁶⁴ and by 24 percent in polluting firms in China.⁶⁵ Closures of coal plants also caused lasting income losses for US miners.⁶⁶ Complementary policies like energy subsidies,⁶⁷ green bonds,⁶⁸ and targeted job training⁶⁹ can help offset these costs and support a just transition.

Lastly, emissions leakage can occur when technology or performance standards apply only to parts of the market. For example, retired coal equipment may be exported to countries with weaker regulations than those in the exporting country, shifting emissions abroad.⁷⁰ In the United States, mandates like the one for catalytic converters and standards for fuel economy in new vehicles

increased the costs of the latter, prompting some people to keep older, more polluting cars longer, offsetting environmental gains. Complementary measures such as scrappage incentives or higher fees for older vehicles can help, though they may burden low-income households.⁷¹ Similar policies can also strengthen standards in the area of water pollution (refer to box 6.2).

Box 6.2 Advancing safe and efficient use of water through standards and complementary policies

Growing urbanization and climate change are making the need for safe and efficient use of water more critical. Contaminated water and inadequate sanitation contribute in a major way to the transmission of diseases, including cholera and diarrheal illness, and could increase mortality from digestive cancers.^a Contaminations originate from diverse sources, including industrial waste, agricultural activities, and the infiltration of pathogen-laden surface water into groundwater as a result of weak infrastructure. In addition, water loss in distribution and inefficient use, in areas such as irrigation or industry, waste resources at a time of growing scarcity.^b

Standards and complementary policies play a critical role in addressing these challenges by setting clear benchmarks for safety and efficiency, monitoring, and accountability. Recognizing the importance of controlling water pollution, 103 out of 125 countries in a World Health Organization survey had adopted national standards for fecal coliforms by 2019.^c

Yet improving water quality is challenging on account of the relatively low visibility of water pollution, compared with that of air pollution, and the complexity of measuring it. Monitoring drinking water is particularly difficult, requiring household-level testing and accounting for contamination in distribution pipes.^d

Two complementary policies have been shown to significantly enhance the effectiveness of standards regarding water pollution. First, complementary public investment, such as funding for infrastructure to treat wastewater, can lower compliance costs for polluters and increase compliance with standards.^e However, these investments can have substantial costs. For example, the United States invested US\$650 billion (in 2014 dollars) in such infrastructure between 1972 and 2001.^f

(Box continues next page)

Box 6.2 Advancing safe and efficient use of water through standards and complementary policies (*continued*)

Second, strong enforcement and public awareness, including investments in monitoring technologies and increased transparency, can strengthen accountability and increase compliance.⁹ In contrast, where enforcement is weak and public sector engagement is limited, standards regarding water pollution may fail to yield meaningful improvements in water quality.^h

Standards that encourage water-saving technologies and monitoring systems to detect distribution losses can advance efficient use of water. Public campaigns, behavioral nudges, and financial incentives can further raise awareness and promote water conservation on the consumer side.ⁱ

Source: WDR 2025 team.

a. Ebenstein (2012); UNEP (2021).

b. Liemberger and Wyatt (2019).

c. WHO (2021).

d. Gazze (2024).

e. Keiser and Shapiro (2019).

f. Keiser and Shapiro (2019).

g. He et al. (2020); Olmstead and Zheng (2021).

h. Greenstone and Hanna (2014).

i. Akesson et al. (2023).

Standards for non-point-source solid waste

Municipal solid waste—waste generated by households, businesses, and institutions—can affect air, water, and soil pollution if mismanaged. Out of the estimated 2.24 billion tonnes of waste generated worldwide in 2020, about 37 percent was managed through some form of landfill, 13.5 percent was recycled, 5.5 percent was composted, 11 percent was incinerated, and 33 percent was openly dumped or burned.⁷² Mismanaged waste directly dumped onto land or burned might contaminate land or water, exacerbate flooding if it clogs canals and waterways, cause air pollution, support the spread of vector-borne diseases, or any combination of these.⁷³

Unlike air and water pollution, which come from single, identifiable sources, municipal solid waste, as a type of non-point-source pollution, originates from many dispersed sources, making it difficult to trace and manage.⁷⁴ As a result, governments play an essential role in providing public goods to facilitate waste management and in establishing comprehensive standards and policies to align the incentives of different actors and coordinate in the waste value chain to collectively manage waste. The goal is not only to reduce mismanaged waste, but also to curb the generation of waste.⁷⁵

Standards for management of municipal solid waste are typically set at the national level and further refined and implemented at the local level, from those for waste generation and collection to

those for waste treatment and disposal. Although the minimum desired standards are universal waste collection and safe disposal, the provision of services will differ based on the local context. For example, in Tiquipaya, Bolivia, waste is collected twice a week, with a bell signaling that residents should bring their trash directly to the collection truck, an approach suited to the town's narrow streets and limited sidewalks.

Many countries set standards for postcollection management of waste to coordinate actors along the value chain. For instance, a World Bank project in Ningbo, China (2013–20), implemented a system for collecting certain types of waste separately from the remainder, with results-based payments giving residents an incentive to follow standards for sorting. This allowed the municipality, through a public-private partnership, to process uncontaminated organics using a new anaerobic digester, generating 29,000 cubic meters of biogas daily and increasing dry recyclables to 71,600 tonnes per year. The project resulted in a reduction of 1.94 million tonnes of carbon emissions.⁷⁶

Solid waste can be transported and traded. In some cases, it is more cost-effective to export waste than to process it domestically, creating a global market. As a result, one country's standards for managing waste can have cross-border impacts.⁷⁷ Standards tailored to local needs may not suit other contexts, highlighting the need for international coordination (refer to box 6.3).

However, standards alone are insufficient to enable countries to effectively manage waste. Complementary policies that clearly define responsibility for waste management can enhance accountability and improve overall waste management practices. For example, Extended Producer Responsibility schemes require companies to take financial and operational responsibility for managing their product waste after consumer use. These schemes clearly define who is accountable for managing waste, helping to prevent free-riding among different actors in a supply chain. They also encourage environmentally conscious design, such as reduced packaging or increased recyclability of products as a result of making them easier to reuse, which helps reduce waste at the design stage.

Box 6.3 Standards for contamination from solid waste and their role in shaping global trade

The global trade in solid waste is extensive and can reduce domestic burdens involving waste disposal, but it poses a risk of pollution leakage, especially when waste is sent to countries with environmental standards that are weaker than those in the country that exports the waste. Since the late 1990s, high-income countries have increasingly exported plastic waste to low- and middle-income countries. Before 2018, China alone received more than 55 percent of global exported plastic waste, with an estimated 70.6 percent of it being placed in landfills or mismanaged, for example, dumped or burned openly or handled improperly in a way that causes environmental harm.^a

Standards regulate the composition of imported plastics to address the environmental harms from imports of plastic waste. For instance, the Basel Convention on the Control

(Box continues next page)

Box 6.3 Standards for contamination from solid waste and their role in shaping global trade (*continued*)

of Transboundary Movements of Hazardous Wastes and Their Disposal, adopted in 1989, established expected practices for management of plastic waste, including minimum requirements for treatment and disposal facilities, that govern trade from countries that are members of the Organisation for Economic Co-operation and Development to countries that are not.

In 2018, China's Operation National Sword introduced a strict standard regarding contamination, limiting nontarget materials (such as food and other residues) in plastic waste to 0.5 percent, which effectively banned imports from Japan, the United States, and the European Union.^b Global trade in plastic waste fell by more than 40 percent between 2017 and 2018 and continued declining through 2023. This triggered a shift toward Southeast Asia in trading routes, with Malaysia's imports of plastic waste rising from 176,000 tonnes to 900,000 tonnes from 2012 to 2018 and Türkiye's from 65,000 tonnes to more than 650,000 tonnes from 2013 to 2024.^c In response, Thailand phased in restrictions, culminating in a full ban in 2025. Similarly, Malaysia tightened imports of plastic waste, resulting in a decrease in its imports of plastic waste to less than 335,000 tonnes in 2019.

Beyond reshaping global patterns of trade, Operation National Sword had notable implications for climate. As high-income countries struggled to manage larger volumes of plastic waste domestically, many resorted to incineration, a more carbon-intensive option compared with dumping plastic waste in landfills or recycling it. As a result, the net short-term impact of the operation's essential import ban included higher emissions of greenhouse gases associated with the treatment of plastic waste.^d

The experience with Operation National Sword underscores the broader challenge of emissions leakage in the global management of plastic waste. To mitigate such leakage, countries need to invest in infrastructure to reduce marginal costs of waste processing (such as landfills and recycling facilities), offer or strengthen incentives for recycling, and reduce the generation of plastic waste at the source. At the same time, international coordination is essential to align standards, manage trade flows, and negotiate policies that minimize environmental and climate-related disruptions across borders.

Source: WDR 2025 team.

a. Wen et al. (2021).

b. Bourtsalas et al. (2023); Brooks et al. (2018); O'Neill (2017); O'Neill and Moon (2025).

c. Refer to United Nations Commodity Trade Statistics Database, Statistics Division, Department of Economic and Social Affairs, United Nations, <https://comtradeplus.un.org/>.

d. Wen et al. (2021).

Standards for mitigating dispersed global emissions of carbon

Although wealthier countries have higher emissions per capita, increasing emissions from low- and middle-income countries have also contributed to the global growth in carbon emissions, making cooperation among top emitters crucial. The 2015 Paris Agreement, adopted by 196 parties, aims to limit warming to well below 2 degrees Celsius, with efforts toward keeping it less than 1.5 degrees Celsius. This is to be accomplished through country-specific pledges to take specific climate-related actions and set targets for emissions of greenhouse gases, known as nationally determined contributions. A major challenge to commitment to carbon reduction, however, is that mitigation benefits are global, whereas its costs are local, especially for low- and middle-income countries dependent on fossil fuels, which made up 75.7 percent of emissions of greenhouse gases globally in 2021.²⁸ To broaden participation in the agreement, it is vital to emphasize local cobenefits such as better health and air quality and to develop tools that monetize global gains in regard to climate.

High-income countries: Leading the efforts

Higher-income countries tend to introduce a greater number of climate-related standards, including all standards adopted over time, and on an earlier timescale than low-income countries (refer to figure 6.6, panel a). Many have adopted a broad mix of policies, including carbon pricing and standards such as those requiring portfolios

of renewable energy. However, lower-income countries today tend to adopt more standards than higher-income countries did when they were at similar levels of development. In addition, high-income countries tend to adopt a greater number of climate-related standards as total costs from disasters increase (refer to figure 6.6, panel b).

It appears that many early standards related to climate in high-income countries were not initially driven by climate but were instead introduced to address concerns such as energy security, air pollution, or industrial modernization. They gradually evolved into more comprehensive tools for climate change mitigation that include market-based instruments.²⁹ However, climate shocks, such as extreme weather events, do not consistently translate into stronger standards unless countries' reactions are channeled through responsive political systems and institutional frameworks.

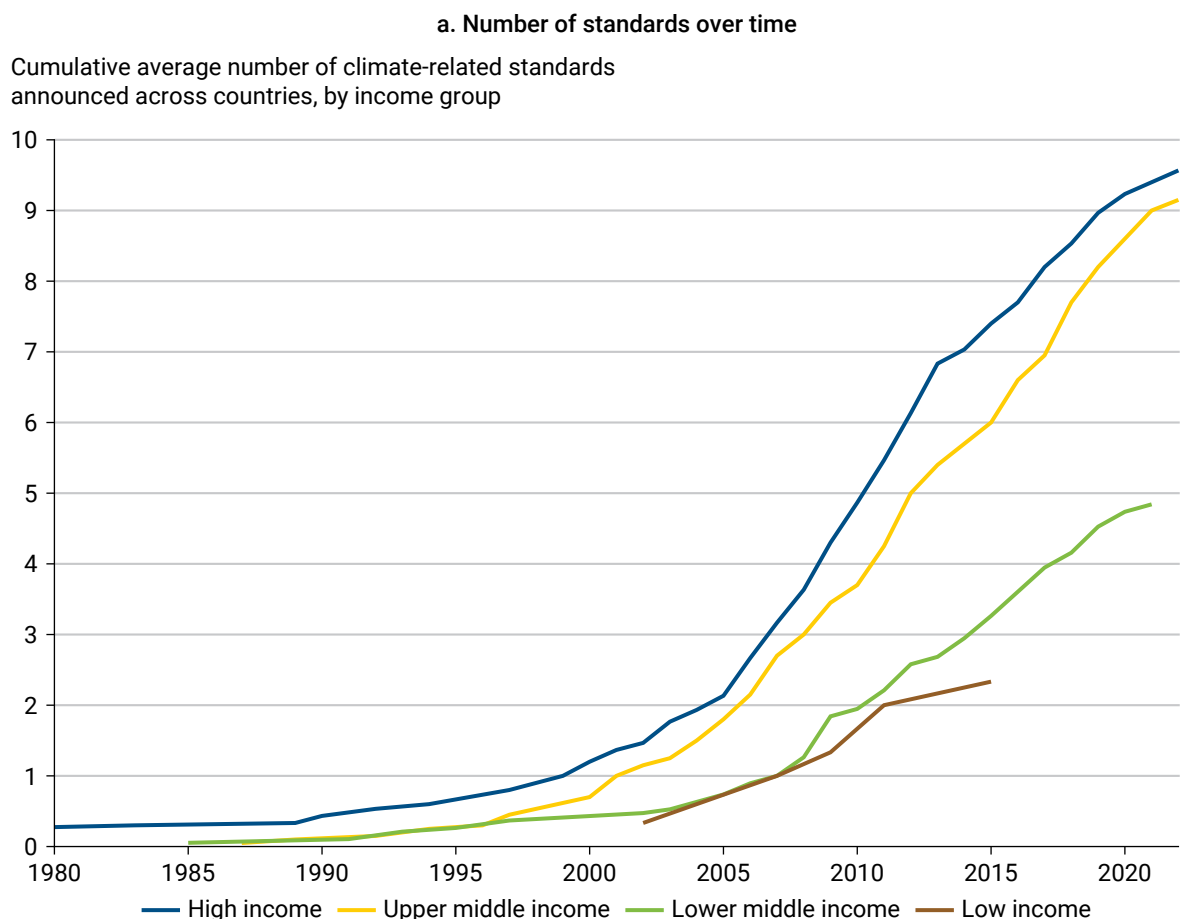
Compared with standards, carbon pricing directly addresses the externality of carbon emissions by making polluters pay for their emissions. It does not require regulators to have private information about firms' abatement costs, because firms can choose their preferred strategy for abatement. As of 2025, instruments for carbon pricing covered 28 percent of global emissions, including 27 percent in high-income countries and 30 percent in middle-income countries. No low-income or lower-middle-income country has adopted such instruments to date (refer to figure 6.7). In addition, revenues from carbon pricing can be used to fund complementary policies, such as subsidies for implementation of low-carbon

technologies, to support a more equitable and effective transition to a green economy.

However, standards still play a critical role in climate change mitigation. Price signals alone may not be sufficient to induce change in all sectors. In the residential sector, for instance, information gaps, financing barriers, risk aversion, and

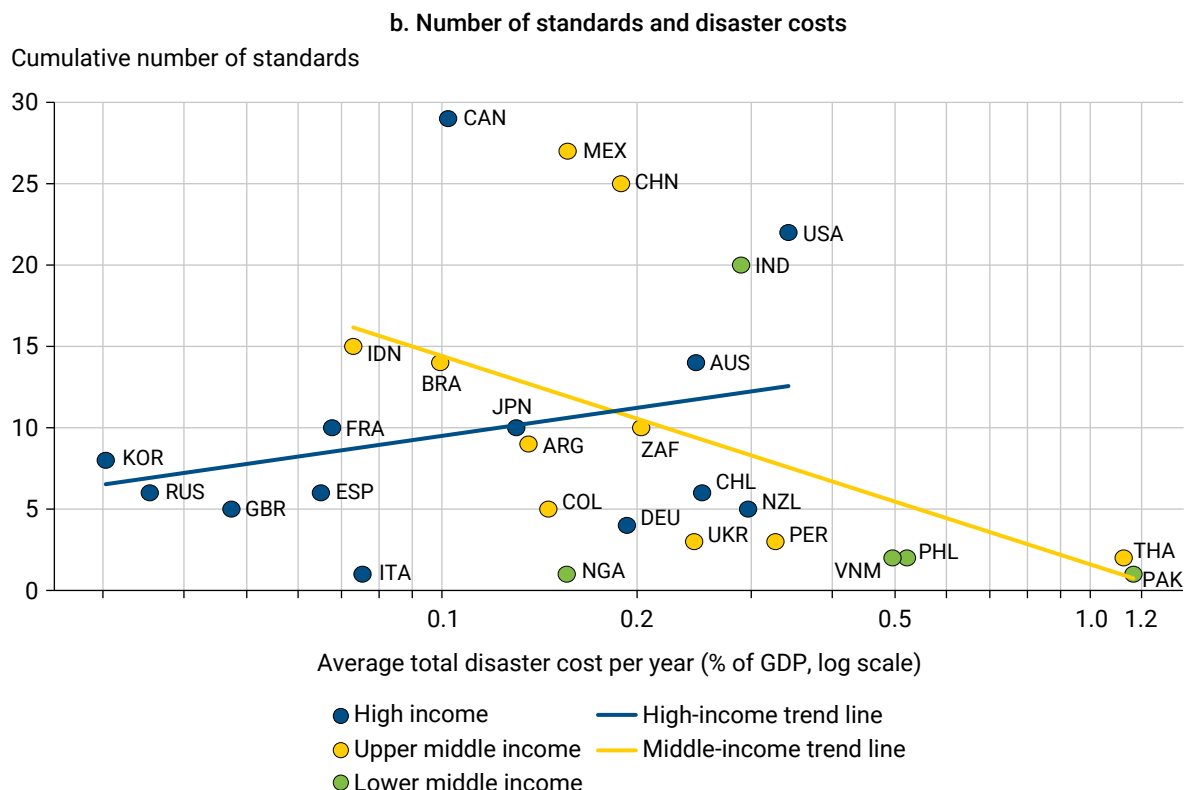
behavioral inertia often constrain the adoption of energy-efficient technologies like heat pumps. Innovators also face uncertainty about future demand, which carbon pricing alone may not address. In such cases, standards can mandate action and help overcome failures in coordination, thereby enhancing the effectiveness of carbon pricing.⁸⁰

Figure 6.6 The number of climate-related standards has grown in higher-income countries, and disaster costs have affected that number more than in lower-income countries



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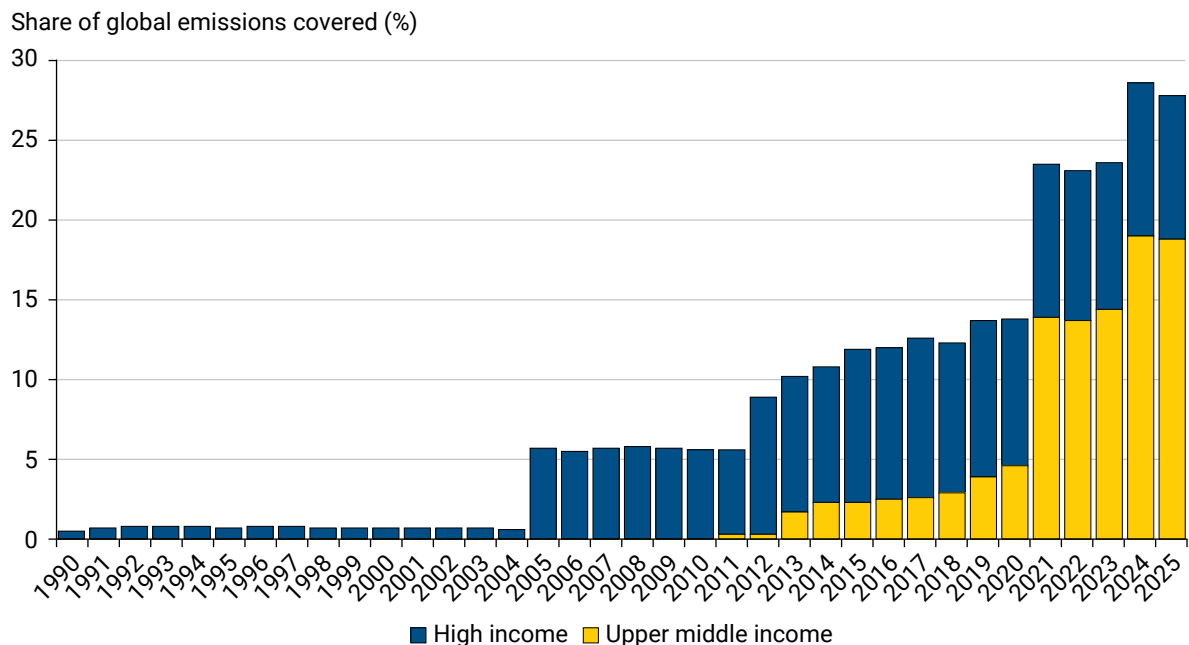
Figure 6.6 The number of climate-related standards has grown in higher-income countries, and disaster costs have affected that number more than in lower-income countries (*continued*)



Sources: WDR 2025 team elaboration, based on 2023 data from Climate Policy Database, NewClimate Institute for Climate Policy and Global Sustainability, <https://newclimate.org/resources/tools/climate-policy-database>; EM-DAT (International Disaster Database), Centre for Research on the Epidemiology of Disasters, Institute of Health and Society, Université Catholique de Louvain, <https://www.emdat.be/>.

Note: The Climate Policy Database is used to track the number of standards. The data on total disaster damage come from the EM-DAT database and include damage from meteorological, hydrological, and climatological disasters that occurred between 2010 and 2023. Panel b includes only countries for which data for cost of damage have been reported for at least five years. Accordingly, the analysis consists of 28 countries: 13 high-income countries and 15 middle-income countries. The income classification is based on World Bank Income Groups, 2023, Our World in Data, World Bank, <https://archive.ourworldindata.org/20250624-125417/grapher/world-bank-income-groups.html>. The solid lines in panel b represent fitted values using countries in the database. For the country labels used in the figure, refer to International Organization for Standardization, <https://www.iso.org/obp/ui/#search> (select “country codes”).

Figure 6.7 Carbon pricing covers a growing share of global emissions of carbon in higher-income countries, but not in lower-income countries



Source: State and Trends of Carbon Pricing Dashboard, World Bank, <https://carbonpricingdashboard.worldbank.org/compliance/price>.

Note: No low- or lower-middle-income country has adopted carbon-pricing instruments to date.

Also, standards for measuring efforts to mitigate carbon are essential for ensuring credibility and unlocking financing for measures related to climate change adaptation. Markets for carbon credits allow firms in high-income countries to purchase credits generated from mitigation activities in low- and middle-income countries as a way of offsetting the firms' own emissions, potentially offering lower-cost pathways to reduce global emissions. However, the effectiveness of these markets hinges on accurately measuring the actual reductions in emissions achieved by the mitigation activities. Challenges such as *additionality* (when credits are awarded for activities that would have occurred anyway) and *leakage* (when emissions shift outside the boundaries of credited projects rather than actually being mitigated) can undermine their environmental integrity.⁸¹ Standards that mandate third-party verification

of reductions in emissions, supported by objective sources of data, can strengthen the credibility of market-based efforts to reduce emissions.

Tradable performance standards, a hybrid of market-based mechanisms and standards, have emerged as a policy tool for reducing carbon emissions while supporting domestic production, particularly in low- and middle-income countries. Unlike emissions-trading systems, which cap total emissions, tradable performance standards set intensity-based benchmarks (such as emissions per unit of output), allowing output to grow while providing incentives for lowering emissions even more than the benchmark requires. However, many programs of this type assign more lenient benchmarks to higher-emitting sources, effectively providing larger implicit subsidies to producers that pollute more heavily. Such a design

reduces the programs' cost-effectiveness and weakens incentives for adopting cleaner technologies. Complementary policies, such as targeted green subsidies, are often needed to correct these distortions and enhance the environmental integrity of tradable performance standard schemes.⁸²

As with those for local pollution, policies for mitigating emissions can lead to emissions leakage when regulatory stringency differs across countries. However, because greenhouse gases are global pollutants, leakage is particularly damaging. Complementary policies can be designed to address emissions leakage. For example, when targeted at firms with a high risk of leakage, output-based subsidies help maintain the competitiveness of domestic industries while providing them with incentives for cleaner production under environmental regulations, which mitigates the risk of leakage of carbon emissions.⁸³ The European Union's Carbon Border Adjustment Mechanism, introduced in 2023, aims to prevent leakage of carbon emissions by charging fees on carbon-intensive imports from countries with regulations weaker than those in the importing countries. Evidence shows that this mechanism and a comparable one in the United Kingdom have increased domestic competitiveness and reduced leakage. And because exporters may prefer domestic carbon pricing to avoid border tariffs and retain revenue, such mechanisms have provided incentives for other countries to adopt stronger climate policies.⁸⁴ However, they may disproportionately burden low- and middle-income countries that have limited financial and technological capacities.⁸⁵

Low- and middle-income countries: Standards that emphasize local cobenefits to encourage mitigation of emissions of greenhouse gases

For low- and middle-income countries, economic growth is still the priority, and addressing global emissions of greenhouse gases may compromise that objective. However, standards that generate

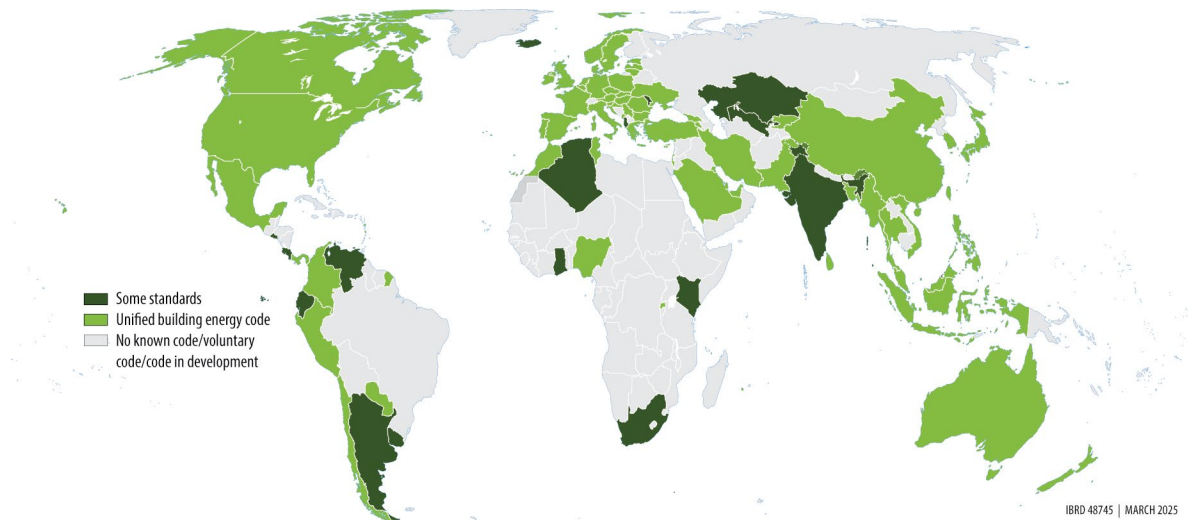
substantial local benefits may also generate climate cobenefits. These standards can serve as an entry point from which low- and middle-income countries can engage in global efforts to combat climate change.

Standards targeting local pollution can deliver climate cobenefits when they reduce reliance on fossil fuels. Electricity generation contributes about one-seventh of harmful air pollution and 40 percent of climate impacts globally. Phasing out coal as a fuel for generating electricity, for example, improves air quality while cutting emissions of carbon dioxide.⁸⁶ Similarly, energy efficiency standards, especially for buildings, which account for 34 percent of global emissions of carbon dioxide, can curb emissions as urbanization drives energy demand, particularly in emerging market economies.⁸⁷

Energy codes for buildings are among the most effective policy tools for reducing emissions in the construction sector. Efficient buildings could yield more than US\$1 trillion in savings in energy costs by 2050, the International Energy Agency (IEA) estimates.⁸⁸ In the European Union, buildings constructed under modern codes consume about half the energy of those built before such regulations, with even greater improvements seen in some countries.⁸⁹ Each dollar invested in building efficiency typically delivers a return of three dollars in lifetime savings, along with cobenefits such as improved health outcomes and enhanced energy security.⁹⁰

As of 2025, 88 countries have energy codes for buildings, but only 52 enforce them consistently, reducing energy savings by up to 70 percent from their potential (refer to map 6.2).⁹¹ Enforcement is strongest in high-income countries, with lower compliance in middle- and lower-income countries as a result of limited capacity. Closing this gap requires aligning codes with broader regulations and strengthening institutional support through technical assistance, training, and financial incentives, especially for households and small businesses in lower-income countries.

Map 6.2 Many low- and middle-income countries have not adopted strong energy codes for buildings



Source: 2025 data from Building Green (global data set), Global Indicators Group, World Bank, <https://www.worldbank.org/en/building-green>.

Standards for adaptation to climate change

Disaster-related losses are rising rapidly, fueled by growing climate risks and intensified by urbanization. In 2023 alone, global disasters resulted in more than 86,000 fatalities and more than US\$200 billion in economic damages.⁹² Although wealthier countries are typically the largest emitters of greenhouse gases, poorer countries bear the brunt of the impacts of climate change and suffer more severe consequences from it. In this context, low- and middle-income countries have a particularly pressing need for climate change adaptation.

Despite the urgency, regulating adaptation is challenging because it is context specific and measuring outcomes to attract investment is difficult (refer to box 6.4). In addition, private capital alone is often insufficient to finance needs related to climate change adaptation because high-risk areas, where adaptation is most needed, tend to deter investors or require high returns to motivate them to invest. In Brazil, regulations requiring banks to hold additional capital for loans directed toward activities that present greater climate risk have led banks to reduce lending to vulnerable sectors.⁹³ Because adaptation also requires significant investments in large-scale infrastructure, public funding is essential. This section explores how standards can support climate change adaptation.

Box 6.4 The importance of standards in increasing financing for climate change adaptation

Access to financing, particularly credit for investments in measures for adaptation to climate change, has been shown to support such adaptation in low- and middle-income countries.^a However, providing such finance, whereby institutions or individuals back-stop loans contingent on the returns to adaptation measures, depends on the ability to measure those returns. Mitigation is easier to measure because it is tracked through emissions reductions. In contrast, measuring adaptation is more challenging owing to its context-specific outcomes and difficulty in quantification. Even when investments for the purpose of adaptation reduce long-term climate risks, it remains challenging for private investors to reflect these benefits in pricing because of the lack of clear, quantifiable metrics and the difficulty of attributing the results of such investments to mitigation of potential future losses. Thus, the lack of reliable measurement remains a major barrier to financing climate change adaptation.

Currently, nearly all funding related to climate change continues to finance mitigation rather than adaptation. Of the US\$1.27 trillion in climate-change-related finance disbursed in 2021/22, 91 percent supported mitigation, and only 5 percent (US\$63 billion) went to adaptation and 4 percent to initiatives for the dual purposes of mitigation and adaptation.^b This distribution stands in contrast to low- and middle-income countries' self-reported needs: Adaptation accounts for about 20 percent of funding requirements.^c Financial institutions need to participate more broadly in financing investments in climate change adaptation to address the growing demand for adaptation financing.

Standards can play a key role in addressing needs for financing climate change adaptation by offering a consistent framework grounded in expert knowledge for guiding and assessing adaptation strategies. In 2019, the International Organization for Standardization (ISO) released ISO 14090, which provides principles, requirements, and guidelines for organizations to use in identifying risks from climate change and developing adaptation plans. In 2024, the Climate Bonds Initiative introduced its first adaptation and resilience taxonomy, identifying 1,444 investments across sectors for addressing various climate hazards that are eligible for financing under the initiative.^d Green taxonomies—frameworks that define what constitutes “green” or sustainable activities—have expanded significantly in recent years. By 2024, the European Union had issued 47 such taxonomies, other jurisdictions 20, and international organizations several to help direct finance toward investments aligned with adaptation to climate change.^e

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Box 6.4 The importance of standards in increasing financing for climate change adaptation (*continued*)

However, translating these frameworks into practical decision-making remains difficult. For example, Mexico's sustainable taxonomy incorporates adaptation as a core pillar alongside mitigation and social inclusion. A pilot involving 10 financial institutions revealed that only 3 percent of their operations could be clearly classified as aligned with adaptation, underscoring the complexity of implementation, especially when criteria require detailed and localized data.

Source: WDR 2025 team.

- a. Berg et al. (2025); Bryan et al. (2009); Da Mata and Resende (2020); Lane (2024).
- b. CPI and GCA (2023).
- c. Isah et al. (2025).
- d. Azizuddin (2024).
- e. SBFN (2024).

Standards for expanding access to solutions to adapt to climate change: Coping with extreme heat

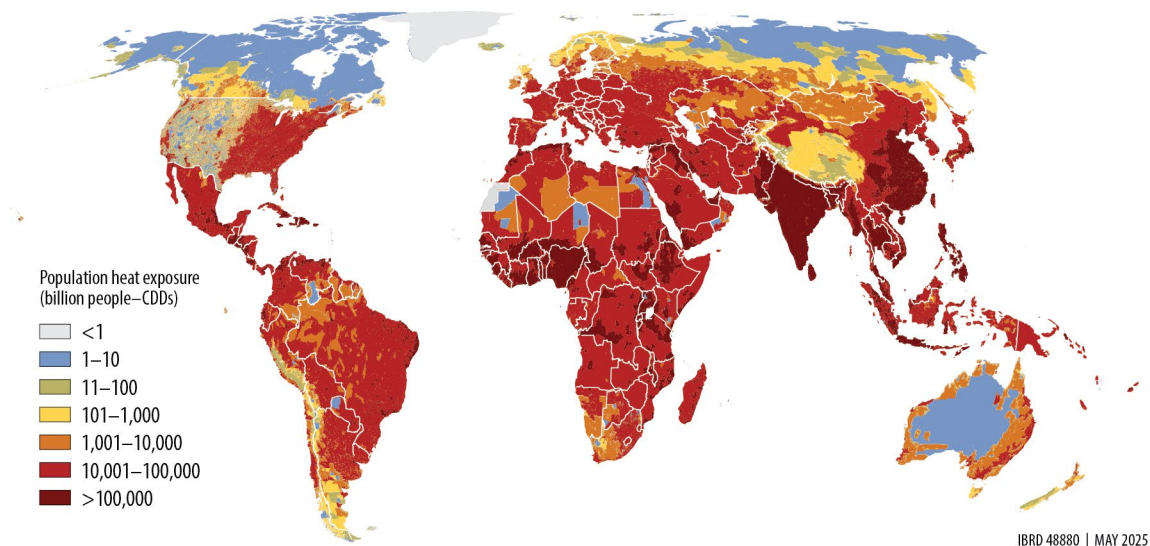
Today, more than 70 percent of the global workforce—approximately 2.4 billion people—faces high risks from heat stress, resulting in millions of injuries and thousands of deaths each year.⁹⁴ Despite widespread exposure to extreme heat, particularly in low- and middle-income countries (refer to map 6.3), the penetration of air conditioning, a widely used adaptation strategy, remains below 10 percent in many low-income countries. To support climate change adaptation as a basic human need, standards that address market failures in adaptation must also focus on equitable access to effective solutions for cooling.

Cooling technologies generally fall into two categories: active and passive. Active cooling involves electricity-powered systems such as fans and air conditioners, whereas passive cooling relies on design strategies, such as natural ventilation

and shading, that harness local environmental resources at low operating costs.⁹⁵ The two technologies complement one another but involve trade-offs. An integrated strategy that promotes access to both can help standards more effectively expand access to cooling options and address these trade-offs.

Active cooling, especially with air conditioning, is highly effective across various climates but is energy intensive, currently accounting for about 20 percent of electricity use globally.⁹⁶ As adoption rises, it will place an increasing strain on power grids and may contribute to outages. Energy efficiency standards can help ease this burden (refer to box 6.5). Moreover, emissions from cooling could reach about 6 billion tonnes of carbon dioxide equivalent by 2050, more than 10 percent of projected global emissions.⁹⁷ Thus, standards must carefully balance climate change mitigation and adaptation goals, ensuring energy efficiency while promoting equitable access to cooling.

Map 6.3 Exposure to extreme heat is widespread, especially in low- and middle-income countries



Sources: Global 1-km Downscaled Population Base Year and Projection Grids Based on the Shared Socioeconomic Pathways, Revision 01 (data portal), National Aeronautics and Space Administration, <https://data.nasa.gov/dataset/global-1-km-downscaled-population-base-year-and-projection-grids-based-on-the-shared-socio>; Lizana et al. 2024.

Note: The map shows the heat-exposed population in 2030, measured as billion people-cooling degree days (CDDs), for a global mean temperature rise of 1.5° Celsius.

Box 6.5 Using standards to meet the increasing demand for electricity

Reliable access to electricity is essential to both economic growth and adaptation to climate change, particularly in response to extreme heat. Energy efficiency standards for common appliances play a critical role in curbing demand in this context. They help mitigate carbon emissions, which are often unaccounted for at the point of purchase, especially in countries that still largely generate electricity from fossil fuels. In addition, by reducing energy demand, these standards ease pressure on the power grid, alleviating congestion and power outages, which in turn enable broader and more equitable access to electricity.

However, in many low- and middle-income countries, where credit constraints are widespread, implementing energy efficiency standards can present trade-offs. Energy-efficient appliances typically have higher up-front costs, even though they offer long-term savings through reduced consumption of electricity (refer to table B6.5.1). These higher initial costs can present a barrier for many households, preventing them from reaping long-term

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Box 6.5 Using standards to meet the increasing demand for electricity (continued)

financial and energy benefits. Policies complementing energy efficiency standards, such as targeted subsidies or financing options for low-income households, can boost the adoption of energy-efficient appliances.^a

Table B6.5.1 Energy-efficient appliances typically offer long-term savings but have higher up-front costs

APPLIANCE	COUNTRY	TYPE ^a	INITIAL COST (US\$)	ANNUAL ELECTRICITY USAGE (kWh)	ANNUAL ELECTRICITY COST (US\$)	AVERAGE LIFE CYCLE (YEARS)	TOTAL COST OVER 10 YEARS (US\$) ^a
Fan	India	Energy efficient	44	22	2	7	80
		Regular	27	60	5	3	135
	Nigeria	Energy efficient	25	36	1	4	74
		Regular	20	120	4	2	140
	United States	Energy efficient	140	12	2	8	197
		Regular	30	24	4	5	103
Refrigerator	India	Energy efficient	289	526	39	10	683
		Regular	197	876	66	8	903
	Nigeria	Energy efficient	262	438	14	12	363
		Regular	121	1,051	35	10	468
	United States	Energy efficient	800	876	158	12	2,243
		Regular	500	1,314	237	10	2,865

Source: WDR 2025 team.

Note: This table assumes the following usage patterns: for fans, 8 hours per day for 100 days per year in India, 250 days in Nigeria, and 50 days in the United States; for refrigerators, continuous operation. Energy-efficient models are assumed to meet or exceed Energy Star standards or their equivalent. Initial costs are based on the average market prices in 2025 for basic models. Electricity costs are estimated to be US\$0.075 per kilowatt-hour (kWh) in India, US\$0.033 per kWh in Nigeria, and US\$0.18 per kWh in the United States. Unreliable electricity grids could further reduce appliance lifespan (Akpojedje 2017).

a. The lower-cost option over the 10-year life of the appliance appears in boldface in the final column.

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Box 6.5 Using standards to meet the increasing demand for electricity (continued)

In addition, improvements in energy efficiency often involve trade-offs with other product attributes, highlighting the importance of an integrated approach that balances multiple objectives.^b These trade-offs can be addressed through sound technical evidence, broad stakeholder consensus, and regulatory coordination grounded in international standards. For example, International Organization for Standardization standard 817, shaped significantly by Japan, provides harmonized safety classifications for refrigerants with low potential for contributing to global warming. This standard has allowed manufacturers to bring more climate-friendly cooling solutions to market while maintaining safety and regulatory acceptance across jurisdictions.

On the supply side, standards can enhance the reliability of energy supply by fostering coordination across the supply chain and ensuring the quality of production and operations. For example, technical standards on voltage and frequency enable different generators and transmission systems to operate seamlessly within and across countries, facilitating electricity trade across regions and strengthening resilience. Likewise, quality standards for transformers and cables, along with guidelines for the operation and maintenance of transmission lines, help ensure the reliability of the energy supply.

Source: WDR 2025 team.

a. Taylor et al. (2008).

b. Gerarden et al. (2017).

Passive cooling does not rely on electricity and involves lower operating costs. However, its effectiveness and cost-efficiency are highly localized, depending on microclimatic conditions, architectural norms, and cultural practices. As a result, it is difficult to regulate passive cooling through specific technology or performance standards.

Instead, building codes that integrate minimum energy performance standards while incorporating passive strategies for cooling can support energy efficiency in active cooling while promoting passive approaches at the design stage.⁹⁸ This could lower the overall cost of cooling technologies and expand households' access to them. As of May 2023, 42 percent of countries, including both high- and low- and middle-income countries, had implemented minimum energy

performance standards for space cooling.⁹⁹ Evidence from India, Indonesia, and Nigeria shows that doubling the energy efficiency of room air conditioners by 2030 could reduce their life-cycle costs by 60 percent and provide an additional 320 million people with access to them by 2050.¹⁰⁰ Combining minimum energy performance standards with building codes allows for flexible, context-specific solutions aligned with local climate and housing conditions.

In addition to promoting access to adaptation solutions such as active and passive technologies for cooling, standards can also support emergency response measures to ensure basic access to essential resources during extreme events. For example, the city of Ahmedabad in India was one of the first in South Asia to implement a heat action plan.¹⁰¹

During periods of extreme heat, the city uses localized thresholds for temperature to activate a set of responses, including emergency hotlines, public advisories, outreach to vulnerable populations, and the provision of cooling shelters and drinking water.¹⁰²

Standards for fostering coordination: Enhancing flood resilience

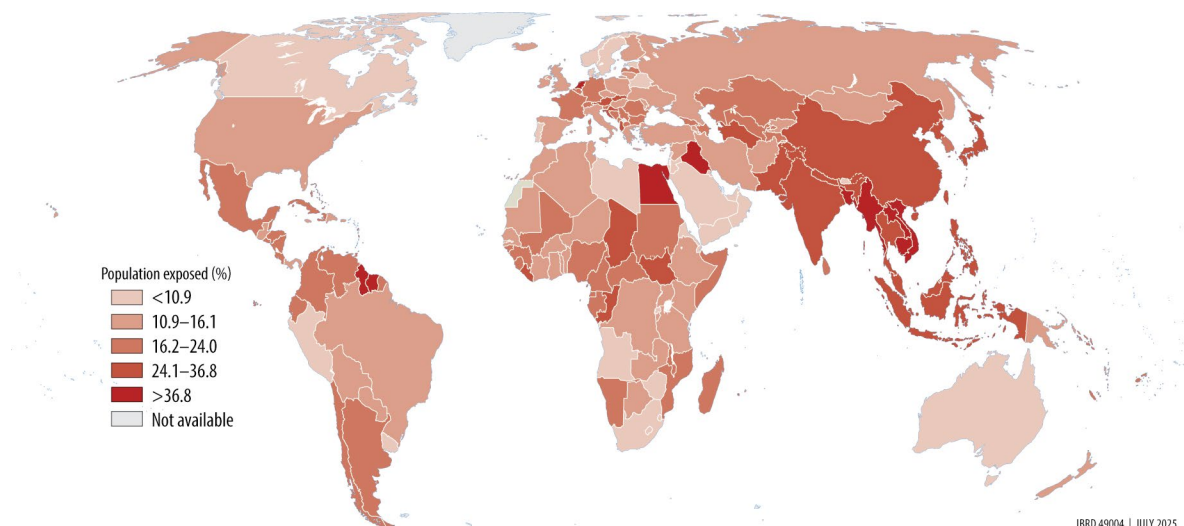
Some 1.81 billion people, or 23 percent of the global population, live in areas exposed to significant risks of flooding (refer to map 6.4). Despite growing risks of flooding as a result of climate change, human settlements have continued to expand rapidly into flood-prone areas, often at a faster pace than into safer zones across many regions.¹⁰³ Globally, nearly 1 billion people live in substandard housing with inadequate sanitation and stormwater drainage, further compounding their vulnerability. Because urban planning, infrastructure quality, and individual building design all shape flood risk, enhancing

resilience requires coordinated efforts across all levels.

Urban planning

To reduce exposure to flood hazards, urban planning must integrate considerations related to risks from climate change. Zoning standards can prohibit construction in areas that are highly prone to floods by defining hazard thresholds. Also, uncontrolled urban sprawl, especially where green spaces are scarce, can exacerbate flood risks and disproportionately affect low-income households, which often reside in high-risk zones. In Dhaka, Bangladesh, for example, slums are concentrated in flood-prone areas.¹⁰⁴ Implementing zoning regulations that require buffer zones or protective greenbelts can mitigate risks of flooding. In addition, early warning systems can be established to provide timely alerts, and homebuyers can be provided with information on flood risks to enable them to make informed decisions, both helping to mitigate flood-related losses.¹⁰⁵

Map 6.4 Nearly one-quarter of the world's population is exposed to at least medium-level risks of flooding



Source: Rentschler et al. 2022.

Note: The map shows risks at the subnational level.

Infrastructure

With climate change intensifying natural hazards, standards for new and existing infrastructure must evolve accordingly.¹⁰⁶ For example, increased variability in rainfall levels, with alternating periods of dryness and drenching rains, can make peak river flows higher and overwhelm dams. Overtopping, the most common cause of dam failure, occurs when water exceeds the capacity of spillways. In Libya, devastating dam failures during extreme flooding in September 2023 destroyed entire neighborhoods and claimed more than 4,000 lives, highlighting the urgent need for reviewing and strengthening national standards for designing dams so that they take climate change into account.

International bodies like the International Commission on Large Dams (ICOLD) play a key role in shaping global practices regarding dam safety by leveraging member expertise and promoting knowledge sharing. As of 2025, ICOLD had 106 member countries, many of which align their national regulations with its guidance. In countries without formal guidelines for dam safety, a common situation in low- and middle-income settings, practitioners often rely directly on ICOLD standards. Development partners such as the World Bank also promote international good practices through project financing and advisory support.

At the same time, infrastructure such as dams can help manage flood risks. For example, Poland's Racibórz Dolny Flood Protection Reservoir reduced downstream peaks during a major 2024 flood, protecting more than 2.5 million people from severe damage. Yet only 18 percent of large dams globally are designated for flood control.¹⁰⁷ With more than 60,000 large dams worldwide, many more than 50 years old, there is an opportunity for rehabilitation, retrofitting, and reoperation to strengthen their role in climate change adaptation. These investments can generate substantial public benefits and may require public financing to ensure regional resilience.

Buildings

Beyond planning and infrastructure, building design could also play a pivotal role in increasing resilience to floods. In the US state of Florida, updated building codes that incorporate risks of disasters have measurably reduced hurricane-related damages, saving an estimated US\$911 million annually.¹⁰⁸ In low-income settings, however, modern building codes designed for high-income countries are not always the best choice. In Pakistan, bamboo homes largely withstood the historic 2022 floods that destroyed more than 2 million houses, mostly of other constructions. This example highlights the importance of locally appropriate and culturally relevant building standards for resilience.

International efforts such as the World Bank's Building Regulation for Resilience Program¹⁰⁹ can support countries by sharing knowledge, offering technical assistance, and providing financial resources. In Japan, where seismic risk is high, investments in earthquake-resistant infrastructure have saved an estimated US\$2.2 billion annually in avoided reconstruction costs. Japan has also contributed globally by sharing its technical expertise and experience through international initiatives.

However, building codes may involve trade-offs between competing priorities. For example, compliance with building codes can increase construction costs, which may in turn affect housing affordability.¹¹⁰ Also, pursuing energy efficiency may, in some cases, raise safety concerns. As a cautionary example, in Mexico City, a seven-story building retrofitted solely for energy efficiency partly collapsed during the 2017 earthquake.¹¹¹ This example highlights the need for integrated building codes that balance objectives relating to climate change mitigation and adaptation against those that pertain to maintaining resilience to other challenges and preserving affordability.

Recommendations for standards for a better environment

Emphasize the broader benefits of environmental standards. Countries, especially low- and middle-income countries, should not view environmental standards as separate from growth goals. Pollution reduction yields broad benefits, including increasing productivity,¹¹² human capital,¹¹³ and housing values and attracting talent.¹¹⁴ Integrating standards with green industrial policies may give countries the opportunity to leapfrog polluting technologies and pursue green growth in sectors like energy and transport.¹¹⁵ Overlooking these benefits risks underusing environmental standards.

- At the firm level, for instance, a study in Bangladesh found that installing air purifiers in randomly selected firms not only reduced indoor concentrations of PM_{2.5} by 15 percent but also delivered significant economic returns: boosting daily labor productivity by 10 percent and monthly profits by 18 percent, compared with those in control firms without air purifiers.¹¹⁶
- At the economy level, China's push for electric vehicles—driven by strict air quality standards and green industrial policies—has cut pollution and emissions¹¹⁷ while enabling the country to leapfrog traditional auto leaders. By 2023, China was the overwhelming market leader in global sales of electric vehicles.¹¹⁸

Design standards in a policy mix to achieve goals related to emissions reduction effectively. Standards are often more effective than market-based instruments, such as emissions pricing, when specific reductions are needed to meet environmental or public health thresholds. However, when multiple market failures are present, relying on a single policy may be insufficient. Complementary policies can strengthen the overall effectiveness of

standards by addressing different market failures simultaneously, enabling countries to take a more comprehensive and efficient approach to reducing emissions.

- The compliance costs associated with water quality standards can decline over time through learning by doing, economies of scale, and innovations in water treatment technologies. However, such advancements may be underprovided in the absence of supportive policies, which justifies public investment.¹¹⁹ In the United States, for instance, grants for building infrastructure for wastewater treatment under the Clean Water Act have been shown to reduce compliance costs for polluters and decrease the likelihood of violations of water quality standards by 0.5 percentage point per grant.¹²⁰

Adapt standards to local contexts while taking potential leakage of emissions into account. Countries should tailor environmental standards to local environmental challenges, economic conditions, technological readiness, and enforcement capacity. A careful analysis of the costs and benefits of setting standards and of firms' capacity to comply with any standards that are set will help countries develop and enact more effective standards that are sensitive to context. However, different standards across regions and sectors may result in emissions leakage. When this leads to negative environmental outcomes, well-designed unilateral measures or coordinated international efforts could help mitigate and compensate for these losses.

- The European Union, for instance, addresses transboundary water pollution primarily through the Water Framework Directive, which mandates integrated management of river basins and cross-border cooperation to achieve “good status” for all water bodies. Policies under the directive have improved

water quality in major rivers shared by multiple countries like the Rhine and Danube and fostered strong cross-country coordination.¹²¹

Meet future demand and drive innovation through forward-looking standards. Standards can have long-lasting impacts, especially when applied to long-lived assets. For instance, coal-fired power plants can operate for 30–50 years, creating lock-in effects that delay the transition to cleaner alternatives. In a fast-evolving world, standards need to be forward looking to meet future demand and support the development of emerging technologies. Specifically, standards should be evaluated from a longer time horizon, not just contemporaneously, to take future demand into consideration. Also, when technologies are rapidly advancing, standards should be flexible enough to enable and encourage innovation.

- Active cooling, particularly through air conditioning, is a highly effective way to adapt to extreme heat but remains energy intensive. As adoption increases, it will increasingly strain power grids, especially in regions with limited electricity infrastructure. In Nigeria, for instance, the federal government approved new minimum energy performance standards for air conditioners in 2025. The standards aim to save 11.5 terawatt-hours of electricity annually and reduce carbon emissions by 39 million tonnes of carbon dioxide by 2040.¹²²
- The introduction of an emissions standard for automobiles across the European Union that limits sales-weighted emissions of carbon dioxide across manufacturers' fleets has been shown to have given firms incentives to invest significantly in new technologies to meet compliance requirements. As a result, average vehicle efficiency in regard to emissions of carbon dioxide improved by approximately 14 percent from 2007 to 2011,

leading to lower fuel costs over the lifetime of vehicles.¹²³

Enhance and leverage monitoring and measurement infrastructure. Expanding and improving systems for environmental monitoring, particularly in areas with limited infrastructure, is crucial for identifying environmental challenges, enhancing the enforcement of standards, and ensuring accountability. Data collected from such systems can be further leveraged through public information campaigns to raise awareness of local pollution and promote adaptive behavior. Furthermore, accessible infrastructure for monitoring and measurement standards allow independent third-party verification of claims that emissions have been reduced, which is crucial for maintaining the credibility and effectiveness of climate-change-related initiatives such as carbon credit markets.

- In 2013, China launched a nationwide initiative regarding air quality monitoring that began providing real-time data on pollution to the public through daily newspapers and other media outlets. Increased access to information spurred widespread behavioral adaptations, such as increased investment in air purifiers, which are estimated to generate a minimum of US\$13 billion in annual health benefits.¹²⁴
- A recent study in Colombia evaluated carbon credit projects using satellite-based images to measure forest cover and found that natural forest cover increased by 4 percentage points over 12 years.¹²⁵ Evaluations of this type are possible only with publicly available data on land cover and emissions monitoring.

As these examples and recommendations show, a balanced, forward-looking, and context-specific approach to environmental standards, making good use of complementary policies, can yield powerful results.

Notes

1. Greenstone et al. (2024); Tanaka (2015).
2. Chang et al. (2019); Graff Zivin and Neidell (2012); Ortiz-Bobea et al. (2021); Shaddick et al. (2020).
3. IPCC (2021).
4. Shaddick et al. (2020).
5. Greenstone et al. (2024).
6. Weitzman (1974).
7. Greenstone et al. (2025).
8. Jacobsen et al. (2023).
9. Li et al. (2024).
10. Jha and La Nauze (2022).
11. Buntaine et al. (2024).
12. Oliva (2015); Sundström (2013); Williams and Dupuy (2017).
13. He et al. (2020).
14. For analytical purposes, this Report measures state capacity using the Worldwide Governance Indicators, which reflect broad perceptions of governance quality. Refer to Worldwide Governance Indicators (dashboard), World Bank, <https://www.worldbank.org/en/publication/worldwide-governance-indicators>.
15. Duflo et al. (2018). Given the current inspection rate in Gujarat, India, the inspections chosen by the regulator have been shown to induce three times more abatement than would the same number of randomly assigned inspections.
16. Lipscomb and Mobarak (2016).
17. Greenstone et al. (2022).
18. Axbard and Deng (2024).
19. Buntaine et al. (2024); Jha and La Nauze (2022).
20. Yang et al. (2024).
21. Kahn et al. (2015).
22. Chen et al. (2024).
23. UNECE et al. (2024).
24. Ambec (2025).
25. Ambec and Lanoie (2008). ISO 14001 certification validates that an organization meets the internationally recognized standard for environmental management, ISO 14001.
26. Heilmayr and Lambin (2016); Jyväsjärvi et al. (2020); Zwerts et al. (2024).
27. Barla (2007); Blackman et al. (2018); Vidovic and Khanna (2007).
28. Greenstone and Hanna (2014); Greenstone et al. (2021); Isen et al. (2017); Keiser and Shapiro (2019).
29. Isen et al. (2017).
30. Auffhammer et al. (2009).
31. Greenstone et al. (2021).
32. Dechezleprêtre and Sato (2017).
33. Fowlie et al. (2016).
34. Lyubich et al. (2018); Su et al. (2022).
35. OECD (2021).
36. Porter and van der Linde (1995).
37. Lu and Pless (2024).
38. Rodrik (2014); World Bank (2024).
39. Hsieh et al. (2022).
40. IEA (2024a).
41. Chang et al. (2019); Graff Zivin and Neidell (2012).
42. Lavy et al. (2014).
43. Isen et al. (2017).
44. Behrer et al. (2023); Chay and Greenstone (2005).
45. Chen et al. (2022).
46. Houssini et al. (2025).
47. Li and Song (2024).
48. Davis and Kahn (2010).
49. Gechter and Kala (2025).
50. Zhang and Zhao (2023).
51. Tanaka et al. (2022).
52. Okello et al. (2018).
53. Baylis et al. (2024); Ito and Zhang (2020).
54. Oliva (2015).
55. Jacobsen et al. (2023).
56. Greenstone and Hanna (2014).
57. Kellogg (2018).
58. Tang et al. (2019).
59. Mahalana et al. (2022).
60. Cieply and Wang (2025); Reynaert (2021); Rozendaal and Vollebergh (2025).
61. Gowrisankaran et al. (2025).
62. Greenstone and Nath (2024).
63. Nazar et al. (2021).
64. Greenstone et al. (2012).
65. He et al. (2020).
66. Colmer et al. (2024).
67. Khan et al. (2023).
68. Luo et al. (2021).
69. IEA (2024b).
70. Du et al. (2025).
71. Bento et al. (2020); Jacobsen (2013); Jacobsen et al. (2023).
72. Kaza et al. (2018); Kaza et al. (2021).
73. Ritchie (2023).
74. UNEP (2024).
75. O'Neill and Moon (2025).
76. World Bank (2021).
77. Ley et al. (2000).
78. Ge et al. (2024).
79. Aklın and Urpeläinen (2018).
80. IMF et al. (2024).
81. Calel et al. (2025); Filewod and McCarney (2023).
82. Fischer et al. (2024).
83. Fowlie and Reguant (2022).
84. Clausing et al. (2025); Fischer and Fox (2012).
85. Böhringer et al. (2018).
86. Tong et al. (2021); Trencher et al. (2022); Wang et al. (2021).
87. IEA (2023); UNEP (2025).
88. IEA (2019).
89. Liu et al. (2010).
90. Refer to “Rules of Thumb” (tables), State and Local Climate and Energy Program, US Environmental Protection Agency, https://archive.epa.gov/epa/sites/production/files/2016-03/documents/table_rules_of_thumb.pdf.
91. World Bank (2025).
92. CRED (2024).
93. Aguilar-Gómez et al. (2024); Miguel et al. (2024).
94. ILO (2024).

95. Antinucci et al. (1992); Nghlovu (2020).
96. UNEP (2023a).
97. UNEP (2023a).
98. Khosla (2025).
99. UNEP (2023b).
100. CLASP (2025).
101. Knowlton et al. (2014).
102. Casanueva et al. (2019).
103. Rentschler et al. (2023).
104. Shilpi et al. (2025).
105. Burlig et al. (2025); Fairweather et al. (2024).
106. Hallegatte et al. (2019).
107. Refer to World Register of Dams: General Synthesis (portal), International Commission on Large Dams (accessed April 29, 2025), https://www.icold-cigb.org/GB/world_register/general_synthesis.asp.
108. FEMA (2020).
109. The Building Regulation for Resilience Program supports cities, states, and countries in strengthening building regulations, control processes, and implementation capacity to create safer, greener, and more inclusive built environments. It provides technical assistance to help governments advance regulatory, policy, and institutional reforms and increase compliance. For more information, refer to Building Regulation for Resilience (portal), Global Facility for Disaster Reduction and Recovery, World Bank, <https://www.gfdr.org/en/building-regulation-for-resilience>.
110. Glaeser and Gyourko (2003).
111. Margani et al. (2020).
112. Chang et al. (2019); Graff Zivin and Neidell (2012).
113. Isen et al. (2017); Lavy et al. (2014).
114. Chen et al. (2022).
115. Rodrik (2014); World Bank (2024).
116. Garg and Jagnani (2025).
117. Hsieh et al. (2022).
118. IEA (2024a).
119. Keiser and Shapiro (2019); Olmstead (2010).
120. Keiser and Shapiro (2019).
121. ICPDR (2021).
122. UNEP (2023c).
123. Reynaert (2021).
124. Barwick et al. (2024).
125. Bruhn et al. (forthcoming).

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Main messages

- Governments deliver development but too often fall short because of weak foundations in governance. In Ghana, one in three projects financed by local governments, from schools to roads, never gets completed, wasting nearly 20 percent of public investment. The core problem is not corruption, but the mismanagement of people, payments, and procurement. Strengthening the systems for these basic functions is where development begins.
- Governance standards are the hidden wiring of effective states. They codify how governments hire, pay, and procure, turning discretion into discipline. When governments publish budgets and procurement data in line with international standards, as Ukraine did to sustain external financing during crisis, transparency becomes a foundation for trust and stability.
- The hardest part is consistency: making standards stick across every ministry and municipality. Globally, the public sector employs 373 million people, and even within a single government, the share of recruitment based on merit can vary from 20 percent to 100 percent across agencies. Moving from rule of thumb to “rule by standards” involves a quiet revolution that reduces corruption and mismanagement but demands scale, coordination, and realism regarding administrative costs.
- Governments must adapt standards to context, not copy best practice blindly. One-size-fits-all reforms backfire when capacity for implementing them is low. Data from 39 countries show that as nations grow richer, they tighten deadlines for paying contractors but keep the share of on-time payments roughly constant, a sign of learning and calibration. The lesson: measure, listen, and adjust, because standards for governance work best when governments make them their own.
- Performance standards can turn bureaucracies from rule followers into problem solvers. When governments link performance to measurable outcomes, as in the cases of Malaysia’s outcome-based budgeting or Chile’s evaluation-driven reforms, public sector efficiency increases sharply. In Punjab, Pakistan, performance pay for tax collectors increased revenue collection by about 40 percent in just two years, and in Andhra Pradesh, India, teacher bonuses tied to student learning improved learning outcomes across all subjects. Standards that measure what matters empower bureaucrats to deliver results, not just follow rules.

Governance standards: Helping governments deliver on their commitments

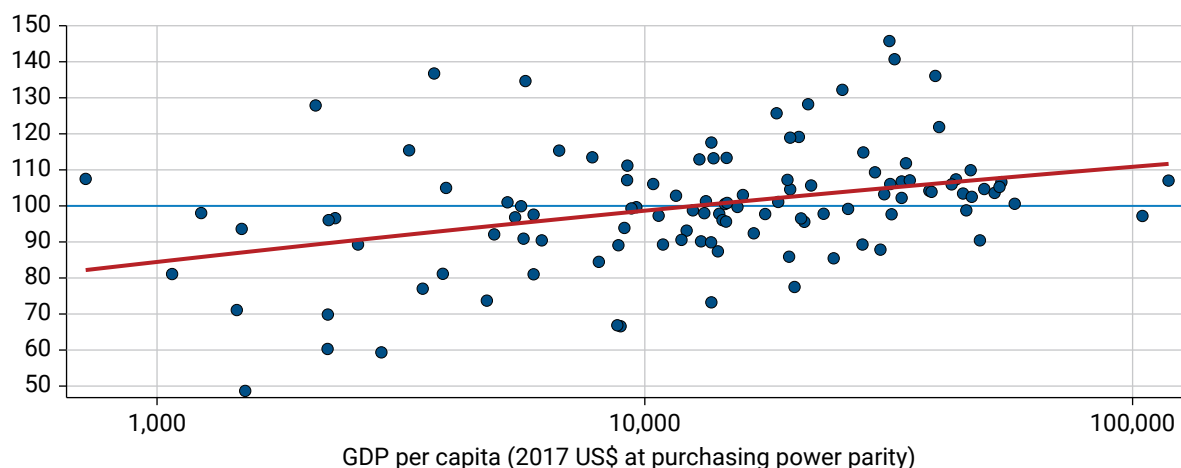
Governments are responsible for implementing public policies and delivering public goods and services that are foundational for development. However, they often struggle to deliver on their policy commitments. For example, in Ghana, local governments carry out projects such as building schools and latrines. A study of more than 14,000 such projects found that about one-third were not completed, accounting for nearly one-fifth of local governments' public investments.¹ This country-level case reflects a global issue affecting both local and central governments. Each year, governments allocate financial resources to various projects and programs. Yet in countries with lower levels of economic development, these budgets are frequently underspent, falling short of the countries' original commitments (refer to figure 7.1).

A key factor behind this implementation gap is the limited capacity of public institutions—understood here as formal organizations in the public sector—to fulfill their mandates.² For Ghana's local governments, corruption played only a small role in explaining the implementation gap.³ In fact, unfinished projects resulted in financial losses for both government officials and contractors, outweighing any potential gains from bribes or collusion. Instead, organizational mismanagement of functions such as personnel, payments, and procurement explained most of the gap. Engineers estimated project costs based on inaccurate data, budget and planning functions were not coordinated, and contractors were rarely paid on time.⁴ To deliver on their policy commitments, governments have to address these types of organizational challenges.

This chapter argues that standards provide institutional scaffoldings for better governance, understood here as the management of core

Figure 7.1 Countries at lower levels of economic development tend not to spend all the funds they have budgeted

Budget execution rate (% of original approved budget), 2022



Sources: WDR 2025 team calculations, based on data from Primary Government Expenditures as a Proportion of Original Approved Budget (%) (data portal), World Bank, <https://data.worldbank.org/indicator/GF.XPD.BUDG.ZS>; Prosperity (dashboard), World Bank, <https://data360.worldbank.org/en/prosperity>.

Note: "Budget execution rate" refers to expenditure by primary governments as a proportion of originally approved budgets. The blue line represents complete spending of the allocated budget (that is, 100 percent). Values above the blue line represent overspending and those below, underspending. The red line represents the best-fit curve using a quadratic function.

organizational functions of government: personnel, payments, and procurement.⁵ The chapter emphasizes institutional variation in governance within the same government and how this affects institutional capacity.⁶ Governments should transition from governance based on rule of thumb to governance based on standards. Rule-of-thumb governance relies on the tacit knowledge and personal preferences of decision-makers in the public sector, which can lead the latter to base managerial decisions on imperfect information and biases. At its worst, rule-of-thumb governance leads to capricious decisions that benefit those in power.⁷ In contrast, standards-based governance employs codified measurements (rulers) that increase transparency and procedural requirements (rules) that diffuse good practices. These standards, when put into practice consistently and at scale, strengthen governance and enable public institutions to deliver on their commitments.

Governance standards should be implemented gradually, leveraging evidence on the impact of implementation and leaving sufficient space for agency. That is because governance standards are costly to put into practice. For instance, complying with standards forces personnel to divert scarce time from implementation to compliance, reducing the quality of policy implementation.⁸ To both reduce the costs of implementation and amplify its benefits, governments need to introduce evidence-based assessments of the organizational impact of standards and implement them through a gradual and priority-driven approach. This requires collecting and analyzing survey and administrative data on organizational processes, as well as listening to feedback from institutions and people in the public sector. This, in turn, enables governments to make pragmatic choices among competing priorities and adapt standards so that they work better for them, rather than pursue general “best practices” that are neither feasible nor suited for their needs.

By examining how standards can serve as a basis for better governance, this chapter emphasizes the organizational and managerial aspects of governance, which are sometimes overlooked. Therefore, the discussion and evidence presented in the chapter highlight operational ways to strengthen governance and enhance policy implementation, complementing debates on the role of political economy and strategic policy making discussed in other *World Development Reports*.⁹ In doing so, this chapter emphasizes how implementation can suffer from gaps even when public institutions and personnel are trying to do the right things but need the help of standards to do so well.

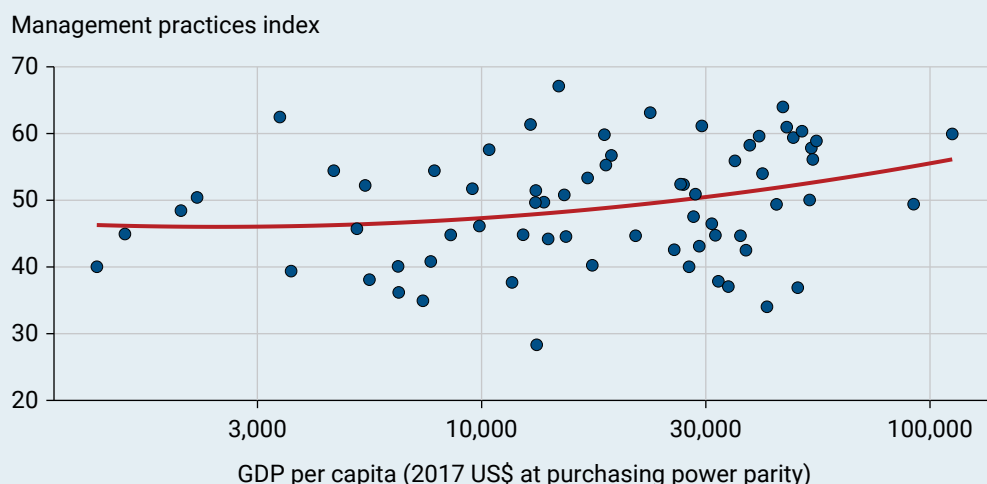
How standards shape the governance of organizational functions

The quality of governance, considered in this chapter to be the management of core organizational functions of government, often varies across public institutions in the same public sector. Some institutions within a government may be “islands of excellence,” well managed and capable of consistently delivering on the government’s policy commitments.¹⁰ Many are not. Empirical evidence on the private and public sectors shows that variation in the quality of organizational management explains differences in performance and policy implementation (refer to box 7.1). The challenge for governments is how to improve the governance of public institutions that trail behind, making the quality of governance more consistent across the public sector. This involves a capacity-building process that requires a constructive approach. In developmental psychology, the term “instructional scaffolding” refers to a pedagogical method that recognizes the need for a collaborative approach to transferring knowledge to learners.¹¹ In governance, standards serve as institutional scaffoldings that help institutions and people manage themselves better.

Box 7.1 Recent empirical research on management confirms its impact on organizational performance

A growing body of empirical evidence has documented large and persistent differences in management quality across firms in the private sector, which drive variation in the productivity of these firms.^a This is true across firms of different sizes and across countries. Building on an empirical agenda derived from this evidence, the World Bank's Enterprise Surveys calculate a management practices index that measures the quality of management at the firm level along a set of dimensions similar to those employed in the World Management Survey.^b National-level averages of scores on this index suggest that the quality of management of firms increases as countries develop (refer to figure B7.1.1). Empirical studies on management have extended beyond firms, investigating how management practices in organizations such as schools affect student learning. For instance, a study comparing school-level management in Brazil, India, Sweden, the United Kingdom, and the United States found that better strategic leadership and governance, in the form of accountability to school boards, correlated with better outcomes in regard to student learning.^c

Figure B7.1.1 As countries develop, the quality of management in their firms improves



Sources: WDR 2025 team calculations, based on data from Prosperity (dashboard), World Bank, <https://data360.worldbank.org/en/prosperity>; World Bank Enterprise Surveys (dashboard), World Bank, <https://www.enterprisesurveys.org/en/enterprisesurveys>.

Note: Each bullet corresponds to a national-level average of the quality of management in surveyed firms in an individual country. The red line represents the best-fit curve using a quadratic function.

(Box continues next page)

Box 7.1 Recent empirical research on management confirms its impact on organizational performance (*continued*)

At the World Bank, a similar empirical agenda to measure management practices across governments has flourished in the past decade. The World Bank's Bureaucracy Lab surveys public servants, providing evidence-based insights on management practices in the public sector. A key takeaway from a growing body of evidence is that the quality of management varies across institutions in the same government, confirming findings from qualitative research on islands of excellence.^d This within-government variation in governance has implications for institutional performance. A recent survey of public schools in Lithuania, for instance, finds that schools with a higher quality of management are better able to support their students' mental health.^e The Global Survey of Public Servants, a research initiative undertaken by a consortium of the World Bank and academic institutions, makes available a globally comparable data set on management practices more broadly and management of human resources management in particular.^f

Source: WDR 2025 team.

- a. Bloom and Van Reenen (2007); Bloom et al. (2010); Scur et al. (2024).
- b. For more information, refer to World Bank Enterprise Surveys (dashboard), World Bank, <https://www.enterprisesurveys.org/en/enterprisesurveys>.
- c. Bloom et al. (2015). In particular, a one-standard-deviation increase in scores on a management practices index is correlated with a 0.425-standard-deviation increase in pupil achievement, measured as the percentage of pupils who pass subject examinations and achieve overall and subject-specific examination scores.
- d. Schuster et al. (2023).
- e. World Bank (2022).
- f. For more information, refer to Global Survey of Public Servants, Bureaucracy Lab, Development Impact Group and Governance Global Practice, World Bank, <https://www.global-survey-of-public-servants.org/>.

Building on its definition of governance, this chapter defines “governance standards” as the set of standards that codify measurements and procedural requirements that shape how public institutions manage core organizational functions. The chapter focuses on the three core organizational functions noted earlier in the chapter: payments, personnel, and procurement.¹² Each of these functions is commonplace, and how well they are managed shapes institutional capacity, defined here as the ability of governments to implement their policy commitments.¹³ Governance standards thus codify measurements and procedural

requirements that shape the organizations, systems, and people responsible for policy implementation (refer to chapter 2).

Because adherence to governance standards is often mandatory, they are a subset of laws and policies, in the sense that they set specific rules for the “how” of implementation rather than the “what” of policy. For example, in budget management, a law can incorporate a standard that requires government financial reports to be prepared by budget offices located in government entities and published annually. As the discussion here implies,

standards support the routine application of practices at the level of public institutions, understood here as the formal organizations in the public sector responsible for the implementation of policies. This perspective complements the focus in *World Development Report 2017: Governance and the Law*, which emphasized the governance of the policy arena, particularly the power asymmetries among actors who decide what policies are to be implemented.¹⁴

Size and diversity of the public sector

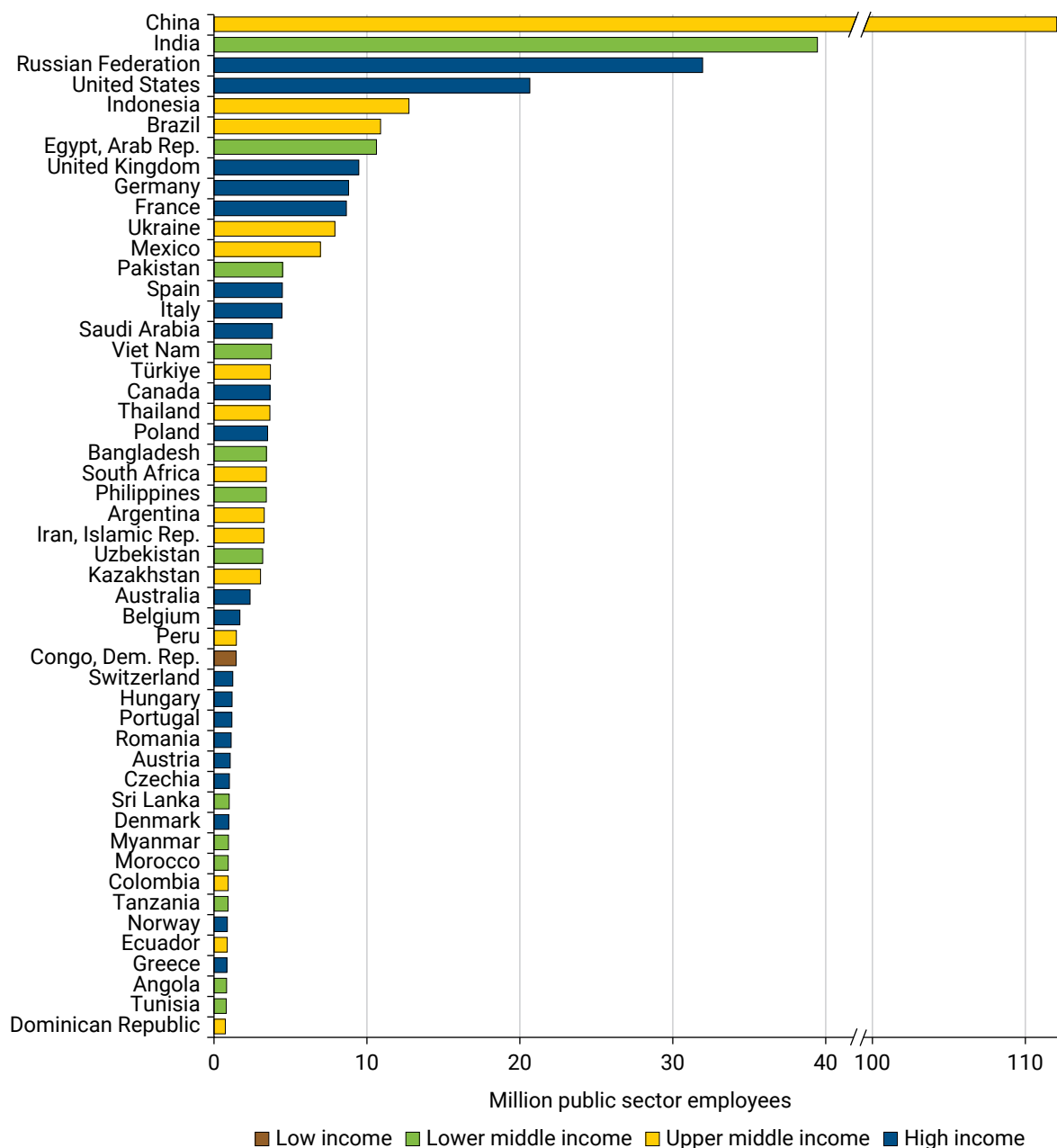
One of the challenges in implementing governance standards is the scale of the public sector itself.¹⁵ The public sector employs 373 million workers across the world, according to World Bank estimates from the Worldwide Bureaucracy Indicators.¹⁶ The 50 largest public sectors account for 361 million public sector employees, or 97 percent of public sector employment across the globe (refer to figure 7.2). Compounding the challenge of scale, the relative size of a country's public sector grows with its level of economic development (refer to figure 7.3). As public sectors grow, governance standards adequate for those of smaller scale break down. For example, a hiring manager can reasonably evaluate five candidates through a job interview. However, if the number of candidates is much larger, the same recruitment standard (that is, a job interview) is no longer feasible. The term “bureaucratic overload” describes contexts in which bureaucracies are unable to keep up with the volume of organizational processes they have to manage.¹⁷ This results in a decline in the quality of organizational governance, which in turn reduces institutional capacity to implement policies.

Addressing challenges related to bureaucratic overload rarely requires governments to codify innovative standards for governance. For example,

the international development community has for many decades recommended governance standards such as those related to recruiting candidates through competitive examinations, preparing and publishing annual financial reports, and organizing competitive auctions for procurement.¹⁸ The challenge for governments, rather, is to ensure that the many institutions and people in the public sector put governance standards into practice. That means getting the basics right, consistently and at scale. For instance, evidence collected through surveys of public servants shows that many countries struggle with applying recruitment standards consistently. Indeed, implementation of standards requiring examination-based recruitment can vary from institution to institution within the same government (refer to figure 7.4). According to these surveys, whereas in Brazil's federal government, for instance, public institutions have consistently implemented examination-based recruitment, other governments display greater variation in translating this standard into practice.¹⁹

There is growing evidence that standards enable better governance by enhancing transparency and codifying practices for institutions and personnel to use in common and repeatedly. In particular, *measurement standards* codify a consistent set of classifications and measurement approaches (rulers) that inform organizational management, thus playing a foundational role in evidence-based policy making.²⁰ Just measuring, however, is not enough.²¹ Governments should improve the quality of governance in the public sector by codifying standards that enhance the quality of organizational processes themselves. *Quality standards* codify how public institutions and personnel should manage institutional processes (rules).²² As highlighted in the conceptual framework in chapter 2, quality standards enable the diffusion of good practices, reducing the need to reinvent the wheel and enhancing the quality of governance of organizational processes.

Figure 7.2 The world's 50 largest public sectors employ more than 360 million workers

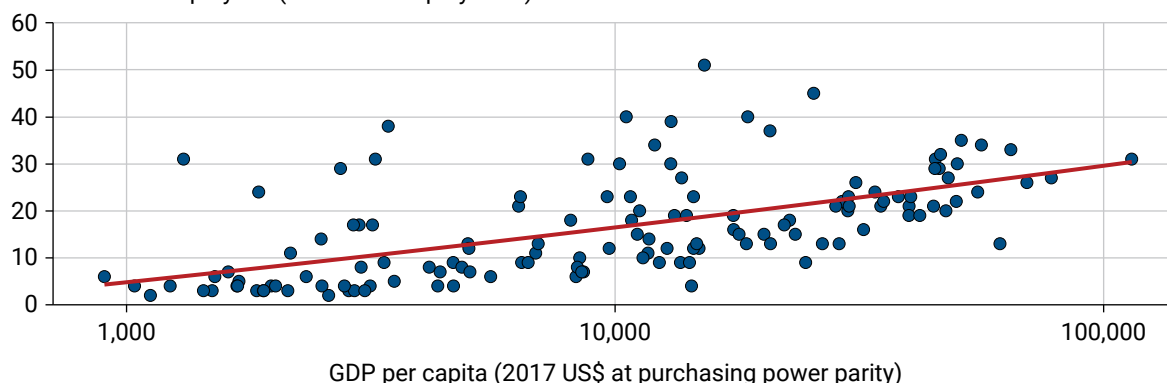


Sources: WDR 2025 team calculations, based on data from Prosperity (dashboard), World Bank, <https://data360.worldbank.org/en/prosperity>; Worldwide Bureaucracy Indicators (dashboard), World Bank, <https://datacatalog.worldbank.org/search/dataset/0038132/Worldwide-Bureaucracy-Indicators>.

Note: The figure reports the latest data available by country. The overall size of public sector employment in a country is the share of public sector employment in total employment times the overall size of the country's labor force, with the unemployment rate accounted for. A country's public sector is the general government and public, or state-owned, enterprises and consists of all institutional units controlled directly or indirectly by the country's central and subnational governments as well as public corporations that are engaged in market-based activities. Income groups are based on World Bank classifications updated in 2025. The share of public sector employment is estimated based on labor force and household surveys harmonized in the World Bank's Worldwide Bureaucracy Indicators. The overall size of the labor force is provided through World Bank education statistics. The unemployment rate is measured in World Bank data on the Sustainable Development Goals.

Figure 7.3 The public sector is relatively larger in more highly developed countries

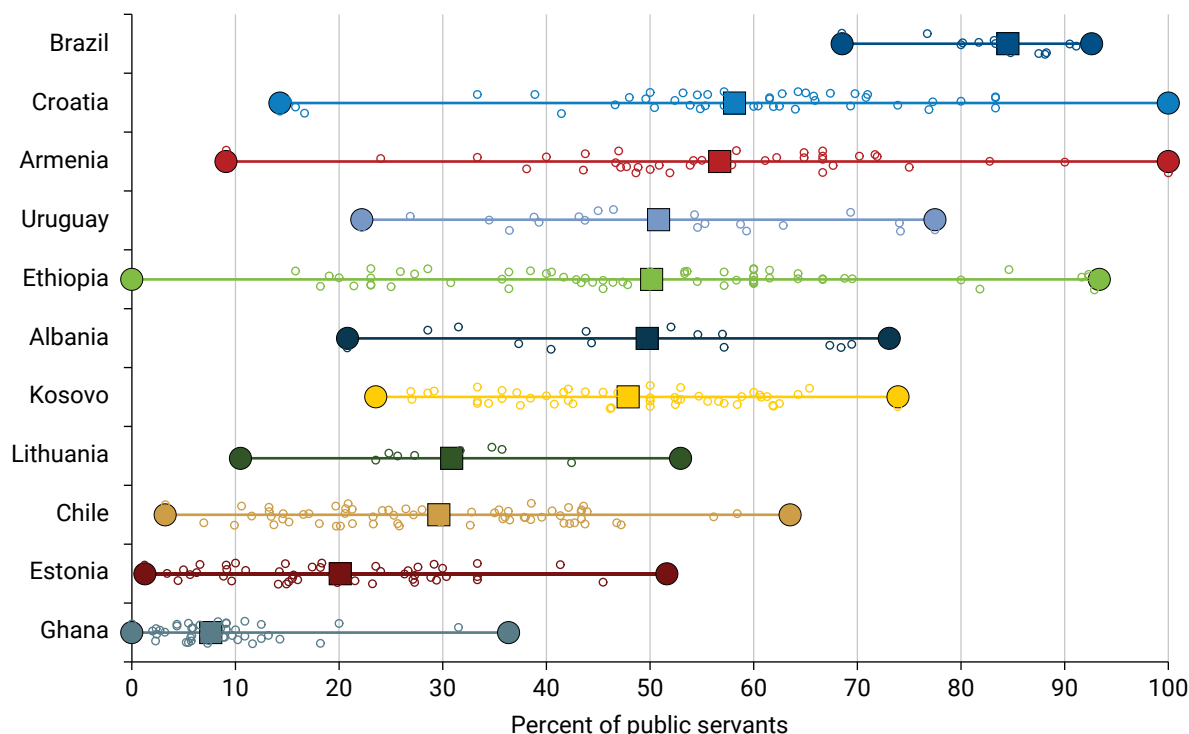
Public sector employees (% of total employment)



Sources: WDR 2025 team calculations, based on data from Prosperity (dashboard), World Bank, <https://data360.worldbank.org/en/prosperity>; Worldwide Bureaucracy Indicators (dashboard), World Bank, <https://datacatalog.worldbank.org/search/dataset/0038132/Worldwide-Bureaucracy-Indicators>.

Note: The figure reports latest data available by country. The share of public sector employment in a country is calculated as the total number of public sector employees in the country divided by the country's total employment. The red line represents the best-fit curve using a quadratic function.

Figure 7.4 Within the same government, public institutions often vary widely in the degree to which they recruit candidates using standardized, merit-based written examinations



Source: WDR 2025 team calculations, based on data from Global Survey of Public Servants, Data Downloads, Bureaucracy Lab, Development Impact Group and Governance Global Practice, World Bank, <https://www.globalsurveyofpublicservants.org/data-downloads>.

Note: The figure reports the latest data available by country. Each small hollow circle in the figure represents an organization-level share of respondents in a particular country who were selected through a written examination, whereas the range of each horizontal line indicates the minimum and maximum shares (large bullets) observed in organizations in that country. The blocks represent national average shares at the organizational level.

Leveraging standards for better governance

Governments and their institutions are partly blind to their own organizational structures and processes, particularly when they lack “a measure, a metric, that would allow [them] to ‘translate’ what [they know] into a common standard necessary for a synoptic view.”²³ Governance standards provide standard classifications and measurements that increase the transparency of the public sector and its organizational processes. This addresses the problem of information asymmetry identified in the Report’s conceptual framework (refer to chapter 2). Consider, for example, budget expenditure. Unless two public institutions classify their expenditures using a consistent approach to measurement, their expenditures cannot be compared or aggregated. In these instances, a measurement standard such as the United Nations’ Classification of the Functions of Government is useful. Such a standard establishes a consistent approach for measuring and classifying government expenditures based on their function (like education or health), helping produce information on public financial management that is precise, consistent, and comparable. A standardized approach to measurement also ensures that information is visible from higher levels of a bureaucratic hierarchy. That improves governance, because high-level managers are often distant from everyday organizational processes.²⁴

Another function of governance standards is to codify good practices and make them available for common and repeated use, organizing the functioning of the public sector. Such standards—quality standards—codify procedural requirements and guidelines for organizational processes that public institutions and their personnel carry out.²⁵ For example, a procurement standard can specify that procurement tenders must involve a competitive bidding process.²⁶ Codification of quality standards makes management practices available for common and repeated use, facilitating their diffusion and, as a consequence, institutional learning regarding management practices.

Quality standards address organizational risks such as corruption. For example, the routine publication of procurement tenders through electronic procurement systems enables governments and firms to analyze in real time the transactions that procurement offices engage in and track potential misconduct. Studies have found that such practices are associated with reductions in corruption in procurement.²⁷

The vision of better organizational governance based on standards presented here traces its origins to the Second Industrial Revolution. In that time period, a concerted effort to standardize manufacturing, codifying standards that improve production processes, drove efficiency gains in manufacturing firms (for recent examples from the East Asian miracles, refer to spotlight 1). This effort found an intellectual movement in the *The Principles of Scientific Management*, authored by Frederick Taylor.²⁸ A guiding principle in this movement was to transition away from management by rule of thumb.²⁹ Rule-of-thumb management is characterized by decisions based primarily on the individual knowledge and authority of decision-makers. The limitation of such an approach is that rules of thumb are based on heuristics that are personal, which can lead to inconsistencies and biases.³⁰ In some cases, such an approach also personally benefits those with the power to make decisions with their “thumbs.” In contrast, governance based on standards relies on codified rulers and rules: classifications, measurements, and good practices that are written down and tested. As Taylor puts it, a standards-based approach to governance enables governments to apply “standard implements and methods which represent the best knowledge of the world up to date, [enabling] originality and ingenuity to make *real additions to the world’s knowledge, instead of reinventing things which are old.*”³¹

A Taylorist approach to organizational management can be counterproductive, however, when pushed to the extreme. Taylor often assumed there was one best standard for specific production techniques (such as how to carry pig iron), which

is rarely the case in complex organizational contexts such as the public sector. Instead, it might be better to consider a choice among multiple good options rather than a single best. Nor does recent empirical evidence on management bear out that workers should simply follow the direct orders of their managers, without room for agency.³² Instead, governance should leverage standards as tools for public institutions and their personnel to use, while preserving space for autonomy and judgment.³³ These critiques notwithstanding, the scientific management movement carved space for rethinking how to approach organizational management: an approach less based on rule-of-thumb authority and experience and more reliant on standards that codify measurements, empirical testing, and continuous improvement of organizational functioning.

Governance standards primarily reshape *how* public institutions are managed and operate,

not necessarily what policies they are mandated to implement and what goods and services they are required to offer. This chapter's emphasis on implementation rather than policy making complements *World Development Report 2017*, which outlines how reforming the policy arena—that is, the political and social settings in which individuals and groups interact—can reduce power asymmetries and improve both the design and implementation of policies.³⁴ The policy arena determines the process through which the content of policies is set. Governance standards, on the other hand, determine how the responsible institutions and people will put policies into practice (refer to box 7.2). As such, this chapter reconnects with a strand of literature on governance explored in *World Development Report 1997: The State in a Changing World*, bringing to the fore the operational underpinnings of the state and the issues relating to institutional capacity that constrain it.³⁵

Box 7.2 How standards enable strategic policies to be implemented

Governments often adopt policies that set broad objectives, such as gender policies that seek to reduce disparities between men and women in education, employment, or access to public services and promote equality among genders. However, turning policy commitments into concrete outcomes requires operational standards that guide day-to-day implementation. These include specific procedures, responsibilities, and measurement tools that translate high-level goals into institutional action.

Gender budgeting provides an example of how standards can help put policies into practice. In Canada, mandatory use of Gender-Based Analysis Plus across federal departments supports the government's strategic commitment to gender equality. This operational tool requires Canada's ministries to assess how budget proposals affect different groups of women, men, and gender-diverse people. The findings inform resource allocation and are published annually in the federal *Gender Report*, ensuring that strategic goals are embedded in concrete budget decisions.^a Budget 2024, the fifth consecutive budget for which the *Gender Report* has been published, used Gender-Based Analysis Plus to assess the effects of more than 70 percent of the new budget measures included in the budget in the early or middle stages, and it leveraged

(Box continues next page)

Box 7.2 How standards enable strategic policies to be implemented (continued)

existing analysis in regard to at least another 12 percent.^b In Mexico, the federal government has made significant progress in instituting gender-based budgeting.^c This includes an explicit recognition of gender equality as a budget principle in the country's Federal Budget and Fiscal Responsibility Law. The country's Ministry of Finance issues budgetary guidelines for integrating gender perspectives into policies and programs, as well as preparing reports on budget execution that disaggregate program beneficiaries by gender.

Empirical studies have focused on the adoption of gender budgeting, and rigorous evaluations of the impact of gender budgeting on outcomes (such as gender disparities and accountability) are limited.^d Evaluation of the effects of gender budgeting on outcomes such as gender inequality in access to health services requires greater access to granular survey and administrative data that allows effects to be disaggregated by gender.

Source: WDR 2025 team.

a. WAGE (2025).

b. Department of Finance Canada (2024).

c. IMF (2023).

d. Polzer et al. (2023).

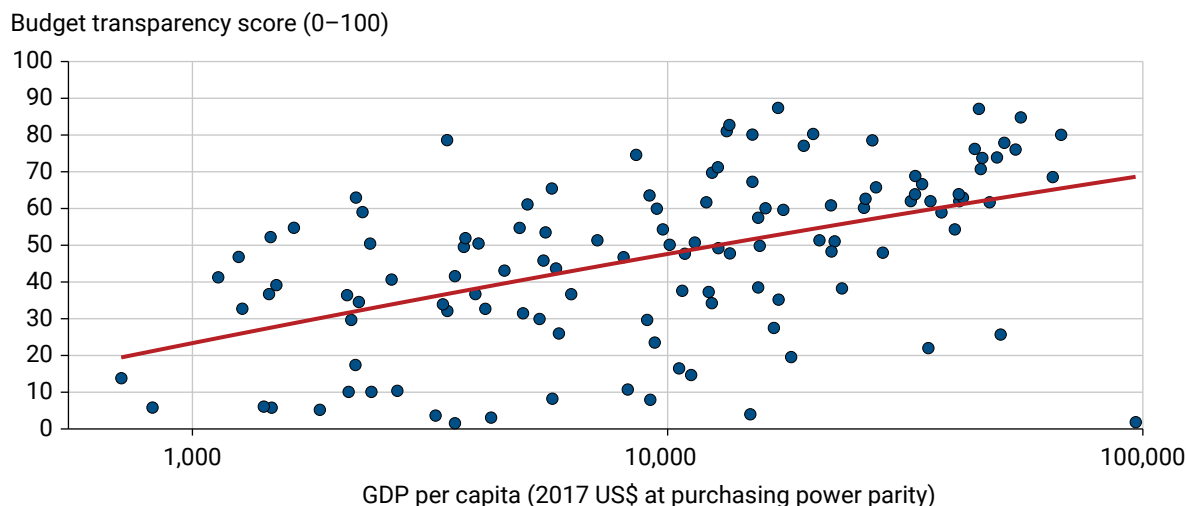
Empirical evidence on the adoption and impact of governance standards

As countries transition from low to high income, they implement governance standards more often (refer to figure 7.5). Standards that enhance budget transparency, such as the annual publication of budget documents (like budget proposals and year-end reports), are one example. For instance, Georgia, consistently rated among the top performers in the International Budget Partnership's Open Budget Survey,³⁶ publishes comprehensive fiscal documents, including a citizens' budget and regular statements regarding fiscal risk, that have bolstered public trust and fiscal discipline.³⁷ In Ukraine, the timely publication of budget execution and debt statistics aligned with international standards has enhanced transparency and has been critical in securing external financing and

sustaining market confidence during periods of instability.³⁸

A similar pattern is evident in regard to management of human resources. In particular, as countries develop, they more commonly recruit personnel through merit-based standards such as written examinations (refer to figure 7.6).³⁹ A notable example is Japan. In the 1970s, the country's Ministry of International Trade and Industry (MITI) began requiring candidates to enter the application process through a highly competitive standardized examination.⁴⁰ This examination-based recruitment practice was foundational for building the competency of personnel while strengthening MITI's autonomy in respect to political interference, a bureaucratic model that became associated with the developmental state in Japan. The Republic of Korea; Taiwan, China; and other Asian Tigers also follow this model.⁴¹

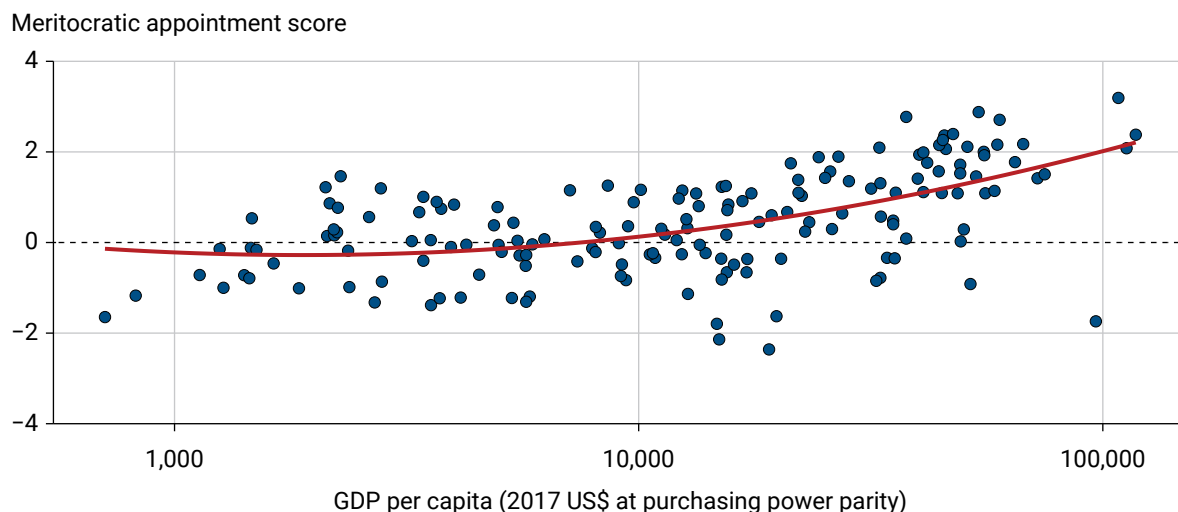
Figure 7.5 As countries develop, they put into practice more standards regarding budget transparency



Sources: WDR 2025 team calculations, based on data from Open Budget Survey (dashboard), International Budget Partnership, <https://internationalbudget.org/open-budget-survey>; Prosperity (dashboard), World Bank, <https://data360.worldbank.org/en/prosperity>.

Note: The red line represents the best-fit curve using a quadratic function. The International Budget Partnership's Open Budget Survey's budget transparency score measures the extent to which countries, in practice, make documents available to the public, as well as the comprehensiveness of the budget information provided in publicly available documents.

Figure 7.6 Highly developed countries make greater use of merit-based recruitment standards



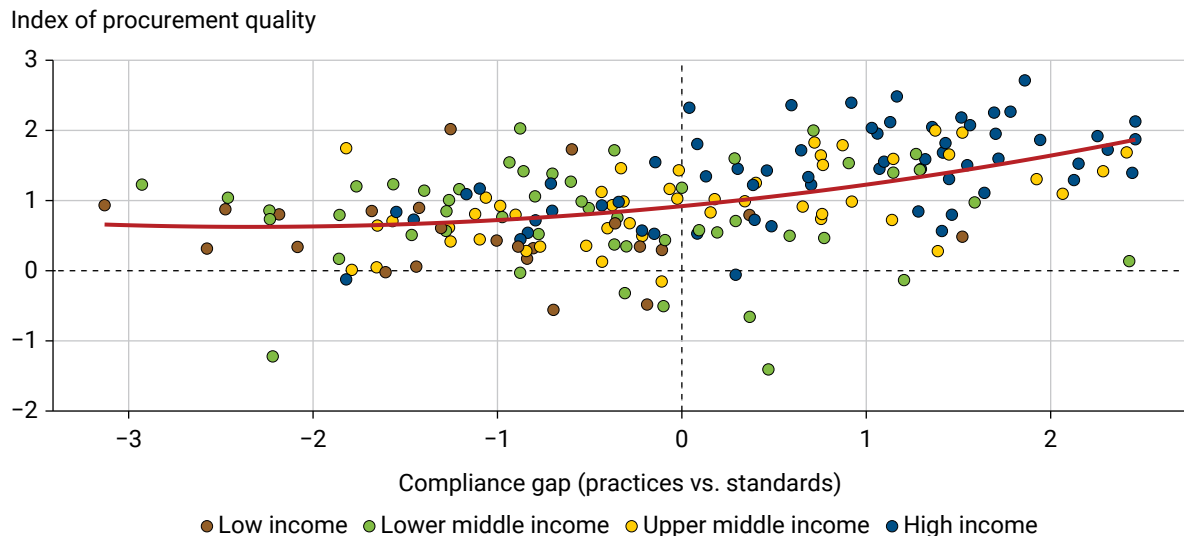
Sources: WDR 2025 team calculations, based on data from Prosperity (dashboard), World Bank, <https://data360.worldbank.org/en/prosperity>; V-Dem (Varieties of Democracy) (data set), V-Dem Institute, Department of Political Science, University of Gothenburg, <https://www.v-dem.net/data/the-v-dem-dataset/country-year-v-dem-fullothers-v14/>.

Note: Meritocratic criteria for appointment scores are based on expert-based surveys that ask the question “To what extent are appointment decisions in the state administration based on personal and political connections, as opposed to skills and merit?” Scores are computed based on a Bayesian item response theory that aggregates across expert responses. For more information on the scoring methodology, refer to V-Dem Institute (2024). The red line represents the best-fit curve using a quadratic function.

It is important to distinguish between standards and their implementation in organizational practices. That is because simply codifying standards does not mean public institutions and personnel will put them into practice. As noted in *World Development Report 2017*, countries often write stringent laws but fail to effectively reshape the practices of organizations and firms in the private sector.⁴² The same applies for the public sector. For instance, a government may set standards, in law, that require procurement entities to make documents and materials or standard contracts publicly available. In practice, however, these entities may fail to disclose these documents and contracts.⁴³ Such a mismatch between what is codified into standards and what is put into practice, or *compliance gap*, is commonplace in the management of personnel, payments, and procurement.⁴⁴

Reducing compliance gaps requires governments to move beyond isomorphic mimicry: that is, situations in which they codify governance standards into law but are unable to enforce the standards.⁴⁵ For example, a government might pass an administrative law that codifies transparency standards, such as a requirement for annual publication of a budget report, but struggle to publish such reports annually and at scale. Similarly, recruitment standards may require candidates to be assessed through a written examination, but public institutions may fall short of applying this standard in practice. Reducing such compliance gaps is beneficial. In public procurement, governments with a smaller gap between practices and standards in procurement tend to have reduced delays in implementation, reduced cost overruns, and better overall project quality (refer to figure 7.7).

Figure 7.7 Reducing the compliance gap improves the quality of government procurement



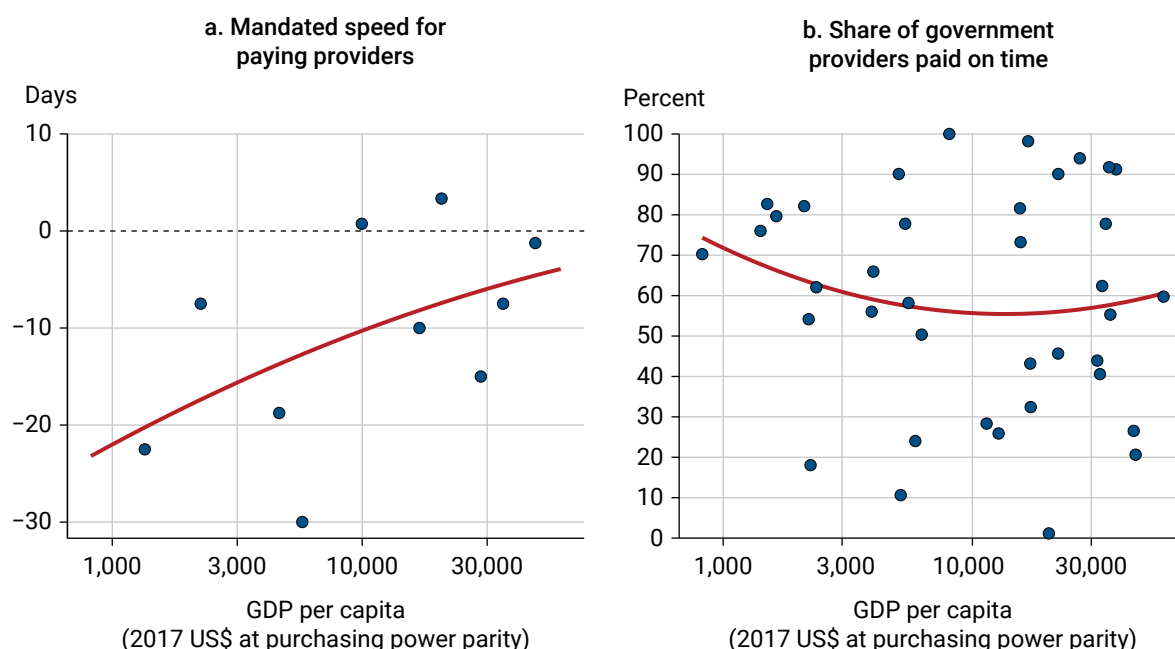
Sources: WDR 2025 team calculations, based on data from Bosio et al. 2022; Data and Code for Public Procurement in Law and Practice, OPENICPSR, Inter-University Consortium for Political and Social Research, Institute for Social Research, University of Michigan, <https://www.openicpsr.org/openicpsr/project/153181/version/V1/view>.

Note: The index of procurement quality used in the figure measures time to commence work, budget overruns, and overall quality of projects. "Practices" and "standards" measure different aspects of managing procurement processes, including transparency, competition, limits to exclusion, and integrity of contract. Higher scores on the index indicate a smaller compliance gap, with positive scores indicating practice scores greater than codified standards, and negative scores indicating the opposite. The red line represents the best-fit curve using a quadratic function. Income groups are based on World Bank classifications updated in 2025 (Metreau et al. 2025).

As discussed in the conceptual framework for this Report in chapter 2 (and illustrated in figure 2.5), governments should match the ambition of their standards to their ability to put those standards into practice. This helps public institutions and personnel, as well as citizens and firms, have realistic expectations about whether standards will be upheld in practice. Figure 7.8 presents evidence that calibration of this type occurs in the area of public procurement with respect to

payments to firms that provide goods, services, and work under government contracts. As countries develop, they tend to increase the stringency of the grace periods they give themselves to pay providers, making their deadlines (in number of days) shorter (refer to figure 7.8, panel a). As a result of this adjustment, the percentage of providers paid on time remains relatively constant across levels of country income (refer to figure 7.8, panel b).

Figure 7.8 As countries develop, they shorten the grace periods government agencies have to pay providers



Sources: Panel a: WDR 2025 team calculations, based on data collected from national procurement regulations across 39 countries by the World Bank Enterprise Surveys team. Panel b: World Bank Enterprise Surveys (database), Full Survey Data, World Bank, <https://www.enterprisesurveys.org/en/enterprisesurveys>.

Note: In panel a, the speed mandated for paying providers under a country's procurement rules is defined as 30 days minus the maximum number of days allowed based on the national regulation; thus higher scores indicate shorter payment deadlines. Bullets correspond to binned stringency averages by deciles based on GDP per capita. Panel b reports, as a measure of compliance with the grace periods mandated in national procurement rules, the percentage of firms in a country that had a government contract that were paid on time. Whereas data from the World Bank Enterprise Surveys correspond to 2025, data on GDP per capita correspond to 2022, the latest year for which data are available. The red lines represent the best-fit curve using a quadratic function.

Reducing corruption and organizational mismanagement through governance standards

Governance based on standards reduces two types of organizational waste: that resulting from corruption and that resulting from organizational mismanagement.⁴⁶ The first of these results when public institutions and people generate waste by personally benefiting from public office.⁴⁷ For example, in the absence of recruitment standards, managers can appoint personnel who are loyal but incompetent, embezzle public funds, and award procurement contracts to politically connected firms. Waste through organizational mismanagement, in contrast, does not personally benefit any organization or people. Rather, it results from management that is of low quality, because institutions and people lack the proper information or technical know-how. For example, public officials might delay the processing of an application for social security because they simply forget about it or pay higher prices for procurement because they lack the skills to search effectively for contractors with better rates.⁴⁸

Corruption is particularly salient in the management of payments and procurement, in which organizations and their staff members can directly benefit from public funds. The lack of robust budget standards heightens the risk of financial malpractice such as embezzlement or fraud. In a study conducted in Indonesia, financial reports produced by the responsible entities failed to account for 24 percent of road construction costs, with evidence of corruption in the form of embezzlement.⁴⁹ Rooting out corruption in procurement presents particular challenges because contractors may collude with one another to secure government contracts.⁵⁰ A study of procurement auctions found evidence of collusion by construction firms in projects

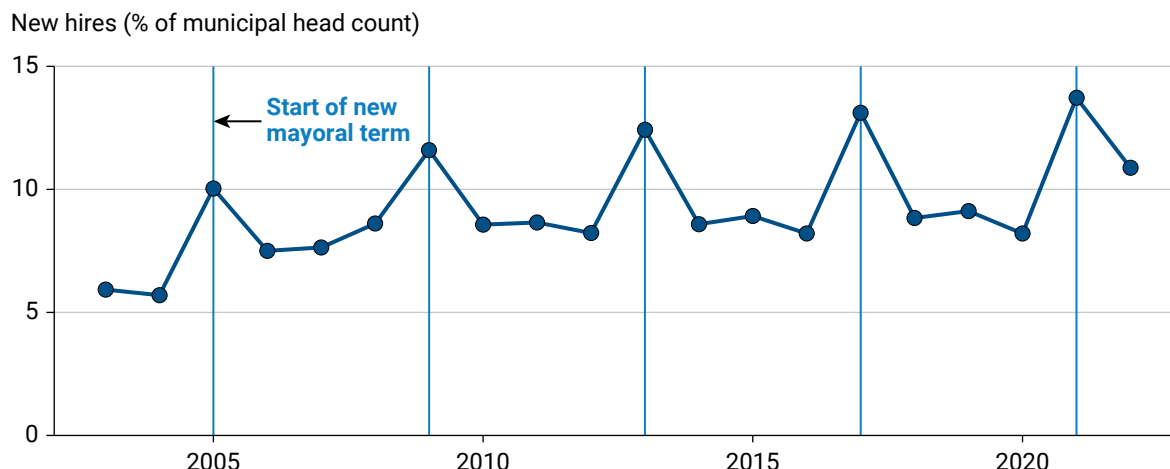
from Japan's Ministry of Land, Infrastructure, Transport, and Tourism; bidding patterns indicated likely coordination among firms for 37 percent of analyzed projects.⁵¹

In management of human resources, corruption takes place through patronage, when policy makers and other senior-level officials recruit loyalists to extract personal gains from office and further their careers. This practice is commonplace in both developed and developing countries.⁵² For example, in municipal-level governments in Brazil, campaign donors and copartisans of elected mayors are more likely to be employed in the public sector after the mayors take office.⁵³ Spoils systems of this type go beyond cabinet positions, affecting recruitment in the municipal government as a whole. Hiring spikes at the start of mayoral terms, in cycles of political and bureaucratic turnover, reflect such recruitment patterns (refer to figure 7.9).⁵⁴

Personnel recruited through patronage channels tend to be less competent.⁵⁵ They also generally have lower levels of education than are required for their roles, and workers transitioning from the private to the public sector tend to have lower skills than their counterparts.

As noted earlier, in contrast to corruption, organizational mismanagement does not directly benefit any official or organization in the public sector. For example, budget officers may intend to produce consistent financial reports but lack standardized forms for doing so, resulting in financial data that are inconsistent and unreliable.⁵⁶ This inconsistency and lack of reliability limits management's and stakeholders' ability to obtain a clear and accurate overview of the public sector's financial system, leading to misinformed decisions related to budget management. For example, before Nigeria adopted a Treasury Single Account, the lack of standardized practices for reporting across ministries, departments, and agencies led to fragmented data and duplicate accounts, making

Figure 7.9 Hiring in municipal governments of Brazil rises and falls around elections



Source: WDR 2025 team calculations, based on data from *Relação Anual de Informações Sociais [Annual Report of Social Information]*, Labor Secretariat, Ministry of the Economy of Brazil, made available by Data Basis (Dahis et al. 2022).

Note: The share of new hires (as a percentage of head count) for municipal governments of Brazil is weighted by the total municipal head count. Vertical blue lines indicate the start of a new mayoral term (for example, 2005–09).

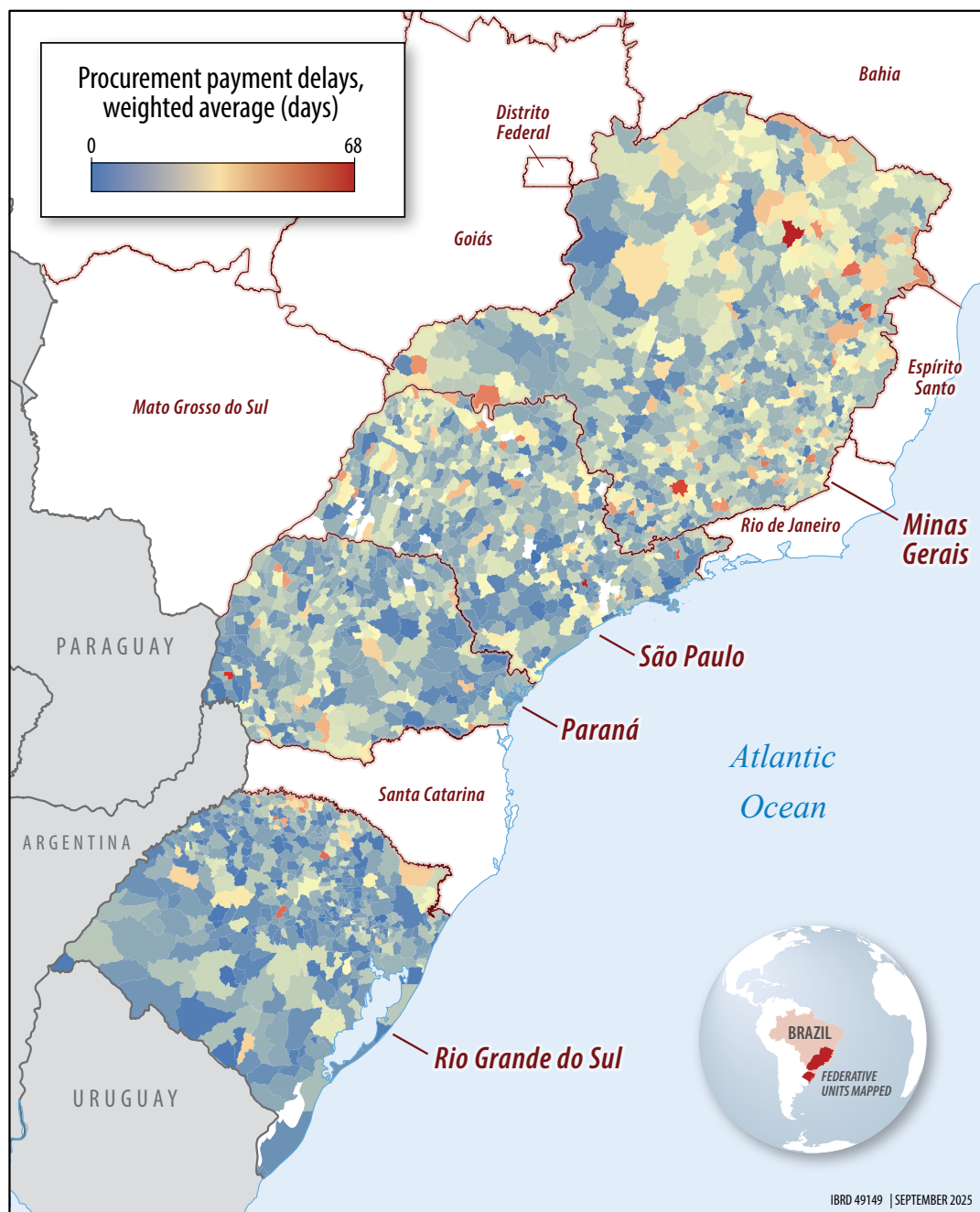
it difficult to reconcile financial information and detect leakages.⁵⁷ Establishing a unified accounting standard for the Treasury improved the quality of reporting and reduced fiscal risks.

In procurement, mismanagement often manifests itself in the form of high prices and procurement delays. Evidence from a study on procurement in Italy suggests that most variation in prices in procurement actions is due to mismanagement, not corruption.⁵⁸ Procurement officers simply lack the expertise and know-how to secure lower prices for procured goods and services. In the federal government of the United States, an analysis of more than 122,000 completed projects found that whereas the average expected duration was 244 days in procurement contracts, projects themselves, including implementation delays, actually

lasted 486 days, on average.⁵⁹ In addition, overruns increased costs from an initial award price of US\$65.2 billion to US\$103.9 billion.⁶⁰

Time from procurement to payment also varies across institutions within the same country. In Brazil, municipal governments decide how to procure goods and services. Although national law requires them to pay contractors within 30 days of billing for services or goods provided, 15 percent of all payments do not comply with that standard.⁶¹ This municipal-level variation in the speed with which payments are made is substantial (refer to map 7.1). Budget standards can reduce this type of organizational mismanagement, ensuring that commitment amounts are properly tracked and payments to contractors are made on time.

Map 7.1 Municipal governments in Brazil vary in the speed with which they pay for goods and services procured



Sources: WDR 2025 team calculations, based on data from Dahis et al. 2023; Reproducibility Package for MiDES: New Data and Facts from Local Procurement and Budget Execution in Brazil (Reproducible Research Repository), World Bank, <https://reproducibility.worldbank.org/catalog/72>.

Note: Colors vary from blue (high speed) to red (low speed) to show increases in the average number of days municipal governments take to pay their contractors. The averages are weighted, at the tender level, by the monetary size of the commitment. Data on municipal-level procurement were collected for the states of Minas Gerais, Paraná, Rio Grande do Sul, and São Paulo. White areas indicate locations for which no data were collected.

Standards increase transparency and reduce information asymmetries

Governance standards improve the accuracy and availability of information on organizational processes, strengthening transparency and reducing information asymmetries. For example, budget standards ensure consistency in how budget processes are measured across organizations in the public sector.⁶² In the absence of standards, different departments may use varying formats, definitions, and measurements to prepare their budgets, which can lead to confusion, errors, and inconsistencies. Standards reduce this type of variation by establishing a unified approach, requiring organizations to use the same templates, budget categories, naming conventions, and reporting schedules.⁶³ For instance, in Tunisia, reforms under the Organic Law on the State Budget (*Loi Organique du Budget de l'État*) introduced a common framework for measurement and standardized indicators across ministries, which increase the comparability and improve the quality of expenditure tracking.⁶⁴ The consistency provided by the framework and indicators ensures that financial data collected from various sources can be compiled, compared, and analyzed without extensive reformatting or clarification.

Accounting standards enable transparent and reliable financial reporting, a foundational principle for budget governance. An example of global accounting standards is the International Public Sector Accounting Standards (IPSAS), issued by the IPSAS Board, which provide a comprehensive framework for preparing financial statements on an accrual basis.⁶⁵ As of 2020, 49 countries had adopted standards for accounting on an accrual basis.⁶⁶ Implementation of IPSAS increases investor

confidence by ensuring that governments offer a more accurate and comprehensive picture of their financial positions.⁶⁷ Accounting standards can also be leveraged to strengthen the corporate governance of state-owned enterprises, improving their financial performance and service delivery. The Organisation for Economic Co-operation and Development (OECD) Guidelines on Corporate Governance of State-Owned Enterprises provide international standards in this area.⁶⁸ These standards strengthen the ownership role of government and increase transparency by requiring publication of regular portfolio reports and audited financial statements. The guidelines also call for the application of strong standards for accounting and reporting, including sustainability reporting, in state-owned enterprises.

Establishing measurement standards also enhances the planning functions of government and enables it to be more forward looking. For example, when they measure budgetary processes using standardized methods, governments are able to forecast budget revenues and expenditures.⁶⁹ That is because these methods enable them to consolidate and analyze data to project costs, revenues, and resource needs.⁷⁰ Over time, such a forward-looking approach enables strategic financial planning and results in fewer unexpected budget shortfalls, reducing organizational mismanagement. In March 2025, the United Nations Statistical Commission unanimously recommended that member countries adopt the most recent update of its System of National Accounts.⁷¹ The system, used as the global standard for national accounts, sets benchmarks for defining key economic indicators such as GDP. Significantly, the most recent revision of the system incorporates important advances in accounting for natural resources and other aspects of sustainability.

Procurement often involves information asymmetries, because contractors have more information on the value of their goods and services than procurement entities and officers have. This asymmetry, in turn, generates uncertainty in price negotiation between contractors and procurement officers. Electronic government procurement systems—with standardized measurements and classifications (for prices, goods, and services, among other things) that are consistent and comparable across procurement transactions—are important tools that reduce information asymmetries and enhance the transparency of the procurement process.⁷² Leveraging standards for measurement in procurement can lead to efficiency gains. In Brazil, for instance, the subnational government of Rio Grande do Sul calculated market-based reference prices on medicines, as reflected in electronic invoices for business-to-business transactions in the state.⁷³ These reference prices were then provided as information to multiple procurement officers, who used the prices as inputs to set their own reference prices for auctions during the tendering process. The adoption of this novel procurement practice, enabled through measurement standards, empowered procurement officers to set more competitive prices, as well as shifting relationships away from contractors who charged more for their medicines than the government's reference prices supported.

Standards codify and diffuse good practices that improve organizational efficiency and effectiveness

Putting quality standards into practice increases institutional capacity. For example, recruitment standards such as those implied in civil service examinations improve both the efficiency and effectiveness of public services. In Brazil,

prospective judges are required to complete written and oral examinations that assess their knowledge of existing law, as well as the quality of the judicial decisions they might make.⁷⁴ Candidates are ranked according to their examination scores; top performers are selected based on the number of available positions.⁷⁵ Judges who score higher on the examinations perform better in their judicial duties, resolving a higher volume of cases without reducing the quality of their rulings.⁷⁶ In Colombia, college students graduating from professional programs, such as those intended to prepare students to be physicians, must complete a standardized examination that assesses their professional skills. Novice physicians who score higher in the health-specific modules of their examinations are generally more competent and deliver better health care services, particularly in the area of reducing health complications at birth among vulnerable mothers.⁷⁷

Beyond the recruiting of competent personnel, quality standards can also increase the efficiency and effectiveness of procurement processes. A study of public procurement in the Russian Federation found that individual procurement officers and organizations explained 39 percent of the variation in procurement prices.⁷⁸ In particular, *how* the procurement process was managed drove the variation. Procurement officers and organizations who adhered to quality standards in the procurement process were able to procure goods and services at better prices. During the tendering process, more effective procurement officers and entities completed documentation accurately, specifying both product names and classification codes correctly more often; conducted more auctions; and recruited larger pools of bidders. Beyond improving operational efficiency, standards can also strengthen the effectiveness of government, ensuring that organizational processes support policy priorities more broadly (refer to box 7.3).

Box 7.3 Putting environmental standards into action: Green budgeting in France and green procurement around the world

The introduction of a green budgeting framework in 2021 marked a major shift in France.^a Since then, all budget programs at the national level have been systematically assessed for their impacts on climate and the environment using a standardized methodology inspired by the European Union's classification system.^b Expenditures are categorized as positive (contributing significantly to climate-related or environmental objectives), neutral (having no significant climate-related or environmental impacts), negative (having potentially harmful effects on the climate, the environment, or both), or mixed (including both positive and negative components). The classification standard embedded in the categorization scheme supports more informed decisions related to budgeting and greater coherence between the budget and the broader strategy of attaining climate and environmental goals. Between 2023 and 2024, environmental expenditures categorized as positive increased from €32 billion to €38.6 billion, and expenditures deemed mixed rose from €2.7 billion to €3.1 billion.^c

In the area of procurement, an emerging set of standards is referred to as “green public procurement.” There is growing evidence that environmental standards of this type have positive effects on firms. A recent study in the United States finds that obtaining green contracts reduces emissions relative to firm size, even in the long term.^d Those firms that have higher revenues from green contracts reduce their emissions more (13 percent versus 4.6 percent) than those with lower revenues from such contracts. A study of German firms finds that the probability a small or medium enterprise will introduce green-friendly products increases by 20 percentage points if the firm is awarded a contract using environmental criteria for selection and by 25 percentage points if it wins green contracts.^e

Many countries face difficulties in implementing green public procurement because they lack consistent standards for doing so. The World Bank and international development partners have played an important role in the design and implementation of policies for green public procurement in a number of countries across regions, helping set up and codify standards that define the scope of green procurement, as well as designing and detailing steps to roll out the standards.^f Areas covered include how to set criteria for selecting the product used to pilot the standards, develop a monitoring system to track compliance with the standards and measure the system's effectiveness, and embed standards for green procurement within an existing electronic government procurement system.

Source: WDR 2025 team.

a. MEFSIN (2020).

b. EU (2020).

c. MEFSIN (2023).

d. Chiappinelli et al. (2025).

e. Krieger and Zipperer (2022).

f. World Bank (2021a).

Performance management integrates both measurement standards and quality standards

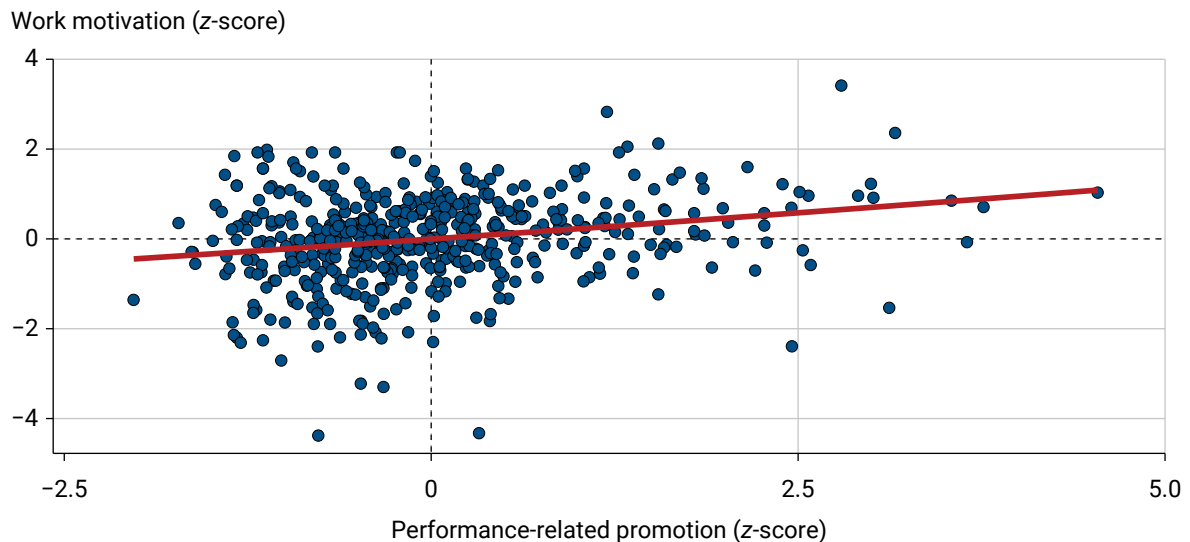
Performance management integrates elements of both measurement and quality standards, offering a useful tool for enhancing organizational efficiency and effectiveness. A key feature of performance management is the codification of measurement standards (such as key performance indicators) and incentives that can help organizations and personnel continuously improve the quality of their practices by linking their actions to measurable results. Performance standards also ensure that organizations and personnel understand what tasks align with organizational goals and policy priorities, as well as how their own performance will be measured.⁷⁹ In addition, performance standards set mechanisms to make personnel accountable for either achieving or falling short of expected results.⁸⁰

Performance-based budgeting codifies targets for service delivery, efficiency benchmarks, and quality metrics to inform budget management. Integrating performance measurement into budget processes significantly enhances public sector performance, particularly when linked to strategic planning and evaluation systems.⁸¹ Experiences of individual countries support these findings. For instance, Malaysia's outcome-based budgeting framework ties ministry budgets to specific outputs and outcomes,⁸² and Chile's evaluation-driven budgeting approach uses program performance to guide adjustments and institutional reform.⁸³

Performance management can also be leveraged to grant greater autonomy to public institutions in how they allocate funds, so long as they meet performance targets. Such an arrangement encourages a balance between autonomy and control, granting managers the space to adapt operations while ensuring transparency through results monitoring. For example, a study conducted in Zambia found that performance-based budgeting led to increases in self-reported autonomy of health facilities driven by improved choice regarding what health care services to provide.⁸⁴

In management of human resources, performance standards increase the accountability of personnel and make institutional goals transparent to them.⁸⁵ Empirical evidence suggests that public servants generally welcome performance management, particularly when evaluations are linked to incentives such as payments and promotions.⁸⁶ A study conducted in the province of Punjab, Pakistan, found that the introduction of performance pay for tax collectors based on revenues generated led to an increase in collection of tax revenue by about 40 percent after two years.⁸⁷ In the Indian state of Andhra Pradesh, a study found that giving teachers financial bonuses based on improvements in student test scores increased learning outcomes both in subjects that the incentives targeted (such as mathematics and language) and in subjects that they did not (such as science and social studies).⁸⁸ There is also evidence that performance management positively affects the mission orientation and work motivation of personnel.⁸⁹ For example, public institutions that more frequently reward high performance with promotions also show greater motivation among workers (refer to figure 7.10).⁹⁰

Figure 7.10 Public servants have higher levels of motivation in public institutions with stronger performance-based incentives



Source: WDR 2025 team calculations, based on data from Global Survey of Public Servants, Data Downloads, Bureaucracy Lab, Development Impact Group and Governance Global Practice, World Bank, <https://www.globalsurveyofpublicservants.org/data-downloads>.

Note: Values are z-scores, computed based on the share of survey respondents who agree that they feel motivated to work and that performance has a positive impact on promotions. Shares are converted into z-scores by subtracting the mean and dividing by the standard deviation of agency level responses for each economy. The red line represents the best-fit curve using a quadratic function. Survey data were collected in Albania, Brazil, Chile, Colombia, Croatia, Estonia, Ethiopia, Kosovo, and the Slovak Republic.

Standards impose administrative costs: Adjusting their stringency helps

Because standards in the public sector are primarily mandatory and enforceable by law, they often impose changes in management through coercive methods (such as audits and legal sanctions).⁹¹ This coercive aspect of standards means that they unilaterally impose costs on institutions and personnel responsible for implementing them. An administrative cost of standards is the time and effort staff members spend completing administrative tasks to document and verify that they are complying with rules (refer to box 7.4). For example, studies of time use have found that bureaucrats allocate 20–30 percent of their work time to compliance tasks such as recordkeeping.⁹²

Because failing to comply with standards involves negative consequences such as sanctions, reducing time spent on compliance is not an option.

Because work time is fixed (and scarce), time spent on compliance with procedural requirements is time not spent in the delivery of services or implementation of policies.⁹³ Excessive growth in the amount of paperwork required to document and verify compliance can paralyze governments, transforming them into “paper tigers”: powerful in writing, but ineffective in practice.⁹⁴ For example, in 2006 a leopard attacked villagers in the Himalayan town of Gopeshwar in India. Local officials took two months to comply with the paperwork required to classify the leopard as a man-eater and thus obtain the hunting permit that would allow the leopard to be legally killed.⁹⁵

Box 7.4 The administrative costs of implementing a recruitment standard in India

In India, more than 3 million candidates applied for 3,500 positions advertised by the Union Public Service Commission in 2021. Organizing an examination for millions of candidates is a complex task. At the state level, the commission relies on an extensive bureaucratic machinery to conduct examinations. These bureaus are often understaffed: in one state with a population of 240 million, 78 senior officials and 300 junior officers were responsible for the entire recruitment process. In another state, the commission had vacancies for 50 percent of its own listed positions.^a

Understaffing compromises the integrity of recruitment examinations and undermines their legitimacy to candidates. Litigation initiated by candidates, which delays the recruitment process, shows the effects of this. For instance, legal challenges can arise from the misapplication of eligibility criteria. In one example, litigants challenged a master of arts in economics as a position qualification, arguing that a master of science in economics was equivalent and could thus be accepted. Another category of challenges deals with positions reserved for members of certain castes and the validity of those reservations. Moreover, related “document verification” for selected candidates is often difficult. Educational certificates, caste certificates, and other paperwork do not incorporate standard evaluation criteria and as such require validation by individual officers. As groups get added or removed from reserved categories, the criteria evolve as well. This creates confusion in implementation, with clerical errors landing in court for weeks or months on end.

Source: Misra 2025.

a. Refer to Annual Reports (portal), Andhra Pradesh Public Service Commission, <https://portal-psc.ap.gov.in/HomePages/AnnualReports>; Recruitment Dashboard, Public Service Commission, Uttar Pradesh, <https://uppsc.up.nic.in/>.

In addition, because the institutions designing and enforcing standards as procedural requirements are different from those responsible for implementing them, such top-down standards can reduce motivation and limit agency.⁹⁶ As such, institutions that set standards should consult with public institutions that implement them, incorporating real-world experience and advice—and realistic expectations about compliance, as discussed in chapter 2 and earlier in this chapter. For example, a survey of public servants conducted in Ghana found that personnel had suggestions on how to put procedural standards into

organizational practice that could enhance their effectiveness. When implemented this way, standards create space for agency in institutions and among bureaucrats, ensuring the latter can exercise judgment in complying with rules rather than blindly complying with rules designed by others.

Indeed, there is growing evidence that adjusting the stringency of standards can improve organizational performance. A study of public servants in the federal government of Brazil, for instance, found that the relationship between organizational performance and procedural rules follows

an inverted U-curve. Too few and too many rules are both associated with lower organizational performance, whereas a moderate number of rules is conducive to better performance.⁹⁷ Another study in Ghana found that personnel who were given greater autonomy and discretion completed their assigned tasks more often.⁹⁸ This positive effect on performance was particularly strong for tasks for which it was difficult to clarify and codify targets before completion (such as complex tasks), rather than administrative tasks the completion of which was easier to verify (such as organizing a review meeting).⁹⁹ A separate study on public procurement in Pakistan found that a policy intervention that increased the autonomy of procurement officers lowered prices of procured goods by 9 percent, reduced procurement delays, and had no observable impact on the quality of purchased goods or likelihood of corruption.¹⁰⁰ The positive effects were particularly great when the senior officers responsible for overseeing procurement were likely to be corrupt.

Policy recommendations: Adaptation of governance standards based on evidence and empowerment

As the discussion in this chapter indicates, there is an abundance of standards for better governance, many enshrined in *World Development Reports* much like this one.¹⁰¹ Governments and practitioners should consider which governance standards solve specific problems they are experiencing and adapt standards to their specific institutional and national contexts. Taking an empirical approach to what standards work (or do not) and paying greater attention to the trade-offs among standards can make the growing number of standards more manageable. Such an approach also empowers public institutions and personnel who implement the standards, moving from a normative (standards as intrinsically good) to an

empirical approach in which governance standards are evaluated according to their impact on organizational functioning.

1. Consider administrative costs when adapting standards

There is a large and growing volume of standards available for governments to adopt. For instance, the 2024 edition of IPSAS comprises three volumes of a thousand pages each. Because of the volume of standards IPSAS includes, governments often exert considerable efforts to put them into practice in the public sector. Doing so can cost them time, money, resources—and foregone opportunities for other activities. When governments acknowledge such implementation costs, they can then carefully adapt standards based on evidence. The World Bank’s Public Expenditure and Financial Accountability framework offers an evidence-based approach to assessing the effective application of standards for public financial management in practice.¹⁰² The framework draws on policy reviews, data analysis, and engagement with government officials to provide a credible and evidence-based diagnostic for public financial management. Findings from application of the framework help highlight gaps between formal standards and actual implementation, supporting targeted reforms to improve the effectiveness of public financial management.¹⁰³

- Viet Nam’s government demonstrated a pragmatic approach to reform by adapting IPSAS through a tailored national framework: the Viet Nam Public Sector Accounting Standards.¹⁰⁴ Recognizing the significant implementation costs and complexity of a full-scale overhaul of accounting in the country’s public sector, the government rolled out new accounting standards gradually over multiple years. This phased implementation involved introducing different modules sequentially, from standards regarding assets to the effects of changes in foreign exchange. Institutionalizing these

standards required substantial investment in training for public sector accountants and establishing new mechanisms for monitoring, such as audits, to ensure compliance.

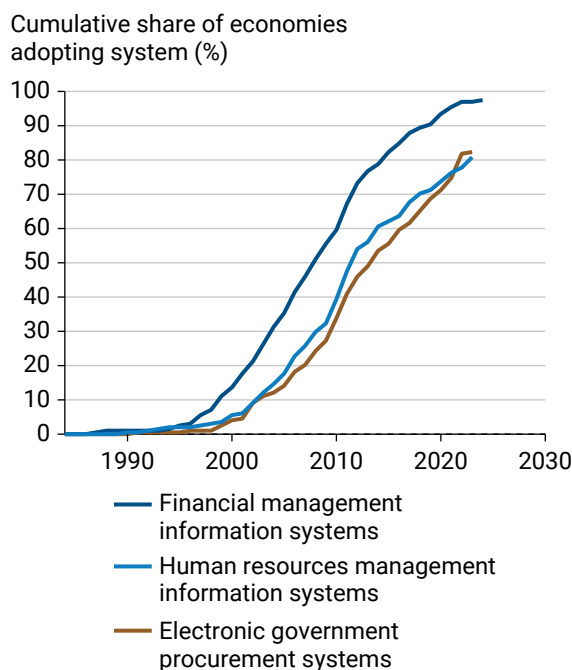
2. Leverage administrative data to gauge the effectiveness of standards

Governments are better positioned today to leverage data to evaluate the impact of governance standards on the functioning of public institutions.¹⁰⁵ This is in large part because of the proliferation of administrative data from management information systems for finance, e-government procurement, and human resources (refer to figure 7.11). This greater availability of data is enhanced by a growing global agenda to harmonize data, as exemplified by the Open Contracting Partnership's Open Contracting Data Standard, as well as standardized procurement taxonomies like the United Nations Standard Products and Services Code and the European Commission's Common Procurement Vocabulary, which enable data on procurement processes and outcomes to be collected in a standardized manner.¹⁰⁶

But just collecting reliable and standardized data is not enough; the use of data to inform diagnostics and make projections remains limited, as seen in regions like Latin America and among countries adopting standards for accounting on an accrual basis.¹⁰⁷ It is therefore critical for governments to move beyond data collection to analysis. By doing so, they can increase the information available to help them understand the real-world impact that standards have on management and performance, recognizing that governance approaches must be tailored to specific institutional and national contexts to be effective.

- In Brazil, the subnational government of Rio Grande do Sul leveraged administrative data to improve procurement outcomes. The government analyzed electronic invoices from

Figure 7.11 Management information systems for public finance, procurement, and human resources are diffusing rapidly around the world



Source: WDR 2025 team calculations, based on data from GovTech Maturity Index 2022 Update (dashboard), World Bank, <https://www.worldbank.org/en/programs/govtech/2022-gtmi>.

Note: Each curve in the figure measures the cumulative share of countries that have adopted each type of management information system. "Financial management information systems" corresponds to systems that collect information on public financial management. "Electronic government procurement systems" refers to systems that collect information on public procurement. "Human resources management information systems" shows systems that collect information on management of human resources. The data include 189 countries surveyed for the World Bank's GovTech Maturity Index initiative.

business-to-business transactions to calculate market-based reference prices for medicines. This information enabled procurement officers to set more competitive prices and shift away from contractors who charged rates higher than the market indicated. Such diagnostic use of data is a notable exception to the broader trend

in Latin America, where only 40 percent of countries use information regarding procurement to analyze whether policies are having their intended effects.¹⁰⁸ That figure declines to only 29 percent of countries when data on human resources are considered, and it is still rare to find both diagnostic and strategic use of budget data in countries adopting standards for accounting on an accrual basis.¹⁰⁹

3. Use standards to empower organizations and people to apply good governance practices on their own

Standards can play the role of instructional scaffoldings, providing information that can be acted upon and codifying good practices. The ultimate goal of the instruction offered through these scaffoldings is to empower organizations and people to apply good governance practices on their own and exercise their own judgment.¹¹⁰ There is an opportunity to leverage standards to confer more agency on institutions and people that put them into practice. This can happen in two ways. First, governments should codify standards for adoption by institutions in the public sector and, upon verification and accreditation (refer to chapter 3), transfer responsibilities to those institutions to grant autonomy for management. Second, governments should listen to feedback from the institutions and bureaucrats who have to put standards into practice. This transforms the codification of standards for governance from a one-off event into a dynamic, learning-oriented process that can adapt to changing circumstances and the needs of its users.

- In the Philippines, the Civil Service Commission (CSC) plays an oversight and capacity-building role in scaling up of good practices in the area of managing human resources. The commission classifies institutions according to four maturity levels under its Program to Institutionalize Meritocracy and Excellence in Human

Resource Management. Level 1 agencies perform basic, transactional functions related to human resources with minimal strategic value, whereas level 2 agencies have consistently implemented commission-compliant, documented systems across core areas in management of human resources. At level 3, agencies adopt integrated, competency-based systems for managing human resources aligned with organizational goals. Level 4 agencies demonstrate strategic, innovative, and evidence-based practices for managing human resources that drive organizational transformation. CSC accredits agencies that meet the standards at level 2 or higher, which empowers them to decide on appointments and to establish and implement their own mechanisms for managing human resources without prior approval from the CSC.¹¹¹

- In Ghana, a survey and focus group involving public servants showed that many of them had concrete proposals about how to better implement standardized processes.¹¹² Rather than clashing with existing standards, these employees' ideas sought to reinforce and strengthen application of the standards. However, managers generally silenced the voices of their own staff members and often failed to create spaces for lower- and middle-level officers to express their proposals. Putting standards into practice requires conferring more agency on institutions and bureaucrats responsible for making the public sector operate.

These policy recommendations recognize that bureaucracies are dynamic and respond to governance standards in sometimes unintended and undesirable ways. Bureaucracies, as institutions, and bureaucrats, as people, are agents who change their behaviors in response to such standards.¹¹³ The organizational complexity that results means that standards, particularly good governance standards, are and should be part of an "evolving and inevitably imperfect system of governance."¹¹⁴ There is no one-size-fits-all in

regard to governance standards. Instead, governments should consider what constitutes good governance for the institutions and people they manage. Doing so enables the public sector as a

whole to function more efficiently and effectively, ensuring governments have the capacity to deliver on their policy commitments and serve the public in promoting development.

Notes

1. Williams (2017).
2. Andrews et al. (2017).
3. On the issue of corruption, a canonical study found that in Indonesia, financial reports produced by implementation units failed to account for about 24 percent of the costs of road construction (Olken 2007). Although the study concludes that theft likely drove most of the expenditures missing from the reports, the author acknowledges that lack of capacity at the local level might account for them.
4. Ayagiba (2022).
5. *World Development Report 2017: Governance and the Law* defines governance as “the process through which state and nonstate actors interact to design and implement policies within a given set of formal and informal rules that shape and are shaped by power” (World Bank 2017, 3). This chapter’s definition focuses on the implementation of policies, particularly the set of formal organizational rules that shape the process of policy implementation.
6. Besley et al. (2022); Best et al. (2023); Schuster et al. (2023).
7. Grindle (2012).
8. Dasgupta and Kapur (2020); Muralidharan (2024).
9. For an in-depth treatment on the issues of political economy and how political economy affects both what and how policies are implemented, refer to *World Development Report 2017: Governance and the Law* (World Bank 2017).
10. Bersch et al. (2017); Geddes (1994).
11. Gonulal and Loewen (2018).
12. Each of these management systems has standards specific to its functioning. Standards in payment management refer to the codified rules and procedures that structure the preparation, execution, and monitoring of public budgets. Budget standards establish consistent requirements for budget classifications, timelines, reporting, and expenditure controls. Standards for managing human resources set the norms, rules, and procedures that govern how personnel are managed in a government. Standards for public procurement organize how governments transact with markets. They consist of codified rules, procedures, and criteria that govern the acquisition of goods, services, and work.
13. Besley et al. (2022); Williams (2021).
14. World Bank (2017).
15. Muralidharan (2024).
16. Estimate based on data from Worldwide Bureaucracy Indicators Dashboard, World Bank, <https://datacatalog.worldbank.org/search/dataset/0038132/Worldwide-Bureaucracy-Indicators>. “Public sector employee” denotes any worker who is currently employed by the public sector, which includes both the central and subnational governments, as well as security forces. The methodology for estimation is available in the reproducibility package on the Report’s website, World Development Report 2025 (dashboard), World Bank, www.worldbank.org/wdr2025.
17. Dasgupta and Kapur (2020); Muralidharan (2024). On the burden of procedural requirements, refer to Bagley (2019); Pahlka (2025).
18. IEG (2008).
19. Public servants included in these surveys are generally mapped to their national governments.
20. World Bank (2021b).
21. Bridges and Woolcock (2023).
22. Rogger and Schuster (2023); Sousa and Voss (2002).
23. Scott (2020, 2).
24. Rogger and Somani (2023).
25. de Vries (1999); Sousa and Voss (2002).
26. A “procurement tender” is a government’s official request inviting suppliers to submit bids to provide goods and services.
27. Jiménez et al. (2022); Puspita and Gultom (2024).
28. Taylor (1919). For more information, refer to the discussion on the Second Industrial Revolution in chapter 1.
29. The following quote illustrates the principles of scientific management:
It is true that with scientific management the [employee] is not allowed to use whatever implements and methods [they see] fit in the daily practice of [their] work. Every encouragement, however, should be given them to suggest improvements, both in methods and in implements. And whenever [an employee] proposes an improvement, it should be the policy of management to make a careful analysis of the new method, and, if necessary, conduct a *series of experiments* to determine accurately the relative merit of the new suggestion and of the *old standard*. And whenever the new method is found to be markedly superior to the old, it should be adopted as *the standard for the whole establishment* (Taylor 1919, 128, emphases added).
30. Conlisk (1996).
31. Taylor (1919, 126, emphasis added). This quote is in the context of a description of how surgeons

- should leverage the best available evidence in their practices and how scientific management mimics this approach, but for organizational management. There is an interesting parallel between this description and the evidence-based medicine movement. Refer to Tenny and Varacallo (2024).
32. In an emblematic example, Taylor (1919, 59) describes workers derogatorily as “so stupid that the word ‘percentage’ has no meaning to [them], and [they] must consequently be trained by a man more intelligent than [themselves] into the habit of working in accordance with the laws of this science before [they] can be successful.”
 33. Honig (2018).
 34. World Bank (2017).
 35. World Bank (1997).
 36. IBP (2024).
 37. Rial et al. (2024).
 38. IMF (2024).
 39. Besley et al. (2022); Evans and Rauch (1999).
 40. Johnson (1982).
 41. Amsden (1989); Evans (1995); Johnson (1982); Kohli (2004); Woo-Cumings (1999).
 42. World Bank (2017).
 43. Bosio et al. (2022).
 44. In political science, this gap between rules and compliance in practice is generally referred to as “institutional weakness” (Levitsky and Murillo 2009). A rich empirical literature has explored the conditions under which institutional actors both comply with and alter the content of rules themselves, particularly electoral and constitutional rules. Such behavior is beyond the scope of this chapter.
 45. Andrews et al. (2017).
 46. Bandiera et al. (2009).
 47. Rose-Ackerman (1975).
 48. Best et al. (2023); Slough and Fariss (2021).
 49. Olken (2007).
 50. Fazekas and Kocsis (2020).
 51. Kawai and Nakabayashi (2022).
 52. Bersch et al. (2017); Brierley et al. (2023); Grindle (2012).
 53. Colonnelli et al. (2020).
 54. Akhtari et al. (2022).
 55. Colonnelli et al. (2020).
 56. Chan (2003).
 57. Zubairu (2019).
 58. Bandiera et al. (2009). Data for the study were collected from a survey of procurement agencies administered by the Italian Statistical Agency between 2003 and 2005.
 59. Decarolis et al. (2020). Data for the study were collected from the General Services Administration’s Federal Procurement Data System and correspond to 2010–15. Descriptive statistics are calculated based on 122,533 completed projects. Expected duration refers to the duration, in days, written in the procurement contract. Actual duration includes both the expected duration and additional days due to implementation delays.
 60. Decarolis et al. (2020).
 61. Dahis et al. (2023).
 62. Fukuda-Parr et al. (2011).
 63. Allen et al. (2013).
 64. PEFA (2023).
 65. Accrual accounting is based on two concepts. The first is recognition of economic events when they occur, rather than when related cash transactions happen (that is, cash basis accounting). The second is recognition of assets and liabilities, as opposed to what takes place in accounting on a cash basis, which typically accounts only for cash and cash equivalents and does not necessarily include depreciation, revaluation, and impairments (World Bank 2024).
 66. World Bank (2024).
 67. Chan (2006).
 68. These guidelines were updated in 2024.
 69. World Bank (2024).
 70. Horngren et al. (2009).
 71. UNSD (2025).
 72. Wu Chebili et al. (2021).
 73. Martinez-Carrasco et al. (2023).
 74. Dahis et al. (2025).
 75. Rank-based approaches to examination-based recruitment of this type are standard around the world and trace their historical origins to imperial China (Fukuyama 2017).
 76. The quality of rulings is measured as whether or not litigating parties repeal the rulings to an upper court. Dahis et al. (2025).
 77. Posso et al. (2024).
 78. Best et al. (2023).
 79. Rodgers and Hunter (1992).
 80. Van Dooren et al. (2015).
 81. Robinson and Brumby (2005).
 82. Tuan Zainun et al. (2023); World Bank (2010).
 83. World Bank (2005).
 84. Chama-Chiliba et al. (2022).
 85. Boland and Fowler (2000).
 86. Meyer-Sahling et al. (2018).
 87. Khan et al. (2016).
 88. Muralidharan and Sundararaman (2011).
 89. Meyer-Sahling et al. (2018).
 90. Results of an ordinary least squares regression of work motivation on performance-related promotion are consistent with this linear trend, and the coefficient is statistically significant.
 91. World Bank (2017).
 92. Muralidharan (2024).
 93. Ganimian et al. (2024).
 94. Mathur (2016).
 95. Mathur (2016). The leopard attack occurred in the town of Gopeshwar in Uttarakhand, India (Mathur 2014).
 96. Honig (2018).
 97. Bersch and Fukuyama (2025).
 98. Rasul et al. (2021).
 99. It might be the case that these menial tasks are more likely to be subject to rules because they are easier to verify.
 100. Bandiera et al. (2021).

101. Grindle (2004).
102. Many Public Expenditure and Financial Accountability assessments are publicly available. For more information, refer to Public Expenditure and Financial Accountability (website), World Bank, <https://www.pefa.org/>.
103. PEFA assessments themselves do not include policy recommendations.
104. World Bank (2024).
105. Rogger and Schuster (2023).
106. Refer to Common Procurement Vocabulary (dashboard), European Commission, https://single-market-economy.ec.europa.eu/single-market-public-procurement/digital-procurement/common-procurement-vocabulary_en; United Nations Standard Products and Services Code (portal), United Nations Development Programme, <https://www.undp.org/unspsc>.
107. Santini et al. (2024); World Bank (2024).
108. Santini et al. (2024).
109. World Bank (2024).
110. Honig (2018).
111. CSC (2021).
112. Williams and Yecalo-Teclé (2020).
113. Moreira and Pérez (2024).
114. Moynihan et al. (2011).

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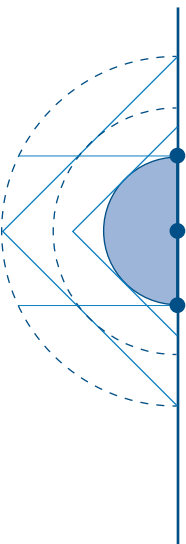
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PART 4

Making Standards a Springboard for Development, Rather Than a Straitjacket

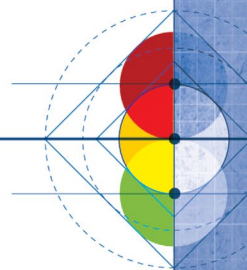
Standards have never mattered more than they do today. However, they are often underappreciated or misunderstood, and sometimes they do more harm than good. Overly prescriptive mandatory standards can stifle innovation or be used to favor politically connected firms. Chapter 8 provides a set of recommendations for how policy makers in low- and middle-income countries—and elsewhere—can use standards most effectively for development.

But standards are not merely technical instruments to be applied correctly. They are also the result of power and influence, steering the direction of technological change. The global community thus faces a dual challenge. In some areas, there is *too much* standardization, resulting in a “spaghetti bowl” of standards or international standards that do not reflect the realities in low- and middle-income countries. But in other areas, there is *too little* standardization, indicating that the global community has failed to manage the worsening risks of emerging technologies and the drivers of planetary crises such as climate change and loss of biodiversity. The absence of crucial standards is often a result of corporate influence or geopolitical competition. This Report takes a renewed look at who sets what standards and who blocks them.

Policy makers in low- and middle-income countries should be sure to use *standards as a springboard for development, not a straitjacket*. This requires a clear understanding of when voluntary standards suffice and when mandatory standards are needed. In most cases, governments should allow markets to shape voluntary standards, as this benefits innovation and knowledge diffusion. Mandatory standards should be used

only with respect to critical public interests such as health, safety, environmental protection, and the prevention of deceptive trade practices. Such standards are particularly useful in situations in which the benefits of prevention outweigh the costs of future damage, especially those in which potential harm, if realized, is irreversible. As this Report emphasizes, voluntary and mandatory standards form a spectrum, and combining voluntary standards with regulation often renders the best results. The Report also stresses that policy makers in low- and middle-income countries need to recognize the benefits of participating in the process of developing international standards and participate more actively in such development.

Regarding the global community, chapter 8 argues that more effort is needed to ensure that international standards align with the realities in low- and middle-income countries from the beginning of the development process. This goal can be accomplished by increasing the representation of low- and middle-income countries in the standards development process; making stronger efforts to reduce the fragmentation of standards, including by enhancing international regulatory cooperation to prevent enactment of nontariff barriers; and changing how the global community views standards in light of the growing list of global challenges, including technological risks.



8 Using Standards to Shape Development and Manage Global Challenges

Main messages

- Standards have never mattered more than they do today. For both policy makers in low- and middle-income and those in high-income countries, the ability to navigate the complex world of standards and to use them effectively has become indispensable (refer to table 8.1).
- For standards to be a springboard, not a straitjacket, policy makers in low- and middle-income countries and beyond should do the following:
 - Create favorable conditions for firms to upgrade the quality of the goods and services they provide, rather than using mandatory standards to enforce quality improvements.
 - Adapt quality standards to the ability of stakeholders to meet them and, for mandatory standards, the government's capacity to enforce them.
 - Show up and speak up in international forums for developing standards.
 - Use national quality infrastructure to realize the full potential of standards.
- To ensure that international standards work for low- and middle-income countries, the global community should take these actions:
 - Support low- and middle-income countries' participation in the process of developing international standards.
 - Promote tiered standards to match different levels of capacity to meet them.
 - Deepen international cooperation to ensure that well-intended standards do not hinder development.
- To meet the growing challenge of global risks such as artificial intelligence and environmental degradation, global action is needed to accomplish two things in particular:
 - Agree upon and implement credible standards that prevent harm.
 - Expand research and amass evidence on standards for development.

Table 8.1 Main policy recommendations regarding standards for development

RECOMMENDATIONS FOR LOW- AND MIDDLE-INCOME COUNTRIES (THAT OTHER COUNTRIES MAY ALSO WANT TO CONSIDER)		
Use standards as a springboard for development, not as a straitjacket.	Learn to use the full toolbox of standards for policy, not just the hammer.	Use quality infrastructure to realize the full potential of standards.
Create the conditions needed for firms to upgrade quality; don't enforce such upgrading with mandatory standards. Improve fundamentals (macroeconomic environment, rule of law) in the country to create demand for standards. Integrate standards into broader industrial policies. Adapt quality standards in line with the capacity of stakeholders to comply with them. Overly ambitious standards that cannot be met create risks. But if standards need to be adapted to the local context, do so systematically to avoid creating hurdles for that country and others. A tiered approach involving standards with varying degrees of strictness may help with systematic adaptation of standards. Show up and speak up in international standards forums and share findings at home. Attend international meetings of organizations such as ISO and the IEC to influence international standards, and use the process as an opportunity for learning. Virtual participation, often now possible, helps reduce travel costs.	Use standards as a flexible tool in public policy. Combine voluntary standards and regulation to pursue innovation-friendly policy approaches. Require all sectoral regulators and other government bodies to use quality infrastructure^a consistently. Using uniform approaches to compliance across the government and sharing facilities like testing laboratories save public resources and avoid creating nontariff barriers to trade.	Sequence the development of quality infrastructure^a according to market demand and country preferences. Infrastructure (such as laboratories) can be expensive and should grow together with countries' demands in order to optimize use of quality infrastructure resources. Develop capacity for compliance as a public-private partnership. It is often more cost-effective for the government to oversee compliance with standards than to carry out all compliance checks in government facilities. Focus on the availability of quality infrastructure, not the location. Not all quality institutions need to be physically located in each country. Share costly laboratory infrastructure with regional partners. Leverage digital tools for better quality infrastructure. Low- and middle-income countries can benefit from leveraging digital technologies to make quality infrastructure more accessible and cost-effective.
RECOMMENDATIONS FOR THE GLOBAL COMMUNITY		
Develop international standards that better serve low- and middle-income countries.	Ensure that well-intended standards do not become barriers to development.	Tackle global challenges.
Support low- and middle-income countries in the process of developing international standards—or risk low uptake. Inclusive processes for developing standards should include voices from low- and middle-income countries. Support is needed to make international standards truly international. Promote tiered standards to match different capacities. From the design stage, standards should integrate varying capacity levels of countries.	Deepen international regulatory cooperation. Regulation grows more complex over time, creating the risk that standards become barriers to trade. Early cooperation on regulations helps prevent this. Tidy up the “spaghetti bowl” of standards. Even if standards are voluntary, fragmentation (multiple standards for the same product or service) has become a problem in some areas. Consolidating by building trust and mutual recognition is key. Amass more data and evidence. Standards are an underappreciated and underresearched topic. More data and evidence are important to inform regulatory impact assessments and guide policy makers.	Set and comply with standards now—or face crises later. The risks of unchecked technological progress like artificial intelligence and environmental degradation grow exponentially, outweighing the benefits. Standards are essential to align technological development with societal preferences.

Source: WDR 2025 team.

Note: IEC = International Electrotechnical Commission; ISO = International Organization for Standardization.

a. “Quality infrastructure” refers to a system of public and private organizations and policies that provide services like testing, inspection, certification, metrology, accreditation, and standardization.

Too much? Too little? Just right?

This Report may seem contradictory at times. It tells the story of *too much* standardization: the “spaghetti bowl” of standards that act as gatekeepers to international markets. Geopolitical rivalry deepens the fragmentation that arises, be it in regard to chargers for electric vehicles, data privacy, or mandatory standards for banking. The result is that low- and middle-income countries face a growing number of more demanding requirements, from measuring pesticide residues on fruit down to the last microgram to ensuring the exact color of dyed fabrics—challenges that advanced economies did not face at similar levels of development.

It also tells a story of *too little* standardization in which the global community has failed to effectively manage the risks of technological development, be it in the realm of artificial intelligence (AI), of social media, or of the drivers of planetary crisis. This is a story of coordination failures and corporate influence that keep the world from developing and implementing credible standards to keep pace with innovation and shape it in line with societal preferences. Doing the latter has become increasingly urgent as technological and planetary risks multiply: A lack of effective standards threatens the very livability of the planet.

And then it tells a story of *just right* standardization. The global economy increasingly resembles a complex machine of interconnected technologies, people, firms, and countries. Having many standards is not a bug but a feature that keeps this complex system running. In fact, when coordination aligns with commercial incentives, actors in markets organize themselves to develop the standards they need. In such cases, standards function not as gatekeepers, but as bridges that lower transaction costs and foster diffusion.

No matter whether standards are too many, too few, or just right, they probably have never mattered more than they do today. And yet they

have long been a misunderstood and underappreciated tool in development, often a technical afterthought. But for policy makers in low- and middle-income countries, the ability to navigate the complex world of standards and to use them effectively has become indispensable. Standards are reshaping the competitive landscape, and complying with them is essential for economic growth and job creation. The diffusion of international standards promises to raise the quality of products and services and enhance the welfare of countries and their citizens, building on the distilled expertise of leading specialists from around the world. And applying standards properly can significantly advance good governance and increase the cost-effectiveness of government policies.

This chapter outlines recommendations for policy makers in low- and middle-income countries as to how they can use standards for development. Most of these recommendations apply to all countries, but there are nuances depending on countries’ income levels. Low-income countries should emphasize building their capacity for complying with standards and enabling firms to upgrade the quality of the goods and services they produce—for example, by attracting foreign investors and encouraging spillovers of technology from multinational enterprises to domestic firms. These countries should also make it a priority to work with international partners to build basic institutions for quality, such as standards and metrology bodies, which enable other quality assurance services to develop over time. Low-income countries face the greatest need to maintain a dual regime in which they may adapt international standards when developing domestic regulations but ensure that exporting firms meet the (unadapted) international standards and provide those firms with assistance to enable them to do so. Those countries will need to be more selective regarding their participation in development of international standards, leveraging regional and international partners to strengthen their voices on the global stage.

Lower-middle-income countries should enhance their capacity for compliance with standards by building smarter public-private partnerships, especially in the area of quality assurance, such as testing and certification. Aligning domestic rules with international standards can increase safety, environmental protection, and market access. Lower-middle-income countries will also benefit from streamlining regulations across the government and from a more active private sector that can shape standards and lead in developing international standards, often in partnership with other countries.

Upper-middle-income countries should focus on adopting a more agile, innovation-friendly regulatory approach using voluntary standards to address technical gaps.¹ Increasing public-private collaboration for quality assurance can help these countries achieve policy objectives more cost-effectively. Upper-middle-income countries should also build expertise in institutions like

metrology and accreditation to support more advanced industries, such as nanomaterials. These countries should also mobilize the private sector to lead standards development internationally.

There is urgency and opportunity for the global community to take standards more seriously to ensure they advance rather than hinder development. Moreover, the global community is facing a growing set of formidable risks—from AI to climate change and biodiversity loss—that standards can play an important role in mitigating or managing. History shows that standards sometimes arrive only after serious harm has occurred: a risky path given the scale of today's technological and planetary challenges. Chapters 4–7, on the economy, human capital, the environment, and governance, respectively, provide specific recommendations. Although the recommendations in this chapter are mainly addressed to policy makers, the private sector is also encouraged to take action, as outlined in box 8.1.

Box 8.1 Recommendations for the private sector

This Report highlights that the private sector develops the majority of voluntary standards to address market or societal needs. At the same time, the private sector also faces the strongest pressure from both markets and regulators to comply with these standards. Although this box does not attempt to be exhaustive, it outlines key recommendations that private sector leaders, particularly in low- and middle-income countries, should consider.

Use standards to improve firms' operations, not just to comply with regulations

Voluntary standards help firms avoid reinventing the wheel and improve collaboration with business partners. The well-known standard for quality management systems, International Organization for Standardization (ISO) 9001, is only one of many that enhance operational efficiency and product quality. Firms should use standards strategically for continuous improvement rather than viewing them merely as tools governments use to compel compliance. This is especially relevant given the digital and green transitions, which require firms to fundamentally adapt business models, processes, and products to evolving expectations.

(Box continues next page)

Box 8.1 Recommendations for the private sector (*continued*)

Engage in standards development—at national, regional, or international levels (or all three)

Participating in standards development provides opportunities for learning, networking, and shaping markets. In addition to engaging in the work of formal standards bodies at national, regional, or international levels, firms can also benefit from participating in initiatives involving voluntary standards for sustainability and the multistakeholder platforms they provide. Active engagement helps ensure that standards reflect local realities and strengthens firms' competitiveness by improving market access, strengthening their reputation, and coordinating with business partners.

Invest in capabilities for performing due diligence that are compatible with leading standards for sustainability

International buyers and regulators increasingly expect suppliers to demonstrate they have exercised social and environmental due diligence across their supply chains. Even in instances in which this is not yet mandatory, investing in such capabilities today can enhance competitiveness and market access. Aligning internal practices with recognized standards for sustainability provides a practical road map for meeting future regulatory and market requirements.

Select credible and trusted standards and certification schemes

Firms can't always select which standards or certification schemes to follow, as markets or regulations often shape these. When a choice is available, however, firms should put a priority on selecting credible standards and certifications that are transparent, independently verified, and aligned with international principles. Such a strategy boosts firms' recognition in export markets and ensures that their investments in certification bring genuine reputational and commercial advantages. When employing quality infrastructure services, firms should depend on accredited providers and confirm the validity of certifications they rely on.

Partner with peers and government to strengthen quality infrastructure

Well-functioning quality infrastructure not only supports compliance with standards but also promotes innovation and learning, through such things as product testing and calibration. Because many quality infrastructure needs go beyond the capacities of individual firms, collaboration among businesses, industry associations, and government agencies is crucial. Firms can help by sharing their specific quality assurance needs, co-investing in shared facilities, and supporting the digitalization of quality infrastructure services.

Source: WDR 2025 team.

Recommendations for low- and middle-income countries (that other countries may also want to consider)

Most standards are voluntary, and most voluntary standards are private, aiming for quality, compatibility, and reduced transaction costs. In most economic sectors, the private sector will therefore develop standards to address a given need. Governments should let market forces determine voluntary standards unless the process of developing standards suffers from issues related to collective action, inclusion, fragmentation, competition, or safety. Governments should use mandatory standards only to address essential public interests such as health, safety, environmental protection, and the prevention of deceptive trade practices.

Use standards as a springboard for development, not as a straitjacket

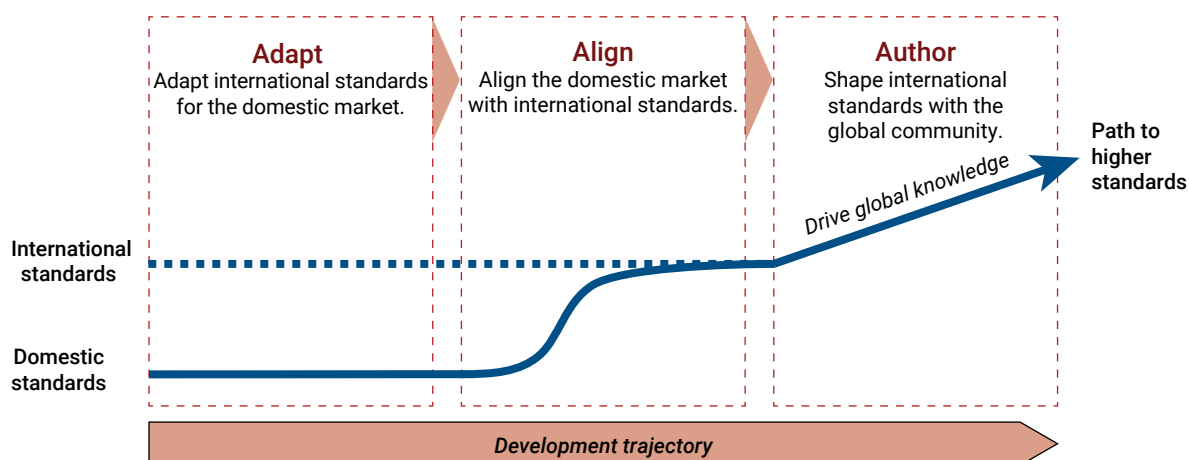
This Report's adapt-align-author framework (discussed in chapter 2 and summarized in figure 8.1) implies that low- and middle-income countries may need to follow a dual-regime approach: in

the case of exports, complying with standards for the international market that cannot be changed, but adapting other mandatory standards for the domestic market to local needs (refer to box 8.2). For example, garment exporters often have no choice but to accept the standards regarding sustainability that international fashion brands demand. But mandating that all domestic producers comply with international standards as a shortcut to upgrading quality could be counterproductive. It would overstretch government capacity for enforcing the standards, introduce costs associated with compliance that may exclude informal and smaller firms from the domestic market, and divert attention and resources from building the supportive system needed to meet international standards.

Create the conditions needed for firms to upgrade quality; don't enforce such upgrading with mandatory standards

Rather than relying on mandatory standards to enforce improvements in the quality of the goods and services firms provide, policy makers should focus on creating conditions favorable to firms' upgrading quality by ensuring access to production inputs, enhancing education in

Figure 8.1 Setting standards along the development trajectory



Source: WDR 2025 team.

their countries and the skills of their workforces, promoting competition, and increasing access to finance—along with providing incentives for the adoption of voluntary standards and promoting a quality culture among consumers. Spotlight 1 discusses lessons from Japan’s experience, and chapter 3 discusses how national standards bodies can promote voluntary standards rather than act as regulators.

Similarly, international experience shows that a country’s demand for standards arises not only from promoting standards, but also from a range of other development policies. Standards achieve limited results when a country’s macroeconomic

environment is weak and when violence and disorder are widespread. If such issues discourage investment and firm growth, why should companies adopt standards and invest in upgrades? The cases of China, Japan, and the Republic of Korea demonstrate how standards can be effective when integrated into broader industrial policies. Additionally, public awareness and citizen pressure often drive stronger environmental standards and enforcement of those standards. For example, in countries with limited infrastructure for monitoring air pollution, US embassies have publicized data on air pollution, prompting people in those countries to demand greater oversight and regulatory action (refer to chapter 6).

Box 8.2 When to use voluntary standards and when to use mandatory ones

A decision tree can help policy makers determine whether and how governments should get involved in developing voluntary standards (refer to figure B8.2.1). First, if collective action by private parties fails and no individual stakeholder has an incentive to develop a standard—despite its being better for everyone—there may be a need for government involvement. However, the government should only convene or coordinate stakeholders—possibly by funding national standards bodies—without prescribing the technical content of voluntary standards. Second, if a lack of stakeholder involvement (such as among disadvantaged groups in the population) threatens the legitimacy and effectiveness of standards, the government might need to become more involved. Third, if fragmentation of standards poses a problem, governments can unify different national standards development organizations under one umbrella or pursue other methods to reduce fragmentation, like fostering mutual recognition arrangements. Finally, government action may be necessary to prevent risks to competition associated with standards, for instance, if dominant market players use proprietary standards to restrict market entry.

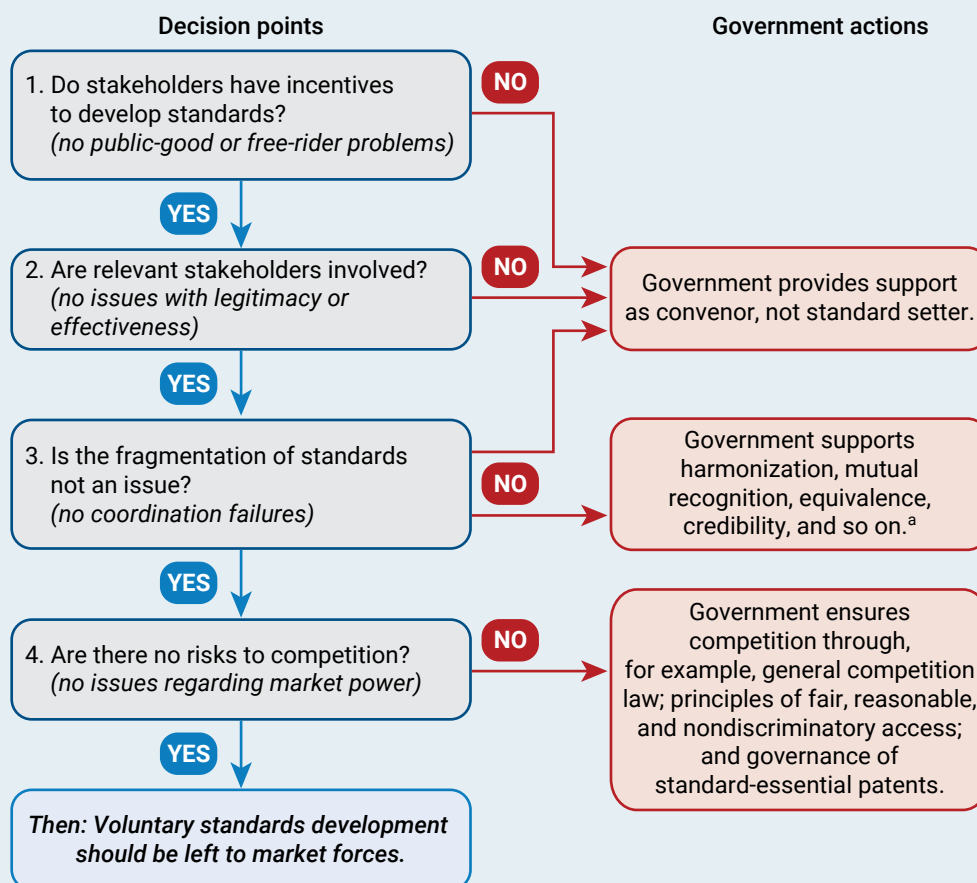
Policy makers can identify whether and how governments should use mandatory standards (refer to figure B8.2.2). They need to determine whether there is a need to regulate, for example, to address market failures. If not, market-driven voluntary standards may be sufficient. Next, they need to assess whether mandatory standards are the best policy instrument for addressing the need by, for example, conducting regulatory impact assessments.

(Box continues next page)

Box 8.2 When to use voluntary standards and when to use mandatory ones (continued)

Then they should ask whether an international standard fulfills the need and can be complied with and enforced. If not, they should adapt the standard or increase firms' capacity for compliance with it. Often, a mixed approach, in which regulation sets the broad requirements and technical details are left to voluntary standards, is most effective (refer to chapter 2).

Figure B8.2.1 Decision tree for voluntary standards: When they can be left to market forces



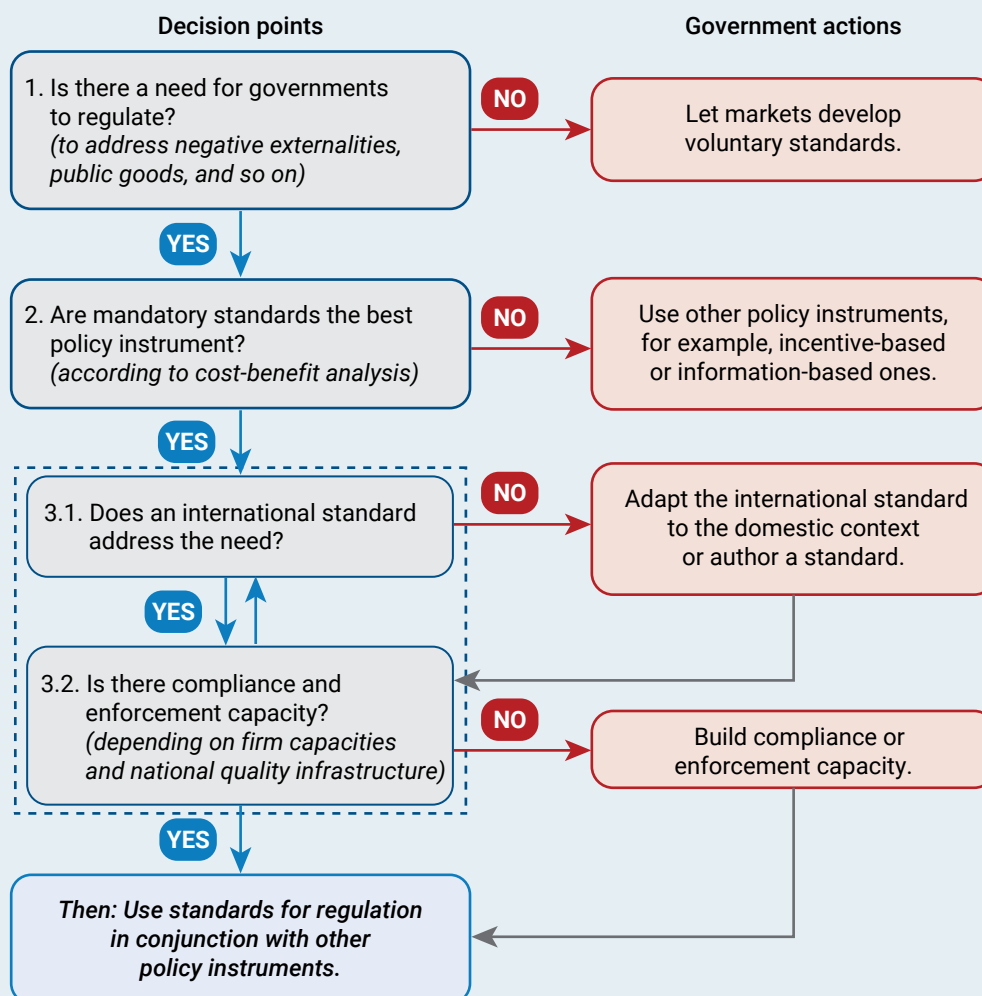
Source: WDR 2025 team.

a. Aside from such government support, private initiatives can help address the fragmentation of standards. For example, the Global Food Safety Initiative benchmarks food safety standards to promote equivalence.

(Box continues next page)

Box 8.2 When to use voluntary standards and when to use mandatory ones (continued)

Figure B8.2.2 Decision tree for mandatory standards: When to use them



Source: WDR 2025 team.

Source: WDR 2025 team.

When industrial policy becomes necessary, governments can leverage standards in at least three ways. First, they can use their convening power to gather stakeholders and help them solve coordination problems, enabling them to adopt higher standards. Second, they can leverage their

purchasing power to encourage the adoption of quality standards through public procurement. Third, they can use standards to facilitate a technological transition, for example, by promoting interoperability standards. Although other policy tools like incentives are generally preferable,

especially where capacity for compliance with standards is low or during urgent technological shifts, standards can still be helpful. For example, banning the import of mobile phones with the 2G standard in South Africa sped up the adoption of phones with faster mobile internet. In India, voluntary standards played a key role in the transition from incandescent light bulbs to more energy-efficient lighting using light-emitting diodes. Although there was no nationwide ban on light bulbs, mandatory certification for light-emitting diodes helped build consumer confidence and guided public procurement.

Adapt quality standards in line with the capacity of stakeholders to comply with them

This Report underscores the need to balance the ambition of high standards of quality against capacity for complying with them, which includes the ability of stakeholders to meet the standards and, for mandatory standards, the government's capacity to enforce them. For example, many lower-income countries set stringent standards for air pollution but are not able to enforce them (refer to chapter 6). Higher standards can be a worthy aspiration, but they risk becoming ineffective or even counterproductive if the compliance gap is too wide. Overly ambitious mandatory standards may push firms into informality or lead to partial and uneven public enforcement, opening the door to corruption. Policy makers in low- and middle-income countries should thus adapt quality standards, particularly mandatory standards, to their countries' compliance capacity. They can consider local adaptation of voluntary international standards, such as the voluntary GLOBALG.A.P. standard for good agricultural practices. For example, in countries like Kenya, there have been efforts to provide simplified requirements for GLOBALG.A.P. to match the capabilities of domestic producers and enable farmers to gradually improve their practices in regard to quality,

access markets, and prepare for eventual full compliance with international standards.²

Adapting quality standards to local contexts may also be necessary because preferences regarding and tolerance for risk vary across societies (usually as a function of income) and because people in low-income countries may not be able to afford compliance with the standard. High standards can even be a case of “the best being the enemy of the good.” As shown by the example of China's barefoot doctors, expanding access to health care for the many using providers that have less advanced credentials can yield better health outcomes in the aggregate than using highly credentialed professionals only and thus limiting access to a few people (refer to chapter 5). Finally, setting high standards can simply be a case of copying a high social or environmental standard to engage in virtue signaling.

Although this Report emphasizes adapting mandatory standards to local contexts, low- and middle-income countries should strive to use international standards without adaptation whenever possible, in line with the Agreements on Technical Barriers to Trade and on the Application of Sanitary and Phytosanitary Measures of the World Trade Organization (WTO). Relying on a single recognized standard reduces compliance costs for sellers and simplifies verification of compliance for buyers and regulators. In contrast, multiple overlapping standards dilute the signaling effect of standards, especially when the standards are not widely known or trusted. To address the proliferation of competing standards, countries should adopt existing international standards whenever possible and contribute to developing them with international partners, to ensure that the standards adequately consider local needs and thus can be adopted without adaptation.

If countries need to adapt international standards, it is important that they do it systematically, following clear criteria. For example, it is important

to use the same terminology and structure as an international standard and note any required deviations systematically. The International Organization for Standardization's (ISO's) Policy on Global Relevance outlines ways to integrate differences in markets (such as social conditions, trade patterns, and market needs) and essential differences among countries (such as those involving climate and technological infrastructure) into international standards.³ But more efforts and guidance are needed to ensure that national standards bodies adapt standards in a coherent manner. For example, national standards bodies can consistently inform international standards development organizations about national adaptations. To date, it has often been difficult to assess deviations between national and international standards, creating unnecessary barriers to trade. Developing more international standards as tiered standards that provide different levels of stringency—for example, classes of energy efficiency—can also help make adaptations less disruptive to trade (refer to “Promote tiered standards to match different capacities” later in this chapter).

Some standards are inherently universal. For many measurement standards, the advantages of universal adoption are evident, especially for those based on universally accepted scientific units derived from natural constants such as an electric volt. Likewise, most compatibility standards require some degree of universality. This does not imply they are perfect, even if developed through expert consensus. However, the effort and resources needed to generate alternatives and the high chance of becoming isolated from prevailing standards if a different standard is adopted strongly encourage countries to adopt international compatibility standards. Universal compatibility standards can maximize the overall benefits of such standards, but initial competition among different standards can still be advantageous. For instance, mobile phone chargers vary not only in plug shape but also in aspects of quality like rate and accuracy

of data transfer, safety, and convenience, creating a gray area between compatibility and quality standards. Therefore, early competition in compatibility standards can promote innovation, even though establishing a long-term standard generally benefits everyone. The European Union (EU), for example, played a key role in establishing USB-C as the universal charging standard by integrating consumer protection with environmental aims. Concerned about electronic waste and the fragmentation of charging standards, the EU initially encouraged voluntary agreements among manufacturers. When these efforts stalled, it introduced legislation in 2022 requiring USB-C chargers for phones, tablets, cameras, and other devices by 2024 and for laptops by 2026. Because of the EU's market size, companies found it impractical to produce separate versions for Europe, effectively creating a global standard, which prompted even Apple to switch from its proprietary Lightning connector standard.

In contrast, some measurement standards address matters that are more subjective, based on values, or hard to quantify—such as outcomes in education or inequality—in which one size does not fit all.

Show up and speak up in international standards forums and share findings at home

High-income countries on average participate in a far greater number of ISO technical committees than low- and lower-middle-income countries, sometimes by an order of magnitude (refer to spotlight 2). High-income countries send between 30 and 60 times the number of delegates to those meetings that low- and lower-middle-income countries do. Small wonder many international standards do not reflect the realities of life in the developing world: Experts from low- and middle-income countries are seldom even at the table when the standards are being developed. The global

community does need to step up to better support the involvement of low- and middle-income countries, but policy makers in these countries should acknowledge the importance of showing up, listening, and speaking up in forums in which international standards are developed. This includes participation in long-established international standards development organizations like Codex Alimentarius and ISO, as well as those developing standards in new technologies, like the World Wide Web Consortium (W3C) and the Internet Engineering Task Force (IETF). In addition to involving themselves in the development of international standards, low- and middle-income countries should also actively participate in international forums related to quality infrastructure, for example, those in accreditation and metrology.

Several challenges hinder low- and middle-income countries in participating more effectively in international standards development organizations. First, resource constraints and limited technical expertise impede their involvement in these organizations' technical committees. Traveling to multiple in-person meetings, engaging domestic stakeholders for input, and preparing technically sound positions require time and money. Second, policy makers in low- and middle-income countries often have low awareness of standards development and pay little attention to it, especially given the recent rapid increase in standards. Third, standards from private organizations are expanding quickly, with even fewer formal mechanisms for participation by low- and middle-income countries. These countries could, in theory, refuse to recognize such standards, but doing so could shut them out of lucrative trade opportunities, because many private standards have essentially become gateways to international markets.

Each low- or middle-income country should put a priority on participating in development of the standards that are most relevant for its own economy and people. Increased coordination among national standards bodies, government ministries,

industry associations, and research institutions, along with support from donors and international organizations, can bridge gaps in capacity to comply with global trade standards and strengthen low- and middle-income countries' roles in shaping these standards. Regional forums for developing standards, such as the African Organisation for Standardisation (ARSO) and the Association of Southeast Asian Nations (ASEAN) Consultative Committee for Standards and Quality, can pool technical expertise and amplify collective bargaining power in global forums.

Engaging in development of international standards is not just about having a seat at the table when future rules of global commerce are being written. The real opportunity for low- and middle-income countries lies in sending experts who not only speak up for national interests but also listen closely, capture insights, and bring them home. Too often, the insights from development of international standards remain with individual delegates but are not disseminated properly. National standards bodies can make these individual experiences available for a wider audience, enabling technical discussions and learning to take place. But policy makers first need to change the way they think about these bodies. Rather than considering them a regulator, they should view them as convenors of knowledge and promoters of innovation. National standards bodies, for their part, should not view themselves as technical research institutes. Instead, they should work with researchers to develop state-of-the-art standards.

Given the rapid pace of technological change, low- and middle-income countries have a strategic interest in taking an active role in shaping standards involving interoperability. These standards increasingly form the backbone of digital infrastructure, global trade, and access to emerging technologies. If low- and middle-income countries do not participate in the development of these standards, they risk becoming passive adopters of rules set by wealthier nations and multinational

firms, locking them into technological dependencies that constrain innovation, increase long-term costs, and limit policy autonomy.

To maximize the benefits of participation, low- and middle-income countries should focus their engagement on the standardization of general-purpose technologies that enable digital transformation, such as digital identity systems, e-payment systems, protocols for data exchange, AI, and devices for the Internet of Things. The standards for these foundational technologies will shape how countries access innovation, finance, and public services in the decades ahead.

Active participation should go hand in hand with promoting open and inclusive standards. When standards incorporate technologies covered by standard-essential patents licensed under fair, reasonable, and nondiscriminatory terms, countries can adopt mechanisms such as patent pools or patent intermediaries to ensure that the licensing for these technologies is affordable and predictable regarding, for instance, conditions and costs. This may particularly benefit small and medium enterprises, as well as public institutions.

Finally, low- and middle-income countries should align their participation in development of standards for interoperability, as well as their processes for determining their priorities in regard to such participation, with their broader development strategies, concentrating on sectors in which interoperability can generate the greatest benefits, such as health, agriculture, and education.

Learn to use the full toolbox of standards for policy, not just the hammer

Use standards as a flexible tool in public policy

The strength of using standards as a tool for public policy lies in their flexibility. Too often, policy makers view standards solely as command-and-control

tools for meeting regulatory goals. In fact, standards can be combined with other instruments. Market-based approaches like emissions-trading schemes are enhanced by having uniform standards for measuring, reporting, and verifying emissions. In public procurement, government standards establish best practices for processes involved in competitive bidding, and standards can also set specifications for the goods and services to be purchased. In Germany, the government promoted the creation of a voluntary Green Button label for textiles, which certifies that garments meet specified social and environmental standards, helping consumers make informed choices regarding the sustainability of clothes they purchase.

An advantage of voluntary standards is that they keep compliance voluntary while supporting regulation. Such standards can fill regulatory gaps and can enable firms to achieve higher performance beyond minimum regulatory requirements. In the area of food safety, private standards often develop in response to public regulations (refer to chapter 4). In 2015, China's government reformed its standards system to reduce the number of government-led standards and create a regulatory foundation for market-driven standards to spur innovation and competition that would surpass regulatory requirements (refer to spotlight 1).

Combining regulation with voluntary standards is also beneficial because regulation cannot and should not specify every technical detail required for compliance. Doing so would create compliance burdens, overwhelm policy makers' capacity and technical expertise, and make regulations too inflexible to allow innovation and accommodate societal changes. Best practices regarding regulations involve drafting them in broader terms and leaving technical specifics to voluntary standards that address regulatory gaps.⁴ For instance, under the EU's New Legislative Framework, legislation sets out only "essential requirements" for the protection of public interests such as safety or health,

whereas technical details are managed through voluntary standards, known as “harmonised standards.” For example, to prevent pieces of electrical equipment from interfering with each other, one of the essential elements of the corresponding EU law broadly requires that any “electromagnetic disturbance generated does not exceed the level above which . . . equipment cannot operate as intended.”⁵ For technical guidance on how to achieve this in practice, companies can—but are not required to—follow the harmonised standard EN 55014-1, which helps them ensure electromagnetic compatibility in household appliances and similar equipment.⁶

The EU’s Artificial Intelligence Act adopts this approach. For high-risk AI systems, like those used in recruiting personnel or credit scoring, the act requires the implementation of a risk management system but leaves the details to interpretation. Such details will be clarified through voluntary standards, giving companies flexibility in how they design their risk management systems. Nevertheless, the act encourages firms to use harmonised standards developed by the European standardization organizations—the European Committee for Standardization (CEN), the European Committee for Electrotechnical Standardization (CENELEC), and the European Telecommunications Standards Institute (ETSI)—by providing firms that adopt them with a “presumption of conformity,” which eases their burden of demonstrating compliance during conformity assessments. This approach aims to be both adaptable and supportive of innovation while promoting the adoption of common European standards.⁷

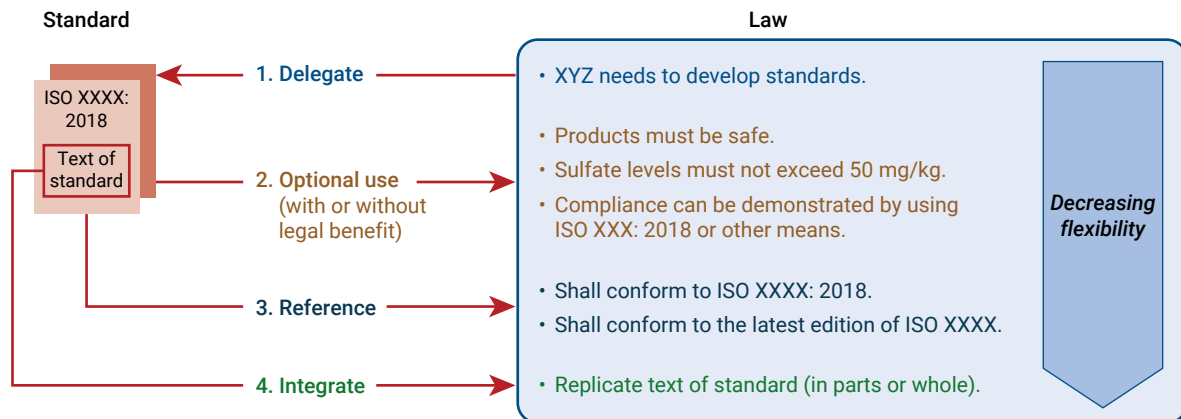
Policy makers in low- and middle-income countries should leverage private standards and third-party systems for quality assurance to make compliance easier and strengthen enforcement. The use of voluntary private standards for

regulation can best be understood through the idea of a *regulatory regime* that combines both public and private mechanisms for governance. The United Kingdom’s Earned Recognition Scheme, for instance, reduces the number of inspections required for firms certified under the program, and the Codex Alimentarius guides governments in evaluating third-party systems for quality assurance. Low- and middle-income countries can adopt such a complementary approach to enhance regulatory functions and strengthen capacity for compliance with standards. However, regulators need the institutional ability to assess and oversee private systems for quality assurance. Without robust oversight of these systems, there is a risk of their fragmentation or overreliance on private schemes with limited accountability.

If countries decide to use standards for regulations, there are four ways of doing so (refer to figure 8.2). The choice of approach matters greatly in regard to ease of compliance, particularly with respect to the flexibility it accords to regulated entities.⁸

- First, governments can *delegate*, by mandating the use of standards without specifying their content and leaving their development to others. For example, the EU’s Corporate Sustainability Reporting Directive assigned a multistakeholder advisory group to draft standards companies must meet in reporting their actions to promote sustainability.
- Second, governments can use standards as an *optional* mechanism to facilitate compliance with legislation by allowing laws to remain general and delegating technical specifications to standards, as with the EU’s Artificial Intelligence Act.
- Third, the legal text of legislation may *reference* standards (ideally, international standards), either in whole or in part, making compliance with those standards mandatory.

Figure 8.2 Four ways of using standards in regulation



Source: WDR 2025 team.

Note: ISO = International Organization for Standardization; mg/kg = milligrams per kilogram.

- Fourth, a law may also directly *integrate* text from a standard and thereby make it mandatory.² This may be useful in regard to certain definitions but makes it difficult for the law to keep pace with revisions of the standard.

Among these options, delegation provides the highest degree of flexibility, whereas integrating the text of a standard into a law provides the least. With less flexibility, regulators may need to update laws more frequently when technical aspects change, and regulated entities may have fewer choices in deciding how to comply, stifling innovation.

To promote innovation and lower the risk that any particular technology will become dominant and entrenched, policy makers should generally favor performance-based standards that specify what outcomes must be achieved, such as targets for emissions levels or energy efficiency, rather than how to achieve them, such as mandates for specific technologies. But in instances in which enforcement is difficult or scale is large, technology standards may be more practical. For example, to control emissions from vehicles, a country

might either mandate catalytic converters (a technology standard) or set emissions limits (a performance standard). Technology standards are easier to comply with and enforce, because verifying the presence of a component in a product made by a handful of manufacturers is simpler than measuring emissions in countless vehicles. Technology standards work best when technologies are mature and widely available. In contrast, performance standards offer firms flexibility and can encourage innovation, especially when options for achieving the standards vary. But their effectiveness depends on robust systems for monitoring compliance.

Regulatory impact assessments evaluate the effectiveness of mandatory standards, the costs of complying with them and enforcing them, and their impacts on competition, among other aspects. A good regulatory impact assessment uses a risk-based approach to assess disproportionate burdens on small firms or favoritism toward incumbents (refer to box 8.3). It examines the nature of requirements, alternatives like market-based policies, and whether a country's quality infrastructure can support assessment of compliance.

Box 8.3 Conducting cost-benefit analyses to assess the regulatory impact of mandatory standards

When are standards and technical regulations effective policy instruments? There are two rules of thumb regarding when mandatory standards may be preferable to other policy instruments. One is when uniform compliance is needed (especially in regard to safety standards, to avert costly risks). The other is when enforcing compliance and achieving compliance are easier with the help of standards. Of course, the decision to use mandatory standards is more difficult in low-capacity environments. One of the most common and useful instruments for assessing regulatory impact is cost-benefit analysis, a systematic way of quantifying, in monetary terms, and comparing the total expected costs and benefits of an intervention.^a Countries should systematically conduct cost-benefit analyses before deciding to employ mandatory standards and use the analyses for policy evaluation after the standards have been introduced.

Mandatory standards have a reputation for being overly prescriptive, costly to implement, and difficult to enforce.^b However, depending on the costs they prevent, they can still be the most cost-effective policy instrument. Cost-benefit analysis helps in making the necessary assessments to decide whether this is the case in any particular situation. A proper cost-benefit analysis can be demanding, because it requires reliable data, trained officials, and a commitment to using its findings in policy making. Figure B8.3.1 provides an overview of the main types of direct and indirect costs and benefits that should be included in an analysis of the impact of mandatory standards.

Five key choices are important when comparing mandatory standards with policy alternatives through cost-benefit analysis. The first is deciding how much to value the future versus the present, reflected in the “discount rate.” The choice made here can be significant, especially in regard to long-term costs like those associated with climate change.^c Second, policy makers must determine and assign a value to society’s risk tolerance. Third, they need to assign a “price tag” to nonfinancial costs and benefits. For example, how much is it worth to save one human life from a risk or disease or one species from extinction? Fourth, as shown in the central part of figure B8.3.1, many costs and benefits are indirect, and policy makers must decide to what extent these indirect effects are included: the “boundaries of analysis.” Although indirect effects often are not fully included in a cost-benefit analysis, this can lead to underestimating of systemic risks.^d It is important to understand the limitations of the cost-benefit analysis in this regard. Fifth, policy makers need to decide whether and how to account for distributional effects, because cost-benefit analyses typically indicate only the overall net benefits of a policy choice.

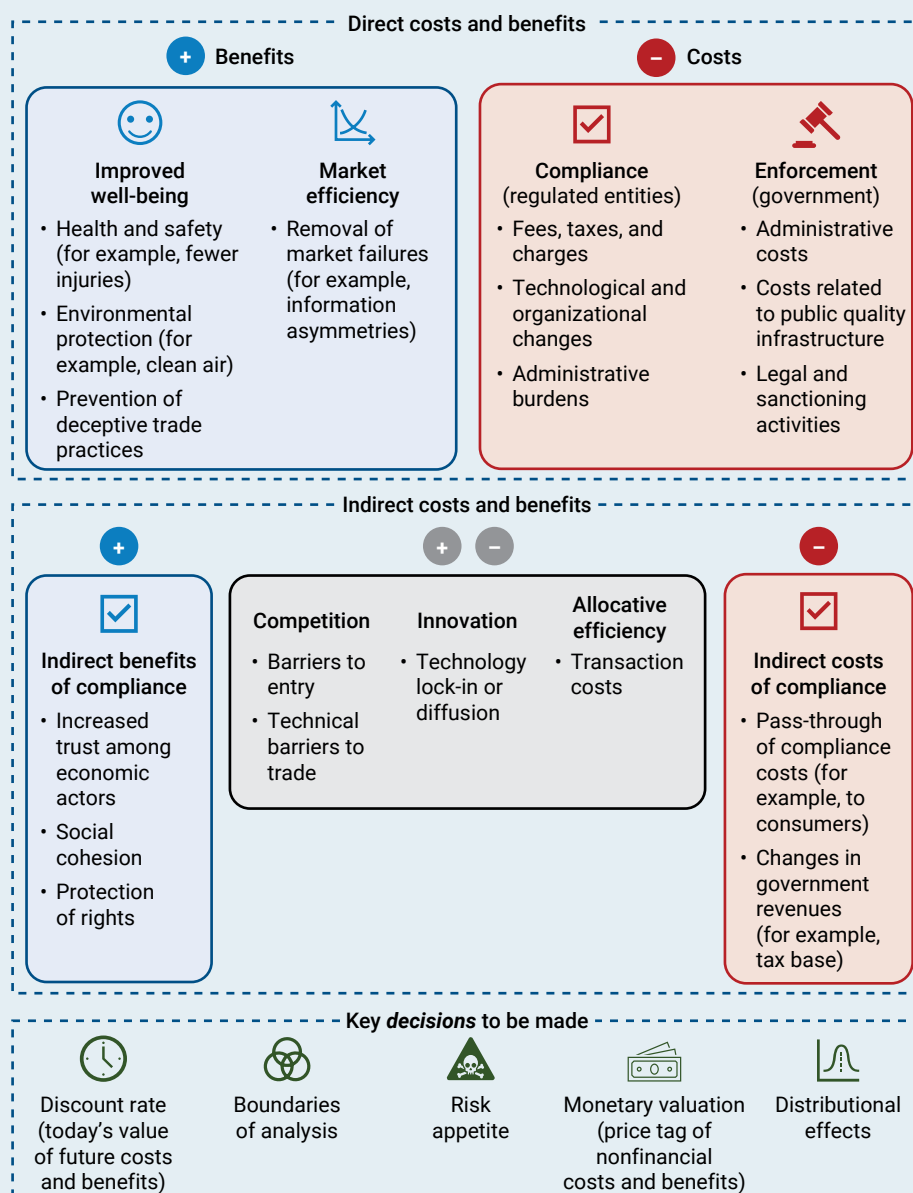
As this Report notes, data on standards are lacking, which makes the assignment of numerical values to costs and benefits difficult. Therefore, there is a demand to collect more data, for example, through monitoring and evaluation of the effectiveness of mandatory standards. Such after-the-fact evidence can provide important guidance for conducting before-the-fact cost-benefit analysis and improve policy making. This chapter therefore includes an appeal to collect more data on standards.

(Box continues next page)

Box 8.3 Conducting cost-benefit analyses to assess the regulatory impact of mandatory standards *(continued)*

The main challenge in assessing impact is knowing what would have happened without a particular standard, but comparing data before and after a standard is introduced, or between regulated and unregulated entities, can help approximate this counterfactual.

Figure B8.3.1 Key components of a cost-benefit analysis for mandatory standards



Source: WDR 2025 team.

(Box continues next page)

Box 8.3 Conducting cost-benefit analyses to assess the regulatory impact of mandatory standards (*continued*)

Governments can use the administrative data they already collect, such as tax filings, procurement records, and inspection logs, to evaluate whether mandatory standards are delivering results. Strengthening the quality, accessibility, and linkage of these data sets enables real-time monitoring and evidence-based evaluation, helping governments measure not just compliance, but the real economic and social benefits of regulation.

Source: WDR 2025 team.

- a. OECD (2014, 2015, 2020).
- b. OECD (2015).
- c. Weitzman (2011).
- d. OECD (2015).

Require all sectoral regulators and other government bodies to use quality infrastructure consistently

Many regulatory authorities, including environmental protection agencies, labor inspection bodies, consumer protection agencies, and financial oversight agencies, establish and enforce mandatory standards. However, most of these authorities do not consistently apply principles related to quality infrastructure to improve regulatory design and enforcement. Instead of relying on existing standards and methods of conformity assessment, they create their own rules and new requirements governing testing and certification, which often do not align with good international practices. They also operate their own testing laboratories, often without accreditation. This results in inefficient use of limited public resources. For example, in some countries, companies complain that they are frequently visited by multiple government agencies conducting the same tests for water pollution, each using their own laboratory. This unnecessary duplication causes inefficiencies, especially when expensive laboratory equipment is in short supply.

Developing a framework for technical regulation can establish the institutional, legal, and procedural structures needed for countries to oversee how mandatory standards (technical regulations) are created, implemented, and enforced. Such a framework might require regulatory authorities to base regulations on available international standards whenever possible, aligning with the WTO's Agreement on Technical Barriers to Trade. It also clarifies how standards are to be incorporated into legislation. Additionally, the framework should include a predefined menu of conformity assessment approaches for regulators to choose from, depending on the level of risk associated with noncompliance with a particular regulation or standard. The approaches may specify who assesses conformity (for example, a third party), how (for example, product testing or factory inspection), and when (for example, during product design or manufacturing process). For instance, an environmental protection agency might mandate third-party testing by accredited laboratories for high-risk industries to verify wastewater quality while using simpler procedures like self-declaration of conformity for lower-risk activities such as waste segregation (refer to chapter 3).

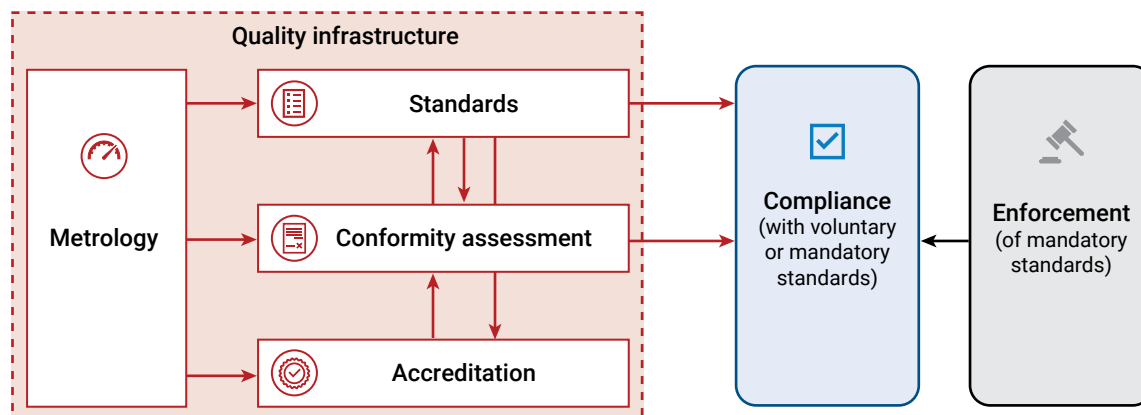
Predefined approaches for conformity assessment allow regulators to select appropriate compliance methods while ensuring those methods are harmonized across government agencies. This enables regulatory entities to share laboratory resources and use private testing, inspection, and certification bodies more strategically. In India, the central government issues Quality Control Orders to require that certain products meet Indian Standards, with conformity assessment conducted by the Bureau of Indian Standards.¹⁰ Although ministries have the discretion to decide which products within their areas of responsibility to regulate and when to issue Quality Control Orders, the harmonized framework for issuing such orders promotes a more consistent approach to technical regulation across sectors.¹¹ The African Continental Technical Regulatory Framework, adopted in 2024, aimed at encouraging the use of regulatory frameworks in countries across the continent, reflects a positive trend in the direction of a more systematic approach to issuing technical regulations.¹² Meanwhile, sectoral regulators may resist frameworks for technical regulation because they are concerned

about their autonomy, making strong leadership essential to mainstreaming principles related to quality infrastructure.

Use quality infrastructure to realize the full potential of standards

As chapter 3 advocates, low- and middle-income countries should invest in a well-functioning system of quality infrastructure, which comprises four core interrelated elements: metrology, conformity assessment (testing, inspection, and certification), accreditation, and standards themselves (refer to figure 8.3). But how can low- and middle-income countries build quality infrastructure effectively? As the discussion that follows indicates, they should sequence the development of quality infrastructure according to market demand and national priorities; develop capacity for compliance assessment through public-private partnership; and collaborate internationally to give stakeholders access to quality infrastructure services, which does not mean that all required capacities must be available domestically.

Figure 8.3 Compliance with standards depends on a quality infrastructure system that functions well



Source: WDR 2025 team.

Sequence the development of quality infrastructure according to market demand and country preferences

Effective implementation of voluntary standards and enforcement of mandatory standards depends on well-functioning quality infrastructure: a system of public and private institutions that includes the four core elements noted earlier and (for regulated areas) market surveillance (refer to chapter 3). Advancing quality infrastructure in a country requires a sequence of actions.

1. First, countries should establish core quality assurance functions: oversight of national standards; basic metrology; and testing, inspection, and certification services. The institutions providing these functions form the foundation for further elements of a country's quality infrastructure system. At this stage, services are typically publicly funded and operated, because of their nature as public goods and limited commercial viability. A key goal is to build capacity in the public sector for, among other things, international cooperation to establish the traceability of measurement standards and the adoption (or adaptation) of international standards.
2. Second, as domestic markets expand and trade integration progresses, quality infrastructure must develop to meet more complex demands, requiring the creation of an accreditation function to increase the credibility of conformity assessments for international trade. This also includes entering into mutual recognition agreements to strengthen the international validity of the results of conformity assessments.
3. Third, over time, responsibilities for testing, inspection, and certification should transition from the public to the private sector, with market demand and sector-specific needs driving investments in quality

infrastructure to ensure the infrastructure developed is relevant and operates efficiently. Although governments can support the private sector through subsidies, these should be carefully tailored in response to market failures, not to particular business interests.

Develop capacity for compliance as a public-private partnership

For quality infrastructure to be effective, the specific roles of the government and the private sector must evolve over time. Initially, governments may need to provide testing and certification services because limited market demand prevents these services from being commercially viable. But over time, as private providers of quality assurance start to become available, governments should shift their focus to their regulatory and oversight functions. Public institutions, which may have become dependent on revenues from conformity assessment services or perceive these services as part of their regulatory mandate, may find the transition to regulation and oversight difficult. Some government bodies also consider it their responsibility to provide affordable testing, inspection, or certification services as a form of industrial policy, for example, to help small and medium enterprises expand their access to international markets. Offering demand-side incentives, like subsidizing firms' certification costs, however, is generally preferable to government provision of services.¹³ Such a strategy increases demand and fosters a competitive market for private services in the area of conformity assessment, promoting long-term efficiency and sustainability.

Focus on the availability of quality infrastructure, not the location

State capacity is a major limiting factor in many low- and middle-income countries. Thus, these countries should leverage both international and

domestic resources to raise their standards. Firms in these countries often send product samples abroad for testing, especially when international buyers require certification from recognized conformity assessment bodies. This method can be effective and commercially practical. However, it can pose challenges when testing is urgent, shipping logistics are difficult, or the exports being tested are perishable goods or bulk commodities traded on tight schedules. For many low- and middle-income countries and small economies, regional or bilateral cooperation provides a cost-effective alternative, especially for expensive and specialized services like accreditation and scientific metrology.¹⁴

Domestically, governments should strengthen and involve professional organizations—whether scientific and engineering societies or those in accounting, education, or medicine, as well as industry groups—in developing and updating standards. These professional organizations often operate their own codes of conduct or liability norms, motivating companies to manage risks even without strict government oversight. Moreover, insurance and tort law can be used instead of (or alongside) enforcement of mandatory safety standards through government inspectors. Improving education and infrastructure in universities can foster a deeper understanding of the importance of standards and quality infrastructure and help build a stronger domestic system of testing laboratories. Finally, governments should encourage civil society to act as quality watchdogs and encourage it to do so, as when, for example, consumer protection organizations offer independent testing and certification.

Leverage digital tools for better quality infrastructure

Low- and middle-income countries, in particular, can benefit from leveraging digital technologies to make quality infrastructure more accessible

and cost-effective. Digital solutions can help these countries overcome geographic and capacity constraints, for example, by enabling remote audits or digital submission of results of conformity assessment. They also enhance traceability through use of tamper-resistant blockchain-based recordkeeping and interoperable data platforms that connect laboratories, accreditation bodies, and regulators. Publicly accessible databases can further strengthen trust by allowing users to verify the validity of certifications and identify accredited providers. Moreover, regulators can harness online information, such as consumer reviews or product data from e-commerce platforms, to detect emerging risks and target their enforcement activities more efficiently. Digital tools can also facilitate firms' adoption of standards by providing online guidance, training modules, and self-assessment tools to increase firms' compliance with international requirements. To realize these benefits, however, countries must invest in robust digital infrastructure, human capital, and governance frameworks that ensure data security, interoperability, and trust across national systems.

Recommendations for the global community

Develop international standards that better serve low- and middle-income countries

Support low- and middle-income countries in the process of developing international standards—or risk low uptake

Advanced economies should support a stronger role for low- and middle-income countries in the development of international standards, not only to make standards development more effective, but also to ensure there is greater uptake of standards globally. This is already a key principle in ISO's Good Standardization Practices.¹⁵ And several

initiatives have been launched to provide more support to low- and middle-income countries, including the ISO Committee on Developing Country Matters (DEVCO), which provides technical assistance and training to low- and middle-income countries.¹⁶ The Food and Agriculture Organization of the United Nations (FAO) and World Health Organization (WHO) Codex Trust Fund, which focuses on strengthening National Codex Committees, is a similar initiative. But progress on strengthening the involvement of low- and middle-income countries remains slow, and participation among countries at different income levels is still structurally imbalanced.

There are no easy solutions. A requirement stipulating that low- and middle-income countries should lead a defined number of technical committees runs up against the need for expertise in deep technical matters and the comparative lack of such expertise in these countries. Setting up a fund that financially supports the development and implementation of international standards in low- and middle-income countries runs into the perennial challenge of scarce financial resources. A more promising approach is to give DEVCO the mandate to systematically review and comment on draft international standards from the perspective of low- and middle-income countries, focusing on feasibility, implementation capacity, socioeconomic impacts, and alignment with development goals, especially if its role is confined to flagging barriers, suggesting adjustments, and promoting pathways for phased adoption as needed. But the approach also runs into a growing challenge from the fact that many standards in emerging technologies are being developed in other (private) forums. Twinning programs that link national standards bodies from high-income countries with those in low- and middle-income countries can build capacity in the latter group to participate meaningfully in the work of technical committees.

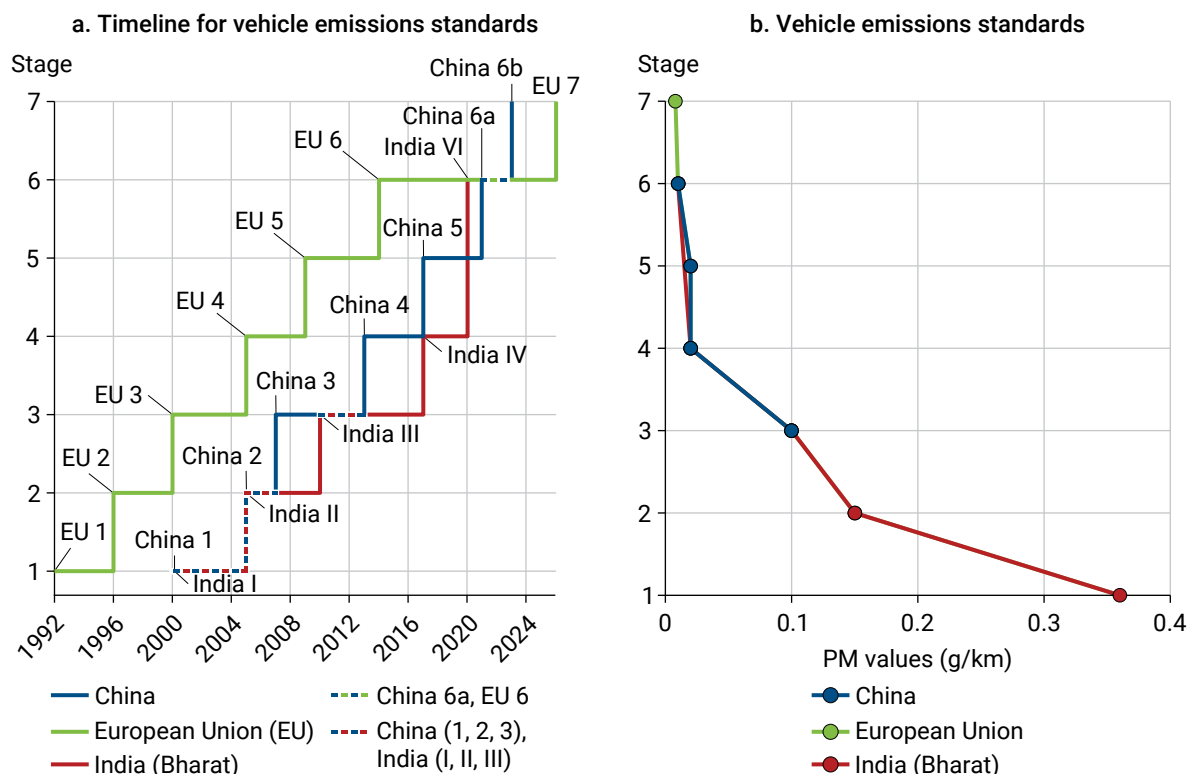
In addition to strengthening low- and middle-income countries' participation in international

standard setting, there is a parallel need to build and enhance their quality infrastructure systems. As this Report emphasizes, well-functioning quality infrastructure is essential for the effective implementation of standards and for achieving a wide range of policy objectives, from consumer protection and industrial upgrading to environmental sustainability and trade facilitation. Yet many low- and middle-income countries face persistent constraints in the areas of technical expertise, institutional capacity, and financing. Establishing national metrology institutes, gaining international recognition for national accreditation bodies, and fostering a dynamic network of conformity assessment services all require sustained investment and coordination. Although several development partners already provide targeted assistance for these types of activities, greater and more coherent support is needed to help low- and middle-income countries fully leverage standards and quality infrastructure as enablers of sustainable development and competitiveness.

Promote tiered standards to match different capacities

The selective use of *tiered standards* can help low- and middle-income countries implement international standards. Tiered standards either apply different levels of stringency to the same standard (refer to figure 8.4) or follow a more modular approach that allows for gradual adoption of several standards that build on one another, with the international standard typically being the highest of these standards. As standards for vehicle emissions indicate (refer to figure 8.4), even the EU took a tiered approach, one that China and India subsequently followed. Using a tiered approach for adapting standards has many benefits, including that standards at all tiers share the same underlying terms and definitions as the corresponding international standard, which eases conformity assessment. Moreover, an organization that complies with a standard at a higher tier automatically

Figure 8.4 Standards governing vehicle emissions and air pollution in China, India, and the European Union followed a tiered approach to stringency



Sources: China: Emission Standards, China: Heavy-Duty Engines (dashboard), DieselNet, <https://dieselnet.com/standards/cn/hd.php>; ICCT 2017. European Union: Emission Standards, EU: Heavy-Duty Truck and Bus Engines (dashboard), DieselNet, <https://dieselnet.com/standards/eu/hd.php>. India (Bharat): Emission Standards, India: Heavy-Duty Truck and Bus Engines (dashboard), DieselNet, <https://dieselnet.com/standards/in/hd.php>; data as of September 7, 2017, from Vehicular Exhaust (web page), Central Pollution Control Board, Ministry of Environment, Forest and Climate Change, India, <https://cpcb.nic.in/vehicular-exhaust/>.

Note: The emissions standards in the figure are those for heavy-duty vehicles (those with compression ignition engines) for steady-state testing. EU = European Union; g/km = grams per kilometer; PM = particulate matter.

complies with those at lower tiers, increasing the likelihood of mutual recognition of the results of conformity assessment. However, it is important to limit the number of tiers—ideally, already built into the international standard—to ensure that such a tiered approach itself does not contribute to fragmentation. In principle, it may be better for countries to use tiered standards as guidance and not make them certifiable standards.

There are several examples of tiered standards. For example, ISO 50005 gives organizations guidance on establishing a phased approach for

implementing an energy management system that targets, in particular, small and medium enterprises. The development of such standards could be promoted to ease compliance. Rwanda offers another good example. Through its Zamukana Ubuziranenge (“Grow with Standards”) program, the Rwanda Standards Board introduced a Standards Implementation Maturity Model that helps micro, small, and medium enterprises assess their current practices, receive targeted technical assistance, and progressively comply with international norms. Since its launch in 2017, the program has reached more than 1,000 micro, small, and

medium enterprises, many of them women- and youth-led, improving product quality, enabling certification, and supporting entry into regional and global markets.¹⁷

Ensure that well-intended standards do not become barriers to development

Deepen international regulatory cooperation

The issues people care about shift over time. As incomes rise, consumers look beyond price to safety, ethics, and environmental impact. For years many firms have ignored the environmental costs of production processes, requiring the public to foot the bill for things such as pollution cleanup and management of waste, but with clearer evidence of long-term risks, a consensus is emerging that it is cheaper to prevent harm now than to pay for it later. Progress of this kind leads to a steady increase in both mandatory and voluntary standards, as policy makers try to find ways to make firms reduce the environmental harms they cause or at least bear the costs of mitigating them. Even if countries have no protectionist intent in enacting such standards, the expansion of regulated areas and the increasing complexity of technologies and commercial relationships can still disrupt trade.

The EU's Regulation on Deforestation-free Products illustrates this point. Designed to reduce the impact of the production of major commodities on forest loss, it requires detailed traceability and proof of deforestation-free production. Yet this well-intentioned regulation has considerable impact on even remote farmers in Brazil, Ethiopia, and Indonesia. As discussed, to avoid having domestic regulations affect international trade is why the WTO has formed agreements such as that on technical barriers to trade and has established measures to promote transparency such

as requirements that member countries inform other WTO members about and provide drafts of upcoming technical regulations. In 2021, the Organisation for Economic Co-operation and Development (OECD) formulated Best Practice Principles on International Regulatory Co-operation, urging policy makers to draw on international standards, justify deviations from them, assess cross-border impacts of regulations they put in place, engage international partners early, recognize foreign procedures for compliance, and pursue mutual recognition.¹⁸ Initiatives such as the ones undertaken by ISO and the WTO, as well as the forums provided by these organizations and others like them, remain essential, but more is needed to ensure that standards and regulations in other countries do not affect low- and middle-income countries negatively.

First, although the stringency of mandatory standards can be left to domestic regulators, the global community should increase efforts to establish shared terminologies, measurement standards, and compliance approaches. Many deviations from international standards are unintentional and can be traced to the complexity of modern life. International coordination can add another layer of complexity and costs for policy makers. International standards are therefore essential, especially as a means for agreeing on common terminology and basic principles. For example, a major benefit of Codex Alimentarius was to provide shared definitions such as basic frameworks for food hygiene and methods for testing for salmonella contamination and not just the quantitative specification of Maximum Residue Levels. In many areas, there is a major gap in agreeing on international definitions. For example, many terms in the field of environmental sustainability are not clearly defined. Initiatives such as the proposed Codex Planetarius, which aims to introduce sustainability standards for globally traded food and commodities, could increase regulatory coherence.¹⁹

Second, building trust between countries is crucial as the basis for their recognizing one another's compliance mechanisms. For this, low- and middle-income countries need more support for establishing trustworthy and internationally integrated quality infrastructure systems that enable mutual recognition of the results of testing, inspection, and certification (refer to chapters 3 and 4). Whereas donor support for quality infrastructure systems in low- and middle-income countries often focuses on the competitiveness of these countries' exports, strengthening the role of quality infrastructure in regulations is also essential to prevent future nontariff barriers from being enacted and reducing existing ones.

Third, in emerging regulatory areas like AI and gene editing, international cooperation on regulatory sandboxes is important. Regulatory sandboxes typically allow regulatory requirements to be relaxed temporarily in a controlled environment (involving things such as increased government oversight) to enable learning regarding policies, particularly in the area of emerging technologies.²⁰ Shared standards on how to design, implement, and evaluate regulatory sandboxes can help align standards and regulations across countries.

Tidy up the spaghetti bowl of standards

This Report shows that although the recent increase in voluntary standards and certification schemes can complement public regulation, the resulting spaghetti bowl of overlapping schemes can create confusion, undermine credibility, and increase compliance costs, particularly for firms in low- and middle-income countries. Many schemes in areas like food safety and sustainability operate outside formal quality infrastructure systems: They often employ standards that have not been developed by recognized bodies, and certification of compliance with these standards may not rely on accredited conformity assessment, limiting trust and international recognition.

The requirements imposed by these schemes are driven more by what consumers and policy makers in high-income countries demand and less by the development needs of lower-income countries, so bargaining power is heavily loaded in favor of the former. Initiatives like the Global Food Safety Initiative, the credibility principles of the ISEAL Alliance, and Better Work attempt to benchmark private schemes against good practices and reduce duplication.²¹ Still, stronger multilateral collaboration is needed to increase the credibility and interoperability of voluntary schemes. An initiative of the United Nations Industrial Development Organization (UNIDO) to establish a global mechanism for benchmarking of voluntary certification schemes marks a promising first step, but its impact as yet is unclear.²²

Credible voluntary standards for sustainability can play an important complementary role in helping low- and middle-income countries achieve policy objectives, particularly those countries where public compliance and enforcement capacity are limited. Many such standards include requirements that mirror national laws, such as adhering to minimum wage provisions or respecting core labor rights, and depend on trained third-party auditors to verify compliance. In doing so, they expand the reach of public oversight and help bridge implementation gaps in instances in which governments face resource or institutional constraints. Ensuring the credibility of these standards is crucial, as they are increasingly used to support emerging regulatory frameworks (refer to chapter 4). For example, the EU's Regulation on Deforestation-free Products recognizes voluntary certification schemes as risk mitigation tools that companies may use to demonstrate they have exercised due diligence in preventing deforestation and ensuring legal compliance with the requirements of the regulation. However, these certifications do not replace firms' legal obligations or guarantee that they are compliant.

Amass more data and evidence

As this Report shows, standards are crucial for development and warrant further research. International organizations and academic institutions can do much in collecting more data and evidence on standards and quality infrastructure. For example, firm-level surveys could collect more information on the uptake of standards across different industries and firm types, enabling a better understanding of how the uptake of standards affects firm productivity and market access. Similarly, more data on quality infrastructure institutions could be collected to identify what models for quality infrastructure work well under what circumstances. Further research should also leverage existing administrative data to evaluate the impact of standards, both before and after implementation. Governments already have rich data sources, but these data sources are not often systematically used as sources of knowledge.²³ Tapping into administrative data could help inform better decisions on how best to use standards as a regulatory tool.

Tackle global challenges

Set and comply with standards now—or face crises later

Mandatory standards are particularly useful when the costs of prevention are lower than the costs of correction, once compliance and enforcement are considered (refer again to box 8.2). Today, the global community faces a rising wave of systemic risks that could have catastrophic or irreversible long-term costs (or both). These include climate change and biodiversity loss as well as the unchecked spread of transformative technologies like AI, gene editing, and social media.

At the root of these harms lies innovation that outpaces governance, with costs that are shifted onto society and nature. For example, the chemicals industry has identified about 15,000 different

types of per- and polyfluoroalkyl substances (PFAS), innovative chemicals that are ubiquitous in applications for water and stain resistance and non-stick capabilities (such as those involved in food packaging, cookware, and industrial processes). Because PFAS do not naturally break down, they are often referred to as “forever chemicals.” Once PFAS are in the environment, they are immensely expensive to clean up: They have been found on top of Mount Everest, in the bloodstreams of wildlife, and in drinking water across many countries. With growing awareness of the health risks associated with exposure to PFAS, such as cancer and other diseases, regulators are engaging in a game of Whac-A-Mole trying to regulate them. For example, in 2024 the US Environmental Protection Agency (EPA) set mandatory standards limiting the use of 6 PFAS (of the total 15,000) in drinking water.²⁴ The race between technology and managing its risks can be expressed in a simple statement: Whereas technology tells us what *can* be done, standards say what *should* be done.

The risks described here interact with and compound one another, which is why experts often refer to the current state of the world as a “poly-crisis.”²⁵ For example, although AI is expected to boost efficiency in economies, under the current incentive structure it will also boost the “efficient” extraction of natural resources like fossil fuels and accelerate unsustainable use of land and water. The data centers required for AI will require immense volumes of water and energy, straining natural ecosystems and impeding the transition to renewable energy sources. The International Energy Agency (IEA) estimates that AI will drive the electricity demand of data centers to about 945 terawatt-hours annually by 2030: roughly equivalent to the yearly power consumption of Japan.²⁶ Meanwhile, the deeper societal impacts of the widespread use of AI, including not only the job losses, but also the cognitive decline across population groups, are only slowly being understood.²⁷

In the past, many technological risks were confined to specific geographic areas or sectors. Today's risks are global, systemic, and fast moving. Geopolitical competition creates a game of chicken in which governments fear that slowing down will mean losing advantage, even though speeding up may lead everyone to catastrophe. At the same time, the distribution of costs and benefits is highly tilted: Whereas the gains are largely private and concentrated among a few large technology conglomerates, society bears the risks. Winner-takes-most dynamics reinforce this imbalance, allowing dominant firms to consolidate influence over markets and governance. For example, big technology firms are heavily influencing the development of standards for AI, as a recent report on development of such standards in Europe illustrates.²⁸

This warning is intended as a wake-up call to the global community. For transformative

technologies such as AI, which carry risks that are poorly understood and evolving faster than regulatory systems can adapt, it is sensible to follow the *precautionary principle*: If serious harm is possible, take preventive measures even if there is not yet full scientific evidence that confirms these risks. For example, if there appears to be a risk that social media use is as addictive for children as gambling or drugs and presents serious risks to their mental health, it makes sense to put in place safety standards to prevent such harm, even as society awaits additional research confirming the risks. Similarly, AI systems used in sensitive areas such as hiring, education, or medical diagnostics should be subject to mandatory testing and certification to ensure transparency, fairness, and accountability before being rolled out to entire populations like large-scale social experiments. In short, it is sensible to implement standards before harm becomes irreversible.

Notes

1. Refer also to OECD (2021b).
2. Park and Gachukia (2021).
3. ISO (2021b).
4. Refer also to OECD (2025a).
5. Directive 2014/30/EU of the European Parliament and of the Council of 26 February 2014 on the Harmonisation of the Laws of the Member States Relating to Electromagnetic Compatibility (Recast), Annex I, Section 1, item (a), European Union, <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02014L0030-20180911>.
6. For further explanation on this, refer to, for example, BMWi (2021).
7. BMWi (2021).
8. ISO (2023).
9. The content of a standard is often protected by copyright, and reproduction without proper authorization is prohibited.
10. The central government assumes this role in areas in which no sector-specific regulatory body has been established.
11. Kaul (2025).
12. Budoo (2025).
13. Kellermann (2019).
14. Miesner (2009).
15. ISO (2019).
16. ISO (2021a).
17. Refer to <https://www.rsb.gov.rw/services/about-zamukana-ubuziranenge-zu-program/description-zu>.
18. OECD (2021a).
19. Refer to Codex Planetarius: To Reduce the Environmental Impacts of Food Production (portal), Markets Institute, World Wildlife Fund, <https://codexplanetarius.org/>.
20. OECD (2025b).
21. In food safety, the industry-driven Global Food Safety Initiative established a benchmarking system to enable recognition of similar certification schemes as equivalent (Havinga and Verbruggen 2023; Henson 2025). The ISEAL Alliance was formed to facilitate collaboration on credible practices for voluntary sustainability systems, creating values defined in the ISEAL Credibility Principles and implementable definitions in the ISEAL Code. Refer to ISEAL Alliance (dashboard), <https://isealalliance.org/>. For labor standards, Better Work, a collaboration between the International Finance Corporation (IFC) and the International Labour Organization (ILO), reduces repeat audits of labor conditions in the apparel and garment industry by offering shared assessments that brands can use.
22. Refer to QI4SD: Quality Infrastructure for Sustainable Development Index—About (web

- page), Knowledge Hub, United Nations Industrial Development Organization, <https://hub.unido.org/qi4sd/about>.
23. Legovini and Jones (2020); Rogger and Schuster (2023).
 24. In the EU, five national authorities (those for Denmark, Germany, the Netherlands, Norway, and Sweden) submitted a proposal to the European Chemicals Agency (ECHA) to restrict the use of about 10,000 PFAS under a group approach (not one by one).
 25. Lawrence et al. (2024, 2) define “polycrisis” as “the causal entanglement of crises in multiple global systems in ways that significantly degrade humanity’s prospects.”
 26. IEA (2025).
 27. Kosmyna et al. (2025).
 28. CEO (2025).

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Standards make everyday life run smoothly. You rarely notice them: the credit card that works in any corner of the world, the Wi-Fi signal that connects a remote village to the cloud, or the vaccine vial that fits syringes from Dakar to Delhi. When standards work, they build trust. They free people and firms to focus on creating, trading, and innovating, confident that the systems around them will hold. When standards fail, the effects are immediate and draining. Payments are declined, signals drop, vaccines spoil—and instead of being productive, people spend their energy just meeting their basic needs.

Standards, in short, are the hidden infrastructure of modern economies—and they have never been more important. Developing countries today must contend with a thicket of increasingly stringent international standards, a product of globalization and rapid technological change. Using standards—and shaping them—is now a prerequisite for export growth, technology diffusion, and the efficient delivery of public services. Yet standards are too often overlooked by policy makers, especially in developing countries.

World Development Report 2025: Standards for Development provides the most comprehensive assessment of the global landscape of standards today and how they can be used to accelerate economic development. It offers a practical framework for countries at all stages of development. Countries at the earliest stage should *adapt* international standards to suit local conditions when needed, whereas at more advanced stages, they should aim to *align* domestic markets with international standards. Meanwhile, all countries should *author* international standards in priority areas.



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