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.

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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.

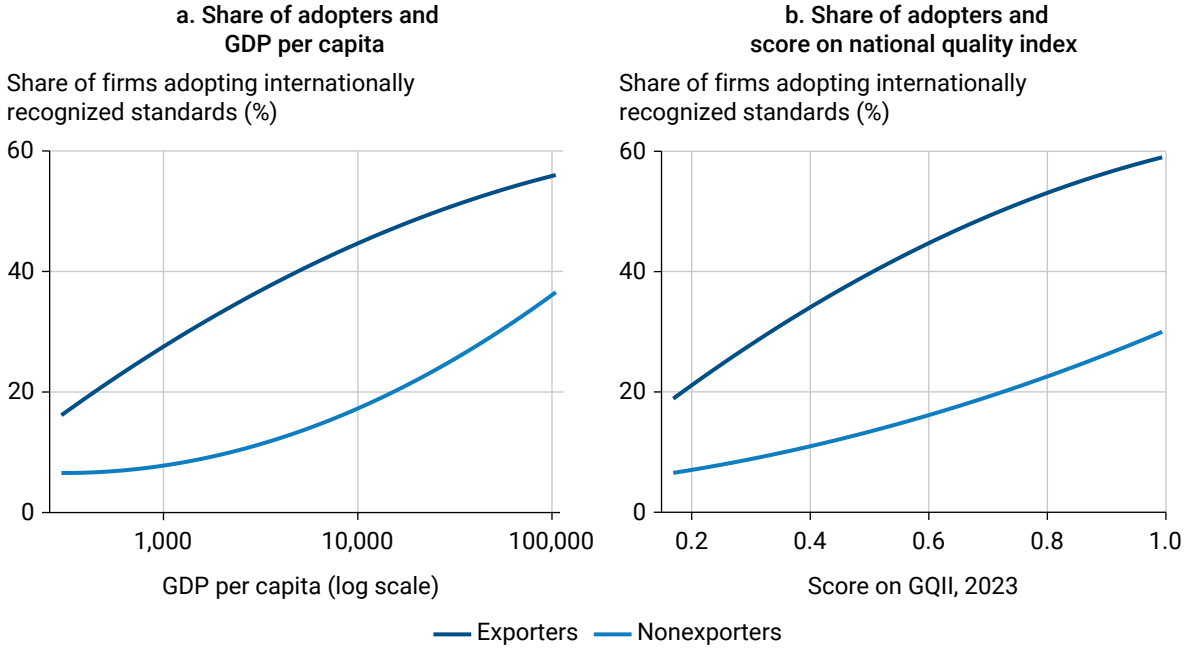
The adoption of standards in domestic economies

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 countries[2] 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 America[5] 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.

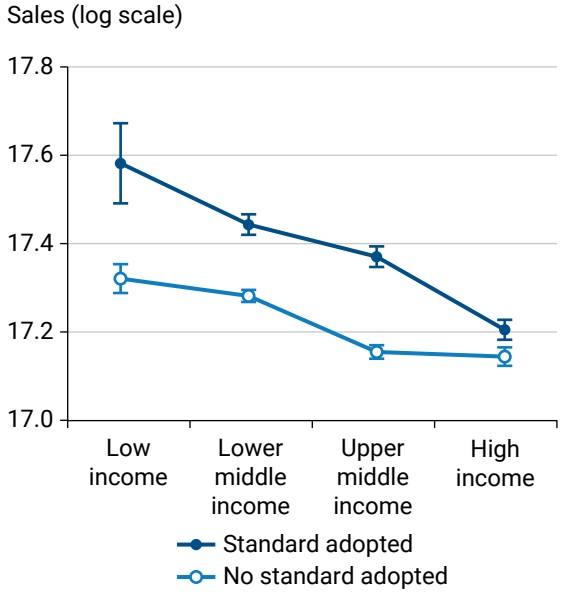
Note: The table summarizes results of 28 studies; 26 of these studies were peer reviewed, and the remaining 2 are working papers at international institutions. "Number of studies" represents the number of evaluation studies for an individual standard. Some studies evaluate more than one standard and, 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.enterprisesurveys.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.

a. 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/.

b. 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.

c. 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/.

d. 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).

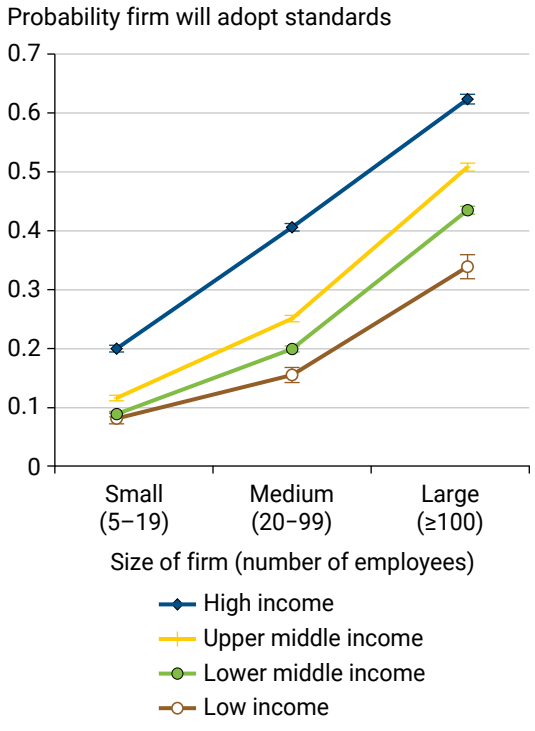
e. The year of the price data is unspecified but is likely 2023. Refer to Authentication Service Pricing and Fee Disclosure Information (website) [in Chinese], BSI Management Systems Certification (Beijing) Co., Ltd., British Standards Institution, https://www.bsigroup.com/globalassets/localfiles/zh-cn/pdf/2023/bsi2023.pdf.

f. 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/.

g. These are the prices as of late 2023. Refer to MB Certification México (2023).

h. 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); Gaigné 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

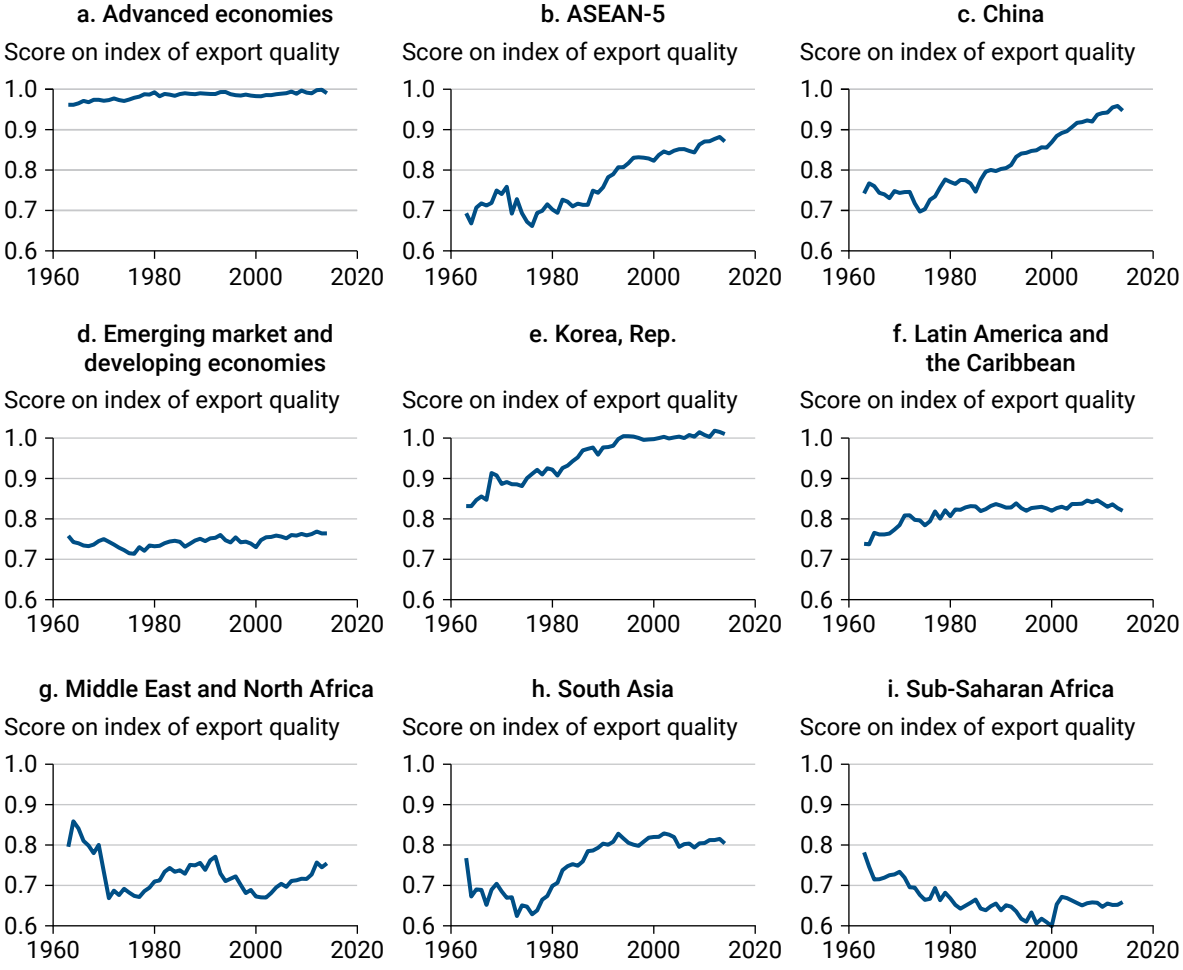
Many developing countries pursue fragmented industrial policies and maintain incentives misaligned with upgrading quality. When regulations result in less efficient or lower-quality firms receiving more resources than they would in a well-functioning market, or when operational costs are high, firms 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

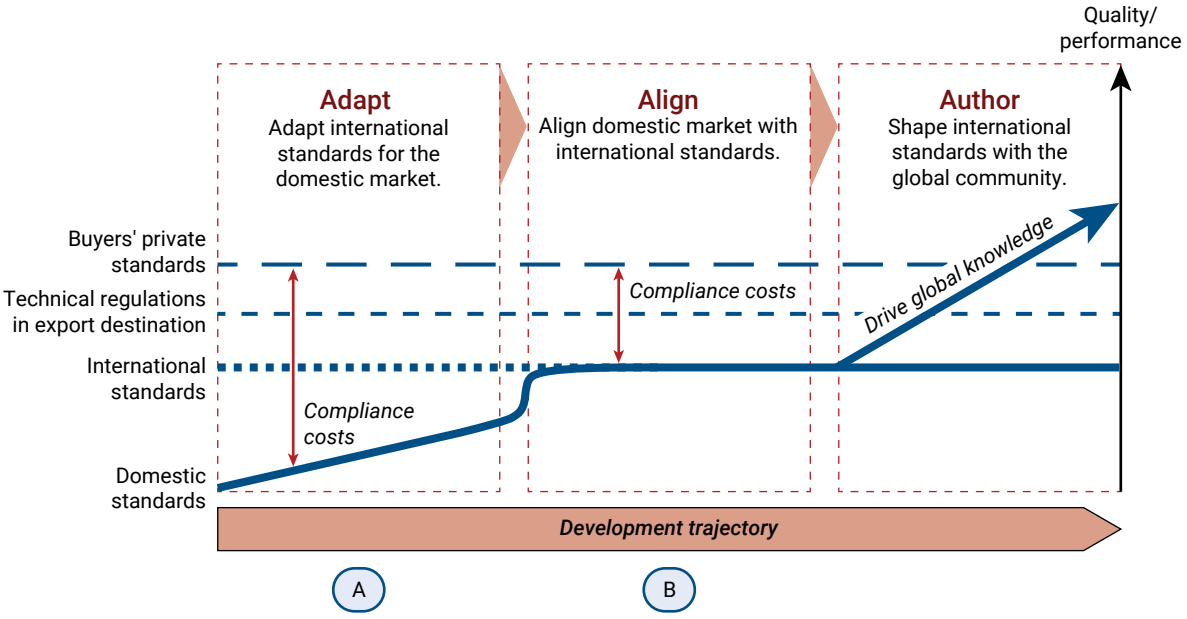


Source: WDR 2025 team, based on data from Henn et al. 2013.

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 WTO[30] 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 measures[32] 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.

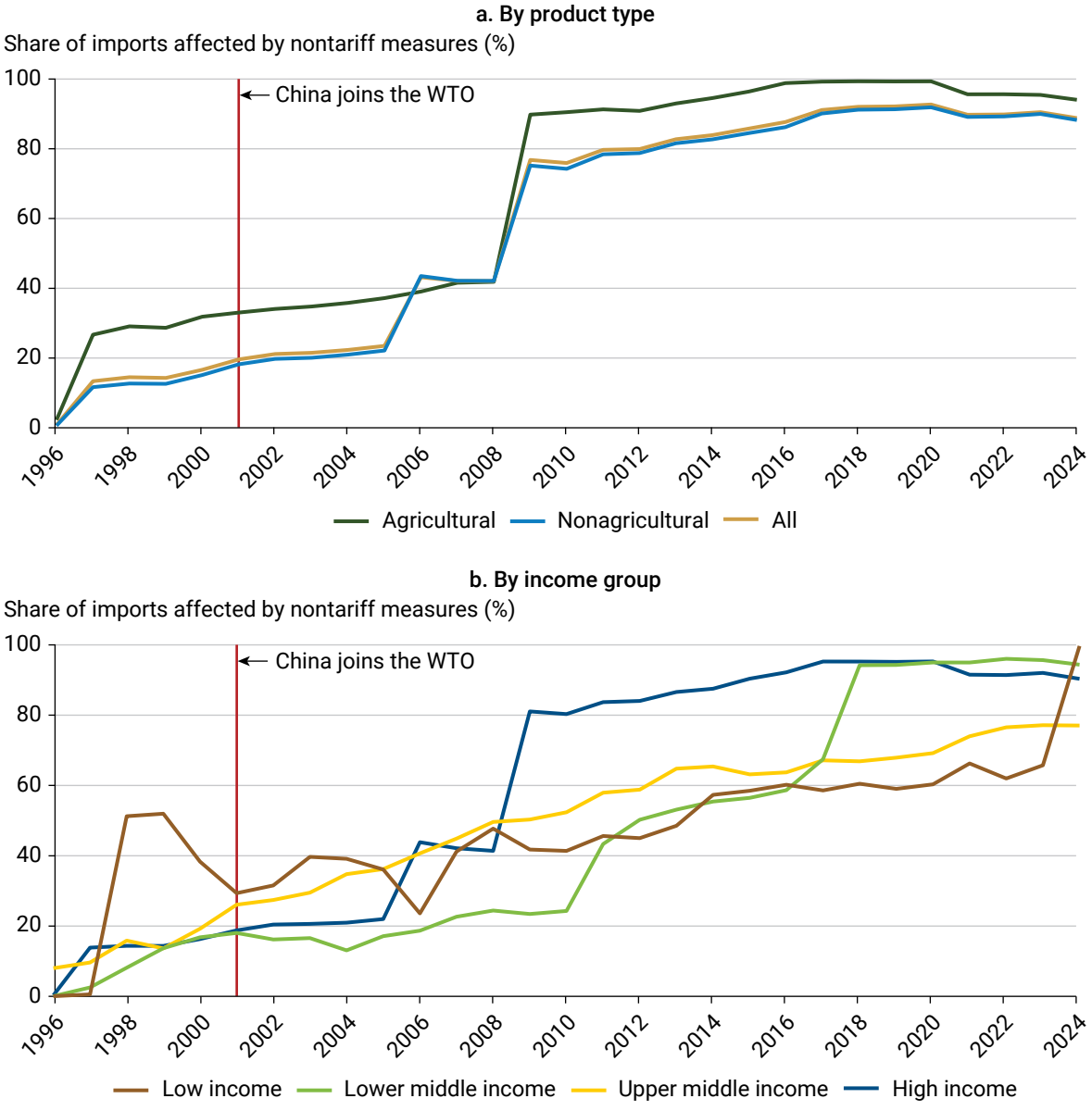
Veiled protectionism?

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/.

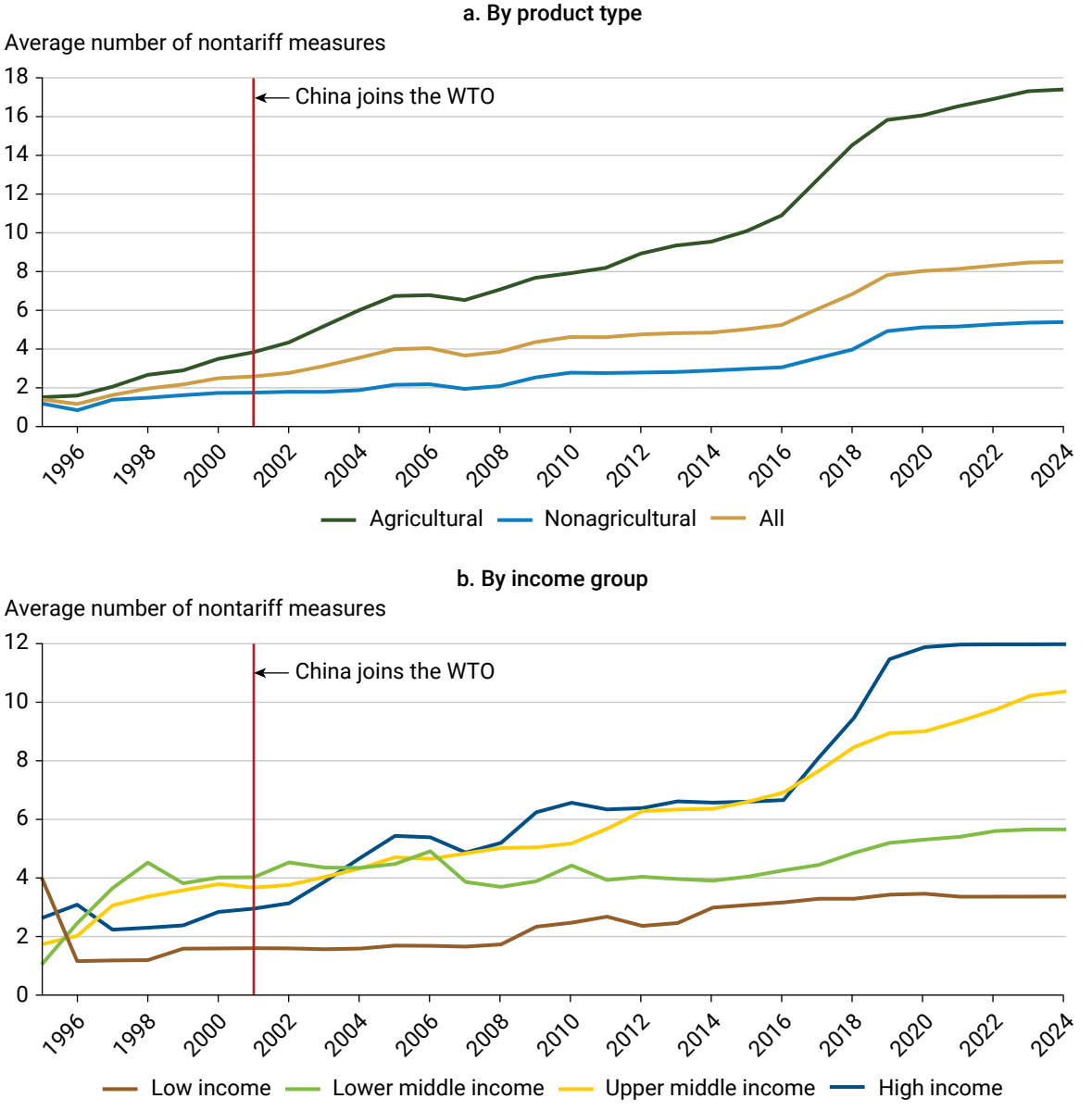
The main challenge for developing countries is not only the number of standards and regulations confronting them as they try to export goods and services but also the diversity and complexity of these standards and regulations. Rather than facing a single coherent rule book, exporters confront a spaghetti 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 Index[41] 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 nontariff 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

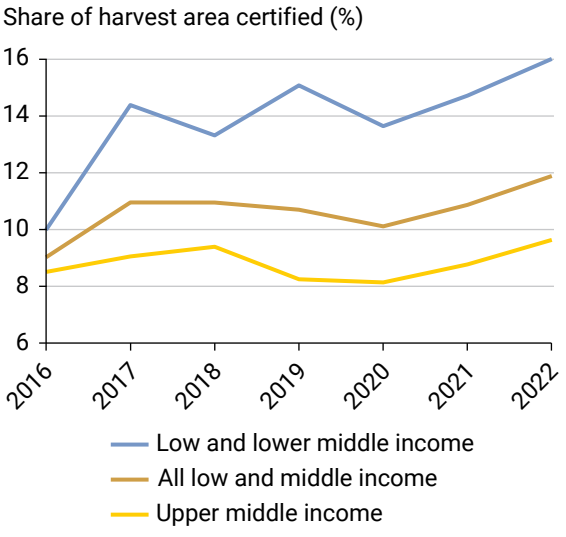
The rapid growth of private standards reflects increasing regulatory demands and consumer expectations. These standards, developed by nongovernmental organizations, industry groups, and global buyers, play a central role in global value chains, especially in countries where public capacity for enforcement 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 [Rountable 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 sustainably[46] 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 standards[61] or mutual recognition of standards among destination countries.[62]

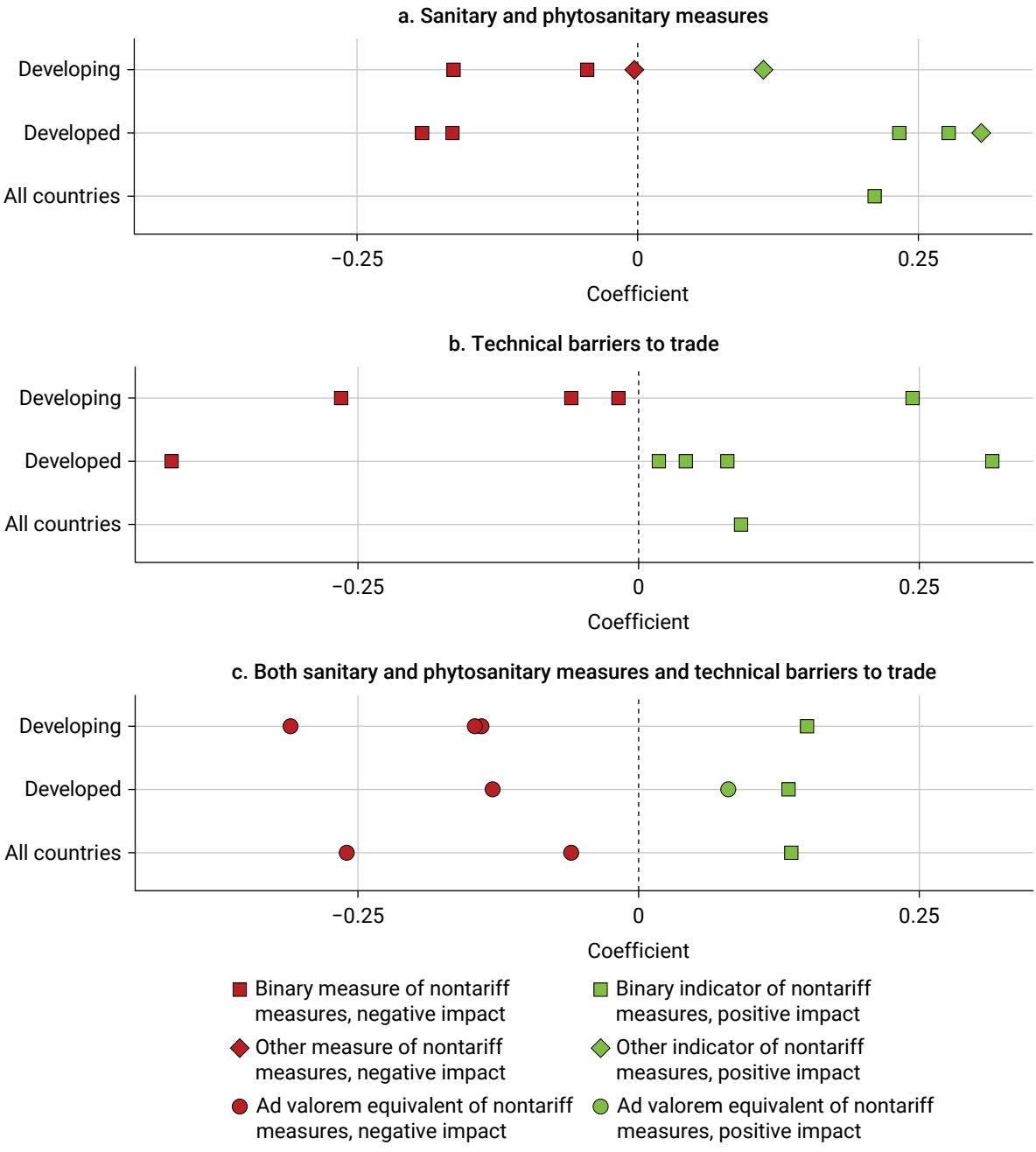
More recent evidence has focused on how increasing technical regulations in destination markets are influencing exports. The evidence generally finds a negative effect, especially in regard to developing countries (refer to figure 4.9). For example, sanitary and phytosanitary measures such as limits 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.

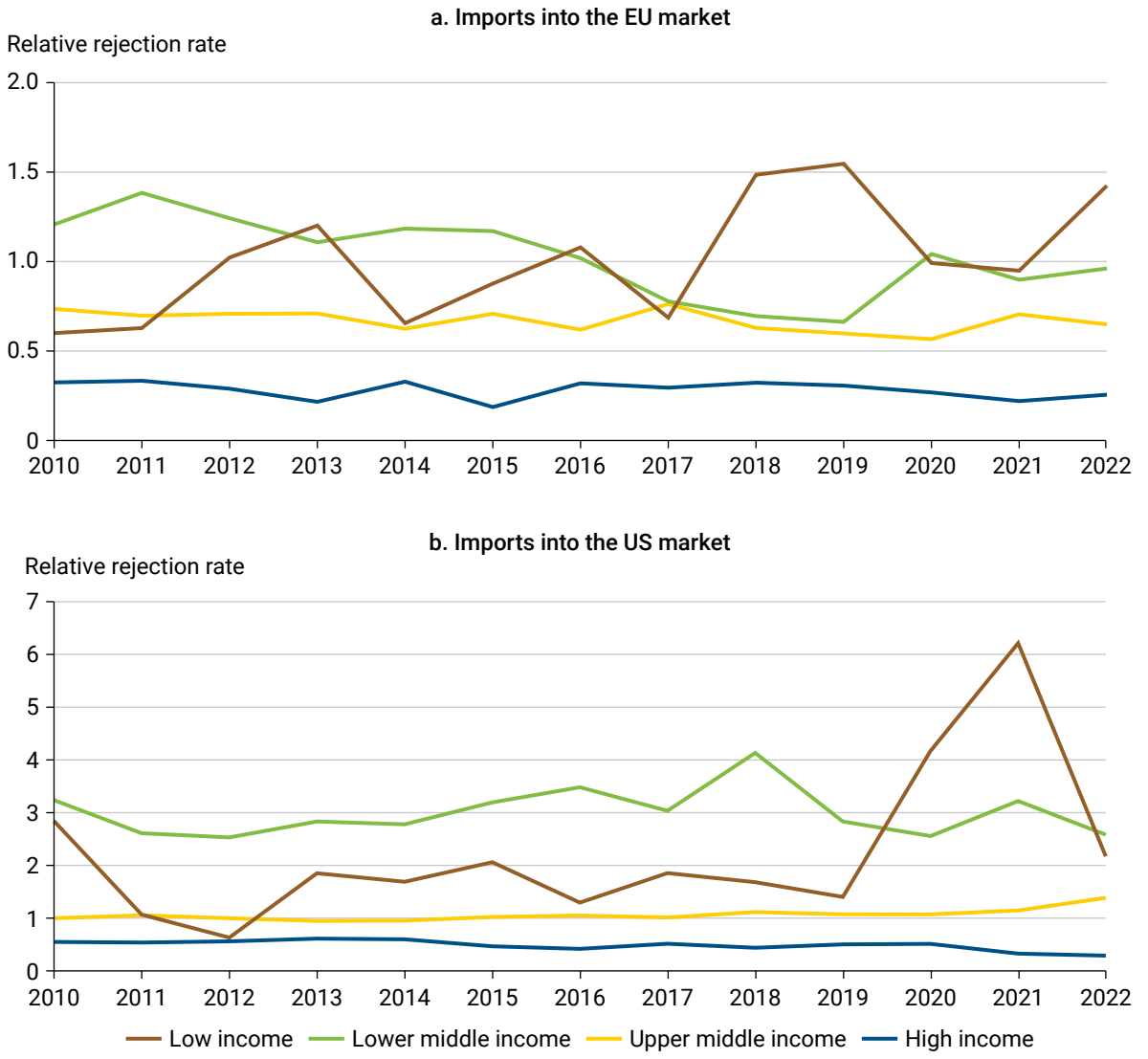
Figure 4.9 Technical nontariff measures generally have negative impacts on exports from developing countries



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 biodiversity[78] 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 China[89] 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

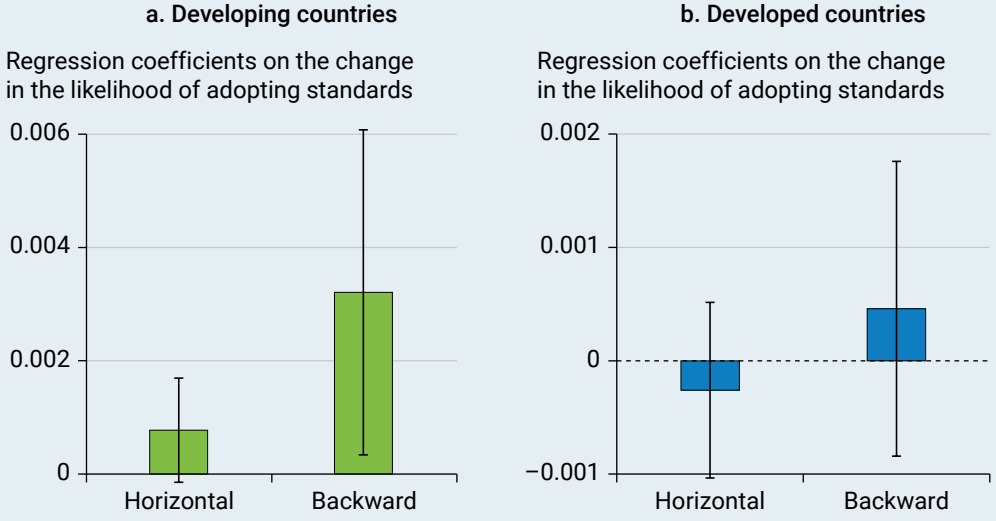
FDI can promote the adoption of international standards through multiple mechanisms. First, direct links between domestic and foreign firms, such as joint ventures and strategic partnerships, allow domestic firms to absorb the practices of multinational enterprises, which are often superior.[94] Second, 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 studies[101] 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 suppliers[102] 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 innovations[113] 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 underadoption 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 "infratechnology."[122] This includes the systems for measurement, testing, and reference that provide the technical foundations for production and innovation. Infratechnology 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

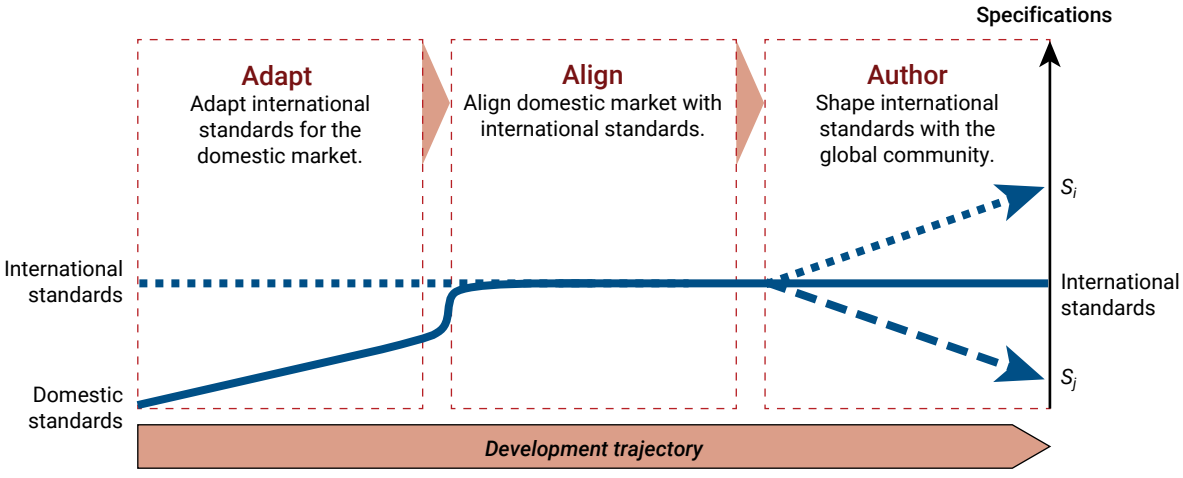
As mentioned earlier, most developing countries are standard takers rather than standard makers and have limited technical capacity and expertise to shape the standards they adopt or adapt. With this in mind, these countries should consider taking four actions in particular in regard to technology standards: 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. Tassey (2008, 2010).
123. Link and Scott (2001).
124. Link and Tassey (1988).
125. Bresnahan (2010).
126. G20 (2023), annexure 1.
127. Sankritik and Shetty (2025).

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