3 Reaching the Full Potential of Standards with Quality Infrastructure

Main messages

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

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

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

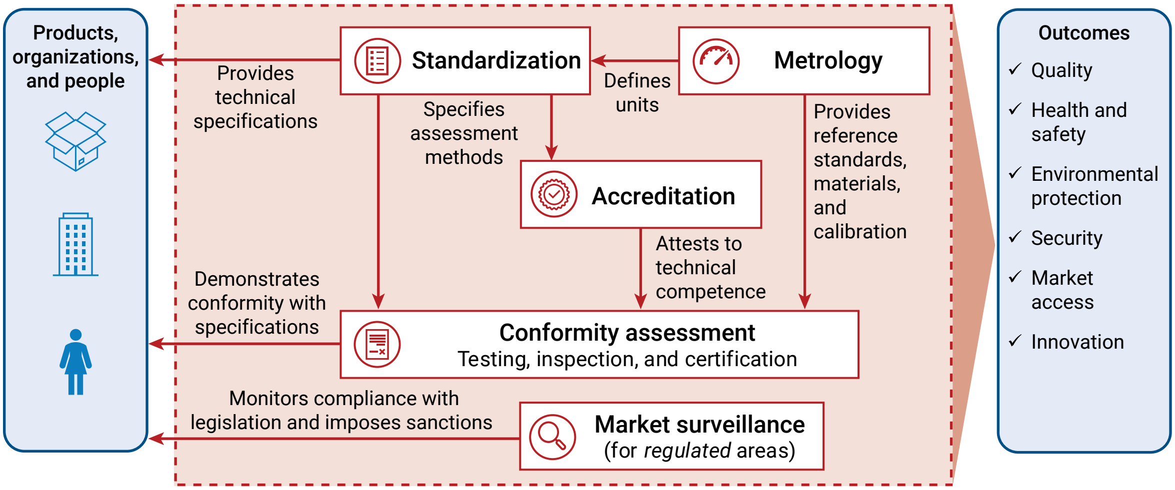
Quality infrastructure involves a network of public and private organizations and policies that support the quality, safety, and environmental sustainability of goods, services, and processes.[1] Most people recognize quality marks or labels on products, but few understand the complex system of testing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

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

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

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

Figure 3.1 Elements of a quality infrastructure system



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

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

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

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

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

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

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

Intersection of quality infrastructure with various policy areas

Most countries have, rather than a single coherent quality infrastructure system, a diverse set of public and private institutions that take on one or several of the five functions of such a system. Although the core functions of quality infrastructure are the same across voluntary and mandatory standards, the entities involved in providing the needed functions may differ, as table 3.1 illustrates. For example, a labor authority uses factory inspectors to monitor compliance with labor laws: a type of conformity assessment. A university typically must receive accreditation by a country's ministry of higher education or another institution before it is allowed to issue degree certificates. An industry group develops and certifies its own voluntary standard for sustainability to cater to a specific customer segment.

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

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

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

(Table continues next page)

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

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

Source: WDR 2025 team.

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

As chapter 2 illustrates, greater ambition in standards must be matched with stronger capacity for achieving and assessing compliance with those more ambitious standards. Quality infrastructure is key to expanding this capacity. Only if the appropriate testing, inspection, certification, and other services are available can firms demonstrate conformity, build trust with buyers, and access regulated or quality-conscious markets. Likewise, governments can be effective only if they are able to enforce compliance with standards cited in legislation. Although quality infrastructure is often associated with manufacturing, this Report emphasizes the role of quality infrastructure as a universal system whose functions are applicable in many areas. Understanding how the distinct functions of quality infrastructure interact, the appropriate roles of the public and private sectors, how to develop and apply the functions, and which pitfalls to avoid is especially relevant—but also challenging—for low- and middle-income countries, which face at least three key substantial challenges, which are discussed next.

Rising demand for quality infrastructure

The demand for quality is rising—both globally and domestically—while low- and middle-income countries continue to face significant constraints on their resources and capacity for assessing quality. Today's quality infrastructure systems must not only support advanced technologies but also respond to a more fragmented set of standards and stricter buyer and regulatory requirements. For example, international fashion brands require suppliers to adhere to strict standards for the accuracy of fabric colors. Testing the compliance of garment exports with these standards relies on precise metrology equipment to calibrate instruments to achieve the degree of accuracy required by such exacting color specifications. A lower-income country like Ethiopia producing garments for export in today's market must grapple with the complex demands of such testing. Higher-income countries, on the other hand, built their systems during eras of industrial modernization and earlier phases of trade integration and did not have to deal with such demands.[8] In addition, many low- and middle-income countries inherited quality infrastructure institutions from a colonial legacy and often focused on import substitution, which influenced their priorities for their quality infrastructure (leading to, for example, a focus on inspecting imports). Beyond these aspects of product quality construed narrowly, buyers and consumers are moving their attention more and more to the ways in which products and services are produced, including social and environmental aspects (refer to chapter 4). They therefore need to have confidence in suppliers' claims of sustainability-related performance, and quality infrastructure is vital for providing this as well.

Costs of investing in quality infrastructure

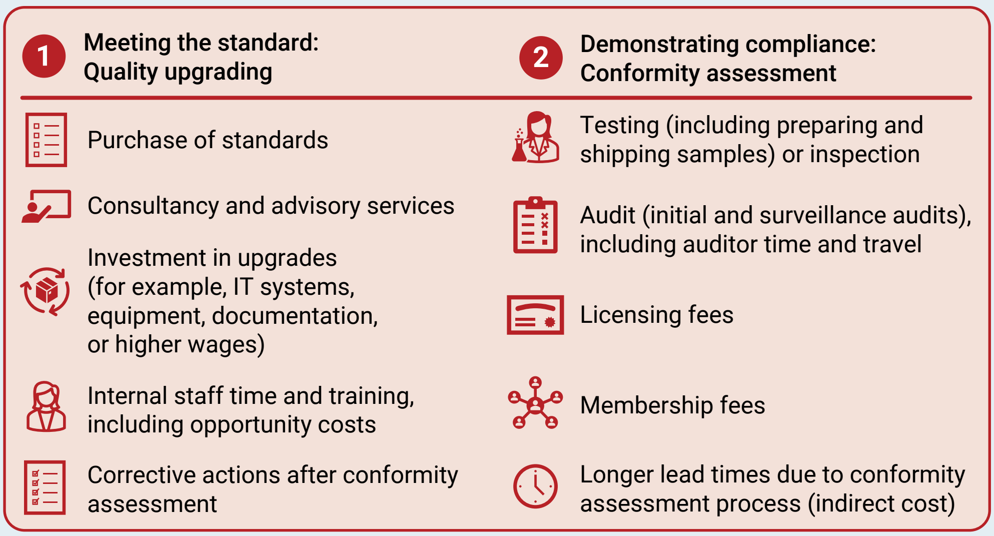
Developing a quality infrastructure system involves substantial public and private investments.[9] It requires specialized equipment for testing laboratories and skilled personnel like auditors and inspectors. Quality assurance also needs to be in place and exercised across a country, adding to the costs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

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

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

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

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



Source: WDR 2025 team.

Note: IT = information technology.

(Box continues next page)

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

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

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

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

(Box continues next page)

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

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

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

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

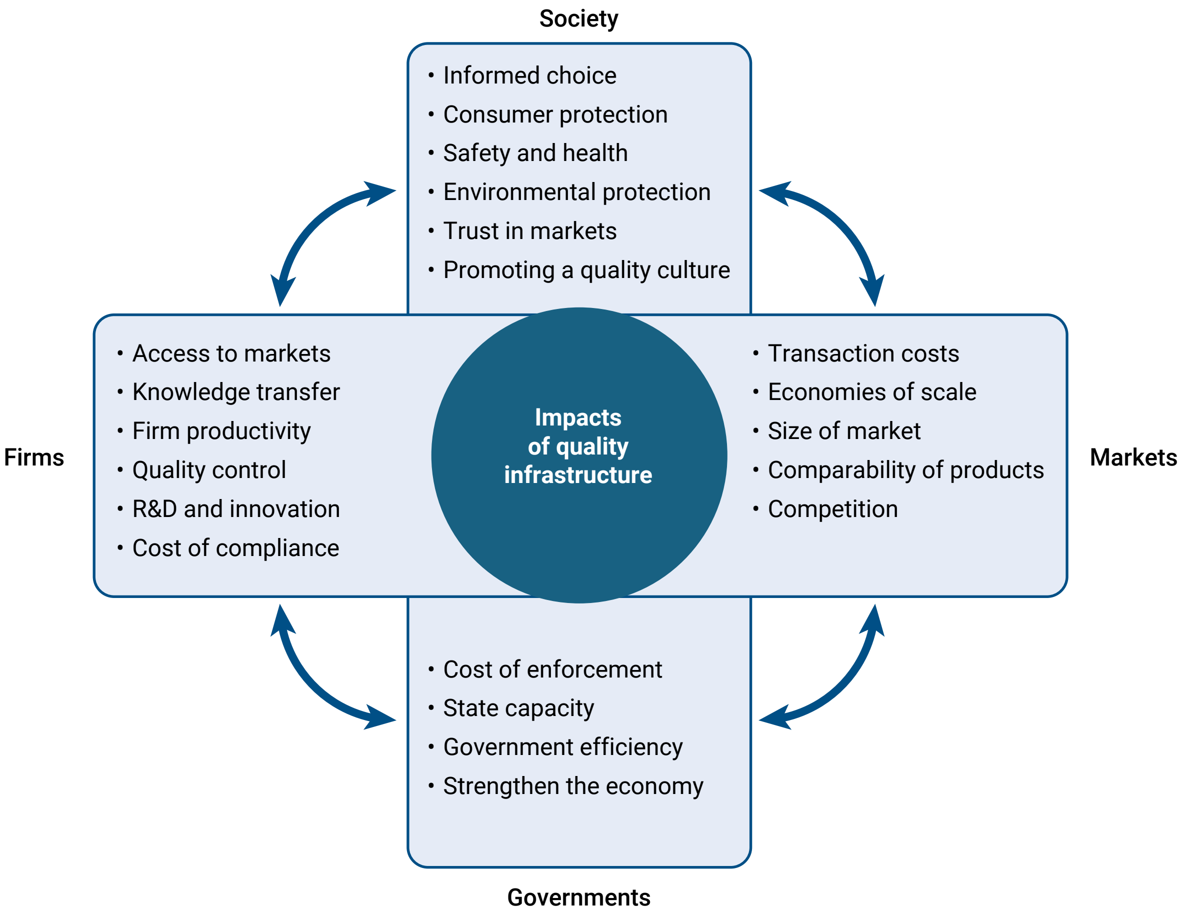
Difficult political economy

Low- and middle-income countries often face a complex political economy when seeking to strengthen their compliance capacity. First, stricter enforcement of regulations such as mandatory standards, though potentially increasing safety and public welfare, can have uneven distributional impacts. Strict enforcement may disadvantage smaller firms, which face relatively higher costs of compliance, or even prompt formal firms to exit the formal sector to evade compliance costs. Second, reliance on government inspectors and testing services can introduce opportunities for rent seeking and corruption, particularly in contexts in which governance is weak. Third, in the absence of a broad industrial base and robust processes for governance, a few dominant firms may capture the regulatory process and shape standards and compliance procedures to serve their own interests. Fourth, investing in quality infrastructure offers long-term advantages, but these advantages may not align with policy makers' short-term political goals, making such investment less attractive. Finally, when to use voluntary standards or set mandatory standards depends on the preferences of policy makers and policy goals in a country.

Quality infrastructure benefits competitiveness and public policy

Quality infrastructure can be used in multiple ways, with positive or negative outcomes depending on how it is applied across society, markets, firms, and the government, as figure 3.2 illustrates.[10] For instance, internationally harmonized standards and testing procedures can facilitate trade, whereas national deviations from these standards and procedures risk creating technical barriers to trade. Moreover, applying quality infrastructure to different objectives often involves trade-offs. Mandatory testing and certification can enhance safety but also can raise costs of compliance with safety standards, often disproportionately burdening small and medium enterprises.[11] Product labels can help consumers make informed decisions, but inconsistent or misleading labeling can create confusion, inefficiencies, and even fraud.

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



Source: WDR 2025 team.

Note: R&D = research and development.

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

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

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

Governments. Quality infrastructure can make regulatory enforcement more effective and efficient.[15] Reliance on market-based standards and private third-party certification can lessen the financial burden of regulatory oversight, reducing or eliminating the need for significant public funding to operate government laboratories and inspection agencies. For example, in the European Union (EU), electronic signatures used in digital transactions depend on a "trust chain" of certified trust service providers. These providers are audited by accredited conformity assessment bodies, ensuring they meet the technical and security requirements outlined in EU regulations. Without this system, electronic signatures would lack the legal certainty required for secure online commerce and government services.[16] Governments can also use quality infrastructure to improve the efficiency of their own operations, as by incorporating standards and conformity assessment requirements into public procurement or budgeting processes.

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

"One standard, one test, accepted everywhere"

A central benefit of a well-functioning quality infrastructure is that it fosters regional and international integration.[17] Systems for conformity assessment using international standards and guides pave the way for mutual recognition.[18] Test results can be recognized across borders if laboratories are accredited by bodies that are signatories to international mutual recognition arrangements for accreditation. These arrangements rely on building trust through international peer evaluations, in which accreditation bodies review each other's practices against requirements provided by internationally accepted standards (such as ISO/IEC 17011). Once a recognized signatory to such agreements accredits a conformity assessment body, other signatories accept that body's results, reducing the need for duplicative testing and certification.[19] Similarly, metrology ensures the international diffusion of measurement standards and scientific units, without which trade and science would be impossible.

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

Empirical evidence on quality infrastructure

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

Most of the empirical evidence exists for individual components of quality infrastructure, which underestimates the benefits of their interaction and synergies. Among these components, standards and conformity assessment have been researched the most.[23] Because empirical evidence on standards is discussed throughout this Report, the analysis that follows focuses on other components of quality infrastructure.

Conformity assessment

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

Most of the existing research has focused on certification of management systems, such as those for quality (ISO 9001) or the environment (ISO 14001). Although evidence is mixed regarding the impact of ISO 9001 certification on firms' performance, there is evidence that such certification has a positive impact on firms' revenues (refer to chapter 4).[26] Meanwhile, ISO 9001 has nuanced effects on innovation, with some evidence suggesting it matters more for incremental than for radical innovation.[27] Regarding ISO 14001, its positive effects on environmental performance are well documented,[28] and several studies also have found positive economic effects.[29] However, as noted earlier, studies generally cannot differentiate the effect of adopting a standard (implementing an environmental management system, for example) from the signaling effect of certification as having met the standard.[30] The macroeconomic impacts of conformity assessment are not well researched, and studies typically use proxies such as the number of certifications of quality management systems issued in a country, which is a small subset of its conformity assessment activities overall.[31]

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

Metrology. Because metrology has particularly indirect effects on conformity assessment, empirical evidence on its effects remains scarce and is often limited to theoretical models.[36] In one of the few econometric studies, Link (2023) found that the number of calibration tests in the United States was associated with aggregate productivity.[37] Similarly, Choudhary et al. (2013) found that measurement activities are important in determining the extent of bilateral EU trade within an industry.

Assessing the performance of quality infrastructure using indexes

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

Box 3.2 Indexes that compare countries' quality infrastructure systems

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

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

(Box continues next page)

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

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

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

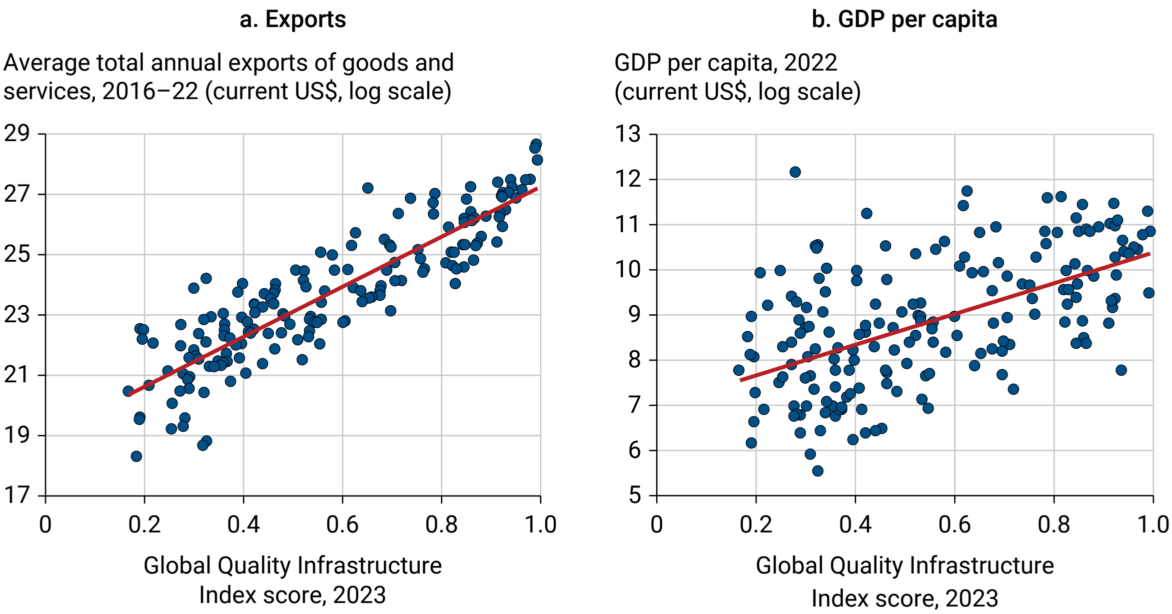
The *Quality Infrastructure for Sustainable Development (QI4SD) Index* assesses the readiness of a country's quality infrastructure to support the United Nations Sustainable Development Goals.[b] Developed by the United Nations Industrial Development Organization (UNIDO) in partnership with the International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

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

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

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

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



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

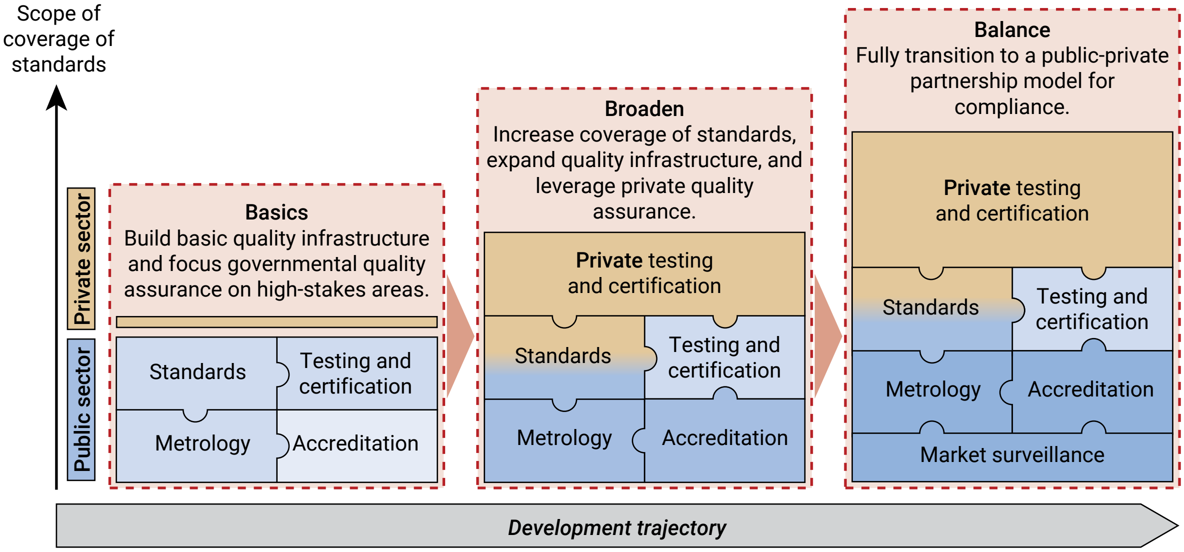
Countries with higher levels of quality infrastructure (based on their scores on the GQII) tend to have higher total exports and higher GDP per capita (refer to figure 3.3). In addition, countries at the same level of income tend to have higher exports the more well-developed are their quality infrastructure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

How to build a well-functioning quality infrastructure system

As countries develop, their approach to building capacity for compliance with standards needs to evolve (refer to figure 3.4). The three phases of such capacity building, which broadly align with the phases of standards setting described in chapter 2 (adapt–align–author), follow an understanding that quality infrastructure in a country needs to be established sequentially and that the role of a country's government in ensuring compliance must evolve over time.[39]

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

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



Source: WDR 2025 team.

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

Broaden. Over time, countries recognize the need to expand the scope of public policy objectives such as health and safety. As the coverage of these objectives grows, so does demand for providers of testing, inspection, and certification, enabling the private sector to play a greater role in these areas. This means that gradually, the government becomes less directly involved in providing quality assurance and instead focuses on ensuring the trustworthiness of private organizations, through accreditation in particular, as well as other areas. In this phase, countries also should increasingly seek international recognition via mutual recognition arrangements through key global forums for accreditation (International Laboratory Accreditation Cooperation, or ILAC; International Accreditation Forum, or IAF); standards development (ISO; the IEC; International Telecommunication Union, or ITU); and metrology (International Bureau of Weights and Measures, or BIPM; International Organization of Legal Metrology, or OIML).[42] For example, in the early 2000s the Kyrgyz Republic moved from a system in which its national standards body certified compliance with more than 23,000 mandatory standards to a liberalized framework that opened up to competition the testing and certification for technical regulation and also introduced accreditation.[43]

Balance. In the third phase, countries typically have achieved comprehensive coverage of public policy objectives related to quality infrastructure, requiring a shift in their approach to compliance. Instead of relying solely on quality assurance and enforcement by the government, countries should adopt a partnership approach in which the government acts as a "referee" and the private sector, including firms and quality assurance providers, carries out much of the conformity assessment that is needed. For regulated areas, the government focuses on market surveillance using a risk-based approach to verify whether parties are complying with mandatory market requirements like standards—and to issue sanctions when they are not. This method promotes a more agile regulatory process that leverages the respective strengths of both the public and private sectors in implementing standards and enforcing technical regulations.[44] For example, before Türkiye entered a customs union with the EU in 1995, the country relied heavily on a system of 1,500 mandatory standards, many of which required premarket inspection, testing, and certification by the Turkish Standards Institution (TSE). By aligning its approach with that of the EU, Türkiye largely transitioned to a system relying on accredited, mostly private conformity assessment bodies and public market surveillance.[45] In this third phase, quality infrastructure also increasingly supports innovation, which involves giving private sector entities a greater role in standards development, as China and Korea did, as highlighted in spotlight 1.[46] As a last step, countries integrate their quality infrastructure systems globally through key international institutions that deal with quality infrastructure.

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

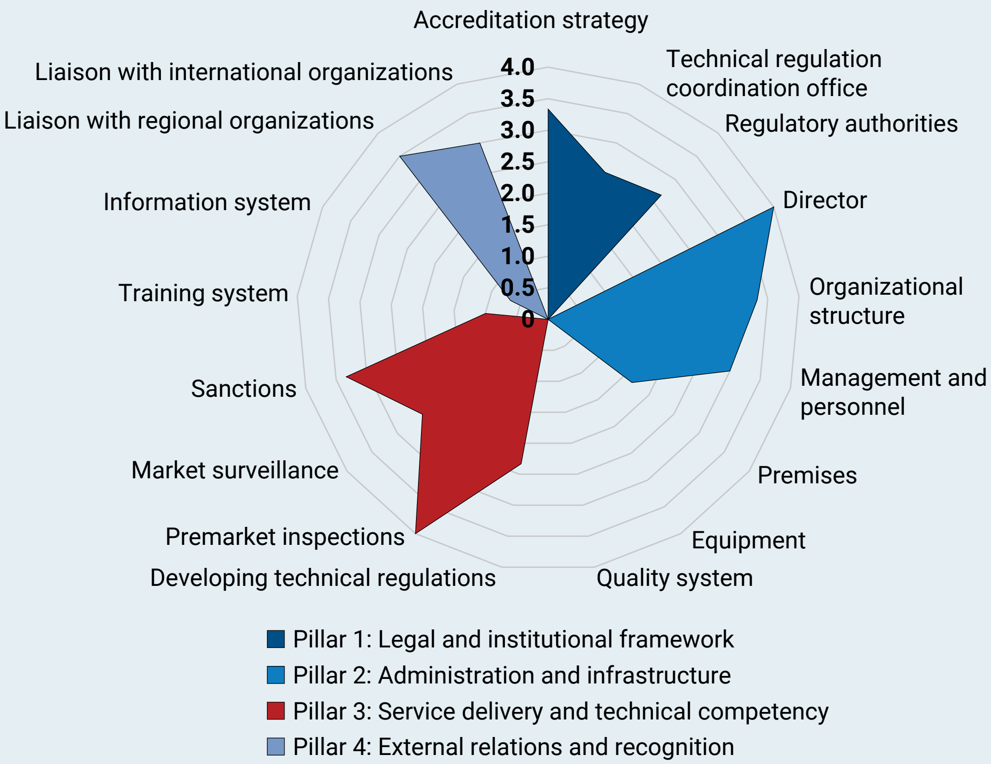
Box 3.3 Assessing the maturity of a country's quality infrastructure: The Rapid Diagnostic Tool

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

(Box continues next page)

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

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



Source: Kellermann 2019a.

Source: WDR 2025 team.

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

Key trade-offs when developing quality infrastructure systems

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

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

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

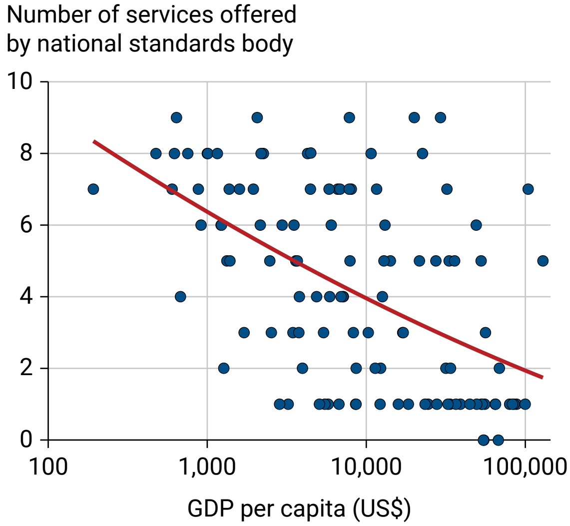
How to resolve these trade-offs shifts over the course of a country's development trajectory. Therefore, there is no single blueprint for developing a quality infrastructure system.

Division of functions of quality infrastructure

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

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

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



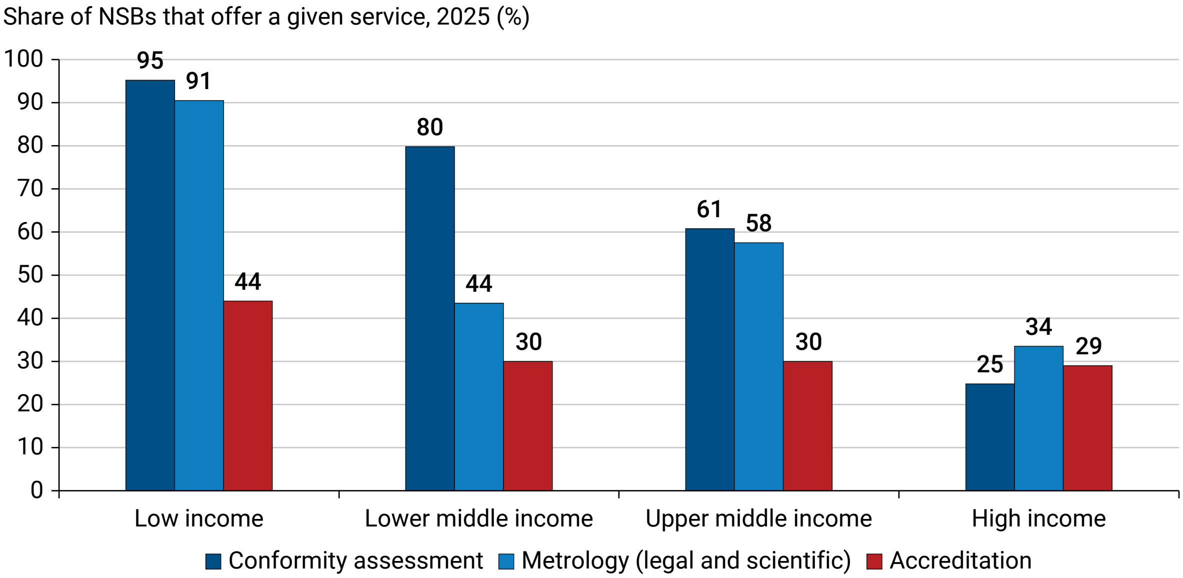
Source: WDR 2025 team, based on World Bank and ISO 2025.

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

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

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

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



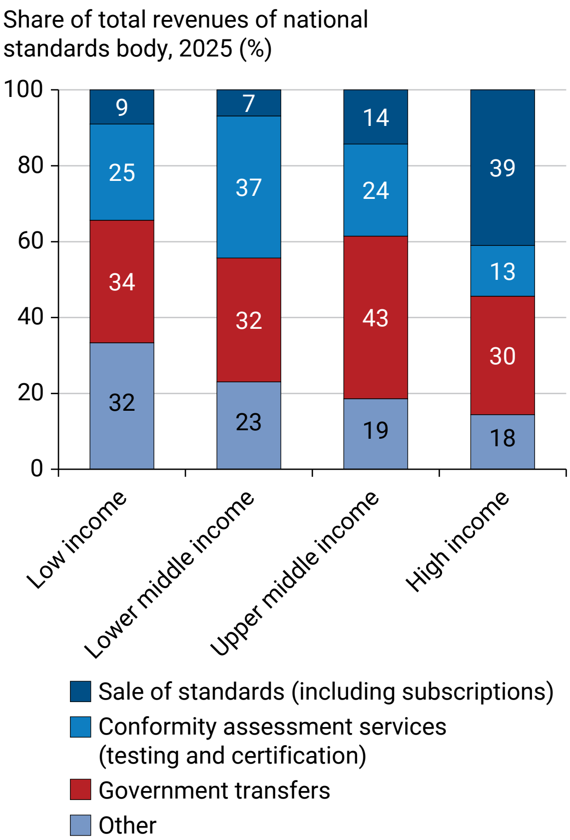
Source: WDR 2025 team, based on World Bank and ISO 2025.

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

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

Conflicts of interest may emerge when standards development organizations rely financially on conformity assessment. On average, national standards bodies earn 19 percent of their revenue from conformity assessment, but this amount rises to nearly 40 percent in lower-middle-income countries (refer to figure 3.7). To prevent certification revenues from influencing standards development, ISO's Good Standardization Practices stipulate that standardization activities need to be independent of other activities such as conformity assessment, which in practice typically means financial and personnel separation (a "fire wall").[49] However, in low- and middle-income countries, limited resources often require conformity assessment experts to serve roles in national standards development as well. An ISO–World Bank survey of 116 national standards bodies around the world found that 22 of these bodies, mostly in low- and middle-income countries, are involved not only in standards development, but also simultaneously in conformity assessment and accreditation.[50]

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



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

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

The combination of standards development and conformity assessment is also common in regard to private sustainability standards like eco-labels in sectors such as agriculture, forestry, and textiles. These labels often encounter governance issues when the same organization handles both the development of the related standards and certification of compliance with them. This can create incentives for weaker requirements and lead to the proliferation of standards, because certification generates revenue. Organizations like the ISEAL Alliance have established codes of conduct to increase the credibility of private sustainability schemes by establishing governance requirements. To mitigate governance issues, organizations creating such schemes should use international standards for conformity assessment bodies and the guides established by the ISO Committee on Conformity Assessment (CASCO). This will ensure competence, impartiality, and consistency in certification and auditing.

Cases involving credit-rating agencies and voluntary carbon markets further highlight the importance of avoiding conflicts of interest. Prominent organizations that develop standards for voluntary carbon markets commonly benefit financially from the number of certificates issued while also accrediting the verifiers, leading to serious questions about the organizations' trustworthiness.[51] Similarly, in the lead-up to the 2008 financial crisis, credit-rating agencies were paid by the issuers of the very financial products they were rating, giving the former incentives to underreport risks.[52] Research in India emphasizes the significance of who pays for audits.[53] A field experiment there involving third-party environmental auditors found that when firms paid those auditors directly, the auditors consistently underreported pollution, whereas shifting payments to a central fund and introducing random audits of auditors resulted in more accurate reporting and lower pollution levels.

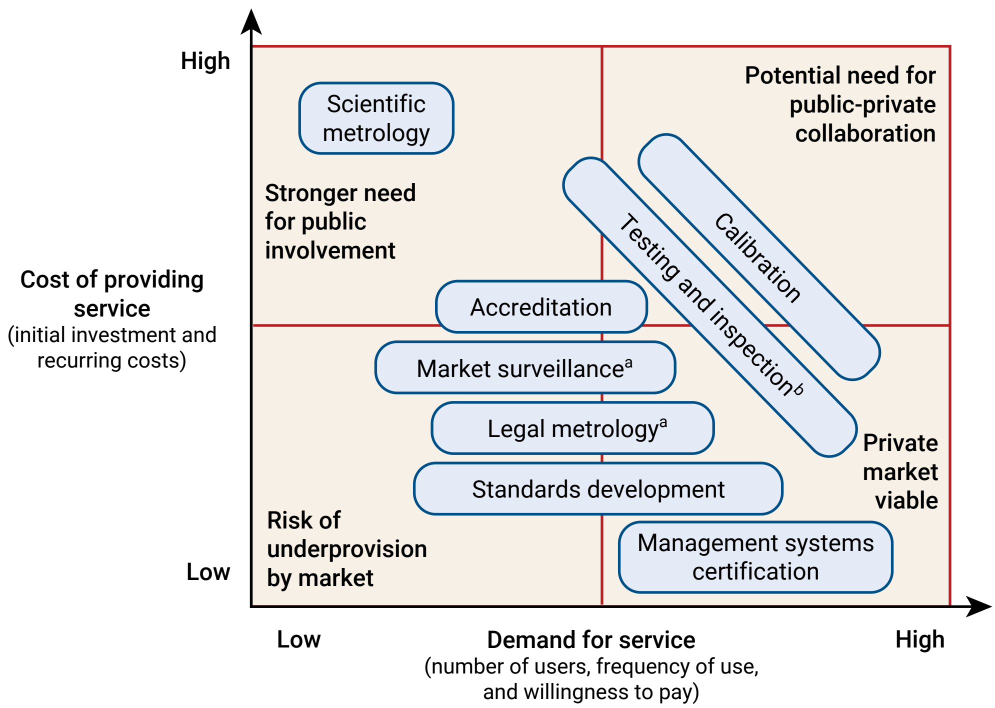
Balancing the roles of the public and private sectors

How many functions in a quality infrastructure system should be carried out by the government, by the private sector, or through a public-private partnership? The answer mainly depends on three factors: (1) the cost of providing the service, which includes initial investment for equipment and staff capacity as well as ongoing expenses; (2) the demand for the service, which is contingent on the number of users, how often they use the service, and their willingness and ability to pay—that is, whether there is sufficient market demand; and (3) whether the function falls within a regulated area under the government's purview. Some quality assurance functions are public goods that the market would not otherwise supply (for example, research-intensive scientific metrology in niche areas), whereas for others, there is a clear market.[54]

As figure 3.8 illustrates, the costs of providing a particular service in the area of quality infrastructure and the demand for it differ widely. Although specific cost and demand data may vary, a few general patterns emerge.

Scientific metrology. Establishing and maintaining national measurement standards is extremely expensive, with only a few specialized users needing the service. Therefore, governments almost always fund and provide scientific metrology as a public good.

Figure 3.8 The need for government intervention in quality infrastructure changes with the profiles of cost and demand



Source: Adapted from Miesner 2009.

Note: This figure is a simplification. For example, it does not account for the fact that the fixed costs of providing a service would decline with an increase in the number of clients. The effect of volume on per unit costs is an important factor to consider in any specific analysis.

a. Regulated.

b. Sometimes regulated.

Legal metrology. The government ensures that measurements, like weights of goods at markets or amounts of fuel dispensed at gas stations, are accurate and fair. This involves inspecting thousands of devices nationwide, a task involving low cost per device but high total costs. Because compliance is mandatory and not driven by market forces, the state almost always takes responsibility for legal metrology. Some countries outsource routine inspections to private companies, and the government maintains oversight and enforcement responsibilities.

Accreditation. Accreditation involves significant expertise and overhead, with a relatively small number of customers because there are only so many conformity assessment bodies to be accredited. For example, it is estimated that an accreditation body needs revenues from 200–250 accreditations to break even (with each accreditation typically being renewed every four to five years).[55] Even in a large lower-middle-income country like Kenya, the government covered 80 percent of its accreditation body's budget until recently.[56]

Market surveillance. Market surveillance typically involves considerable costs associated with taking product samples from the market and testing them. Because it concerns regulated areas, it is typically a government responsibility. However, it can be subcontracted to other entities, as is the case in regard to India's compulsory registration scheme for electronic products and information technology equipment.[57]

Calibration. As with legal metrology, many devices in manufacturing plants, hospitals, testing laboratories, and similar settings need regular calibration. Because demand is therefore frequent and widespread, a market for calibration services can flourish. However, such a market still depends on having a sufficiently large industrial base to enable private calibration laboratories to operate profitably.

Standards development. Developing standards involves significant administrative costs, such as organizing technical committees, participating in regional and international forums, publishing standards, and maintaining information portals. Revenue from selling standards does not always cover these expenses, especially in low- and middle-income countries. However, in some high-income countries and specific sectors, the development of standards can be financially sustainable. One among many examples is the United States, with its hundreds of private standards development organizations. It is important to note that even in cases in which a national standards body is a nongovernmental institution, it has typically entered into a legal agreement with the country's government to function as the designated national standards body representing the country in international standards development organizations like ISO, the IEC, and ITU.

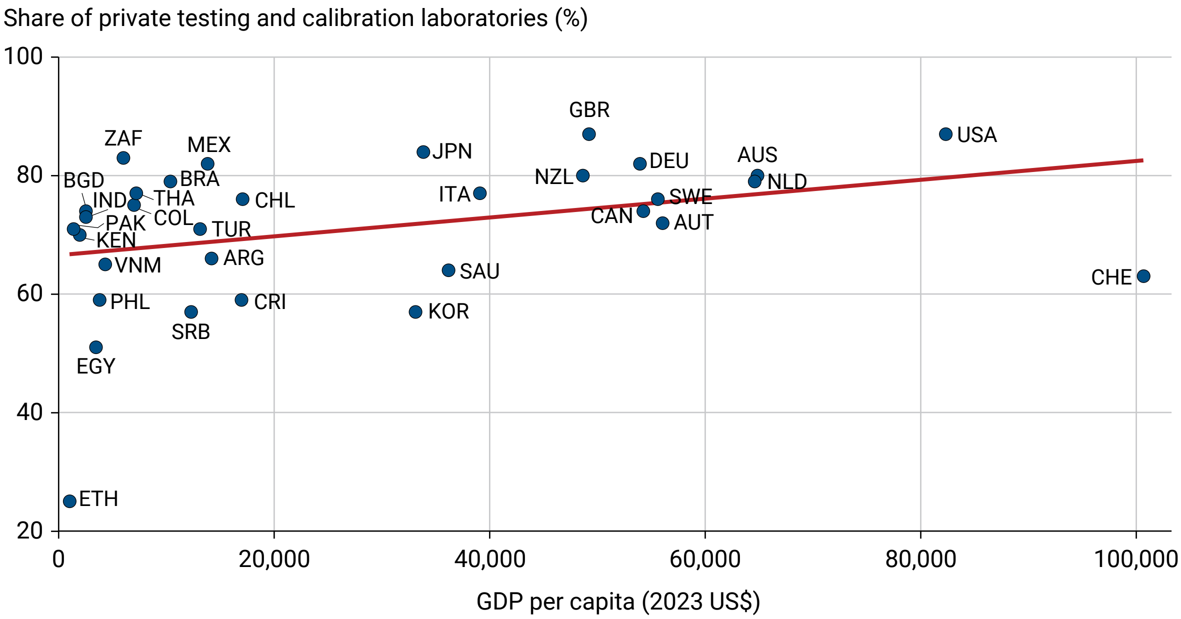
Conformity assessment. The most challenging area for which to determine the appropriate level and role of government involvement is conformity assessment. Product testing and inspection as well as management systems certification form the most diverse group of services in the realm of quality infrastructure, with significant variations in costs, demand, and regulation levels. The conformity assessment sector is a vital industry in itself, employing 1.2–1.7 million people globally and generating more than US$200 billion annually in revenue across 160 countries.[58] Some specialized conformity assessment services can be costly and are sought by few organizations, whereas others have moderate costs and high market demand, such as routine chemical tests and electrical safety tests. Because of competition and volume, in well-developed quality infrastructure systems, the private sector often efficiently handles the latter type of services. Low- and middle-income countries may need more government intervention initially—for example, because of low market demand and limited regulation—but over time, governments in these countries usually step back from providing conformity assessment services directly and allow private sector organizations to take over, while keeping and strengthening their own involvement in accreditation.

Countries show large differences regarding whether the government or the private sector operates testing and calibration laboratories. As figure 3.9 shows, across 32 countries assessed, higher-income countries tend to have a larger share of private laboratories across all accredited testing and calibration bodies. Overall, the government has a strong presence in the market for conformity assessment services, particularly in low- and middle-income countries.

Conformity assessment services that require expensive laboratories may need more government involvement. In contrast, management system certifications like those for ISO 9001 (quality), ISO 50001 (energy), and ISO/IEC 27001 (information security) primarily depend on the availability of competent auditors, not laboratory facilities. Because these services are universally applicable to many types of organizations, the potential market demand for them is substantial. They can thus be provided on commercial terms.

As countries develop, the demand for services in the area of quality infrastructure increases, shifting the roles of the public and private sectors in providing these services. As figure 3.10 shows, this particularly affects standards development and testing, inspection, and certification services, which are more likely to be provided by the government in early phases and then transition to the private sector. There is much less of a shift toward private provision in the areas of accreditation and metrology. Government provision tends to prevail for these areas in most cases.

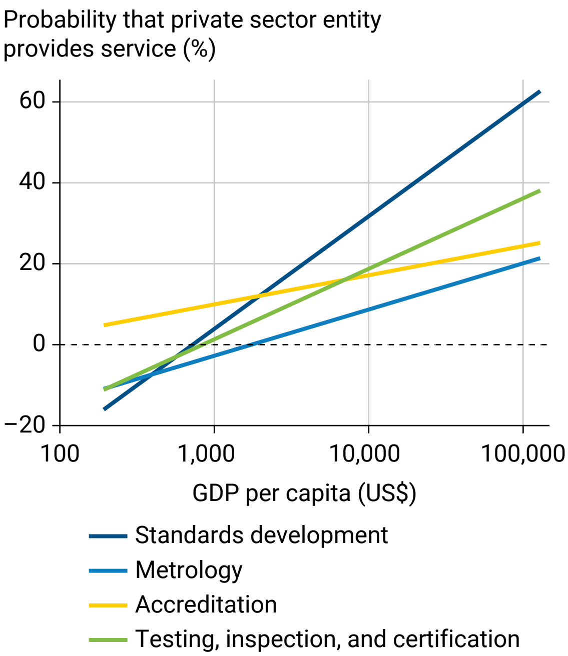
Figure 3.9 The share of private sector laboratories for testing and calibration increases as countries develop



Sources: WDR 2025 team analysis, based on data from national accreditation bodies.

Note: The data show national laboratories accredited to International Organization for Standardization (ISO)/International Electrotechnical Commission (IEC) 17025 (general requirements for the competence of testing and calibration laboratories). Each accredited facility in a country is counted as one laboratory, even if multiple accredited facilities belong to the same firm. For the country labels used in the figure, refer to ISO, https://www.iso.org/obp/ui/#search (select "country codes").

Figure 3.10 The share of private institutions that provide services in the area of quality infrastructure increases as countries develop



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

Note: The figure underestimates the extent to which the private sector provides services in the areas of testing, inspection, and certification because it relies on data from a survey of national standards bodies. The private sector typically accounts for more than 60 percent of accredited testing and calibration laboratories in countries with higher income levels. The survey sample includes 116 national standards bodies: 13 in low-income countries, 28 in lower-middle-income countries, 34 in upper-middle-income countries, and 41 in high-income countries. If the national standards body in a country is classified as private and offers a particular service, it is included in the percentage of private sector entities providing the service.

Coordination or competition among institutions that deal with quality infrastructure. The question of public versus private roles in quality infrastructure is closely linked to whether services should be coordinated or offered by competing institutions, an issue shaped by political traditions and historical path dependencies. For example, in the United States, numerous accreditation bodies compete with one another, whereas the European Union permits only one accreditation body per member country. The European Union regards accreditation as a function of public authority that supports the operation of the single market and considers competition among accreditation bodies to be risky because of concerns about a "race to the bottom." The United States, on the other hand, views competition among accreditation bodies as a strength, with trust upheld through market discipline and international recognition. Similarly, in the United States, hundreds of standards development organizations operate in parallel, with some coordination by the American National Standards Institute (ANSI). In India, the Bureau of Indian Standards has introduced a scheme for recognizing standards development organizations to introduce more flexibility, but such organizations remain coordinated through the national standards body.[59] Although China's quality infrastructure system is highly centralized and state led, market-driven association and enterprise standards are encouraged, but they remain under the supervision of the State Administration for Market Regulation (SAMR).[60] Ultimately, whereas competition among accreditation and standards bodies may work in some contexts like that in the United States, in low- and middle-income countries with lower demand for quality, weaker institutional capacity, and nascent markets, this type of model may be less effective or even potentially harmful.

Different approaches to competition versus coordination among institutions that deal with quality infrastructure mainly concern accreditation and standards development. In regard to metrology specifically, there is widespread agreement on the need for a single national institution because of the low commercial viability of metrology and the importance of international coordination in maintaining traceable measurements. Similarly, there is consensus that most conformity assessment and calibration services can be left to competition among providers, as long as they all follow the same standards and have the same oversight, such as through accreditation. Similarly, no matter which body carries out accreditation, it should follow international standards for accreditation, as defined in ISO/IEC 17000, which underpins a well-functioning quality infrastructure.

Sequencing of reforms to and investments in quality infrastructure

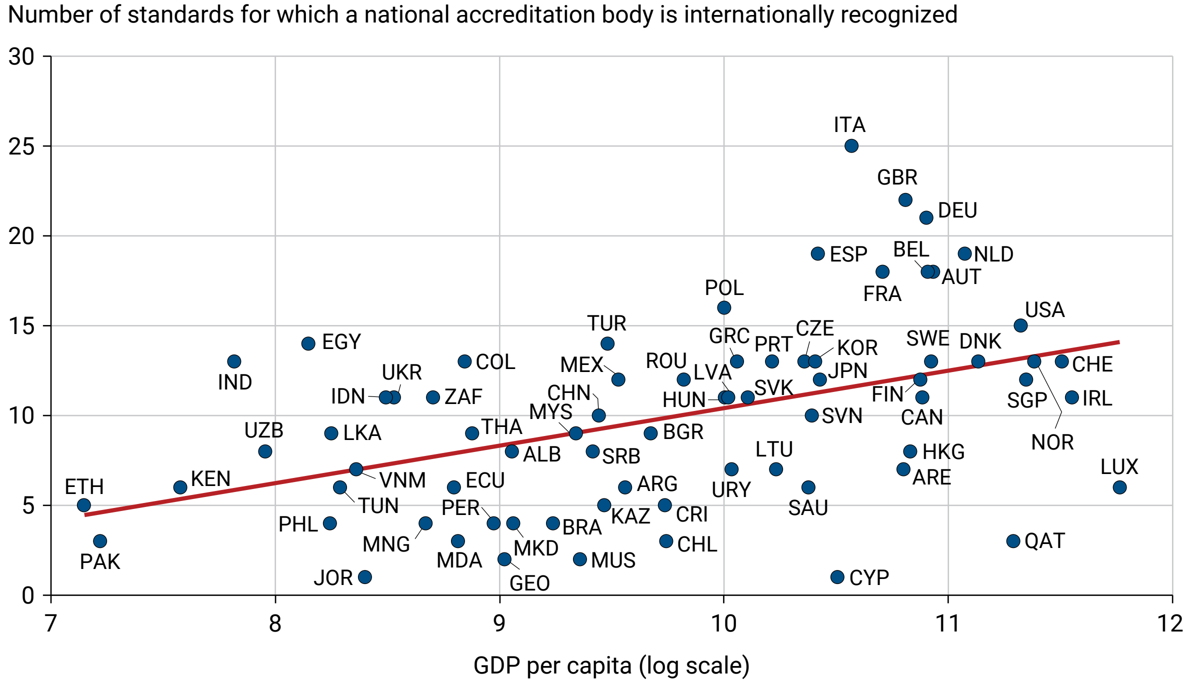
How should low- and middle-income countries sequence development of the various elements of quality infrastructure amid scarce resources? Because quality infrastructure must function as a coherent system, its weakest link limits its effectiveness. For example, testing laboratories cannot operate reliably without access to calibrated instruments and reference materials from metrology institutes. Logical sequencing is therefore essential: Metrology underpins standards, which in turn enable testing and certification. Therefore, the basics–broaden–balance framework recommends strengthening the core functions of metrology, standards development, and conformity assessment first; accreditation follows later.

Some capacities that quality infrastructure must have are widely applicable across sectors (such as reference weights or temperature calibration), whereas others are specific to particular industries (such as testing for pesticide residues in agriculture or calibration of clean rooms in pharmaceuticals). The policy challenge is in developing both sets of capabilities: cross-cutting foundational functions and specialized capabilities in priority sectors. As economies grow, the demand for quality infrastructure services increases and diversifies. In the initial stages, needs usually include standards for food safety and construction materials as well as basic electrical standards. Over time, more advanced requirements surface, such as precision metrology for advanced manufacturing or certification for emissions of greenhouse gases. This changing demand necessitates not only expanding systems, but also upgrading capacities to provide higher-quality services. As figure 3.11 illustrates, national accreditation bodies in higher-income economies are therefore signatories to a broader range of certification areas under the IAF's Multilateral Recognition Arrangement.

There is no blueprint for sequencing. The right approach depends on national priorities, economic structure, and institutional readiness. The case of Korea, presented in spotlight 1, illustrates how a country's quality infrastructure evolves alongside its industrial development. In the early stages of development of Korea's quality infrastructure, export inspections and preferential treatment for certified products supported the growth of light manufacturing. As the country's economy shifted toward heavy and chemical industries in the 1970s and 1980s, more advanced metrology capabilities became essential.[61] Later, the rise of technology-intensive electronics required a greater role for industry-driven development of standards and the strengthening of accreditation systems to ensure internationally recognized testing and certification.

As with industrial policy, governments must carefully balance active and reactive strategies when developing quality infrastructure (refer to figure 3.12). An active approach is needed to address market failures and coordination gaps, for instance, when firms do not demand quality assurance services because those services are not yet available, and providers do not offer them as a result of insufficient demand. Dilemmas of this type can trap markets in low-quality equilibriums. In such cases, government intervention (such as awareness campaigns, subsidies, or government provision of quality assurance) can help stimulate uptake. In contrast, a reactive approach delays investment until demand is clearly signaled, often

Figure 3.11 The scope of certification is greater among national accreditation bodies in higher-income economies



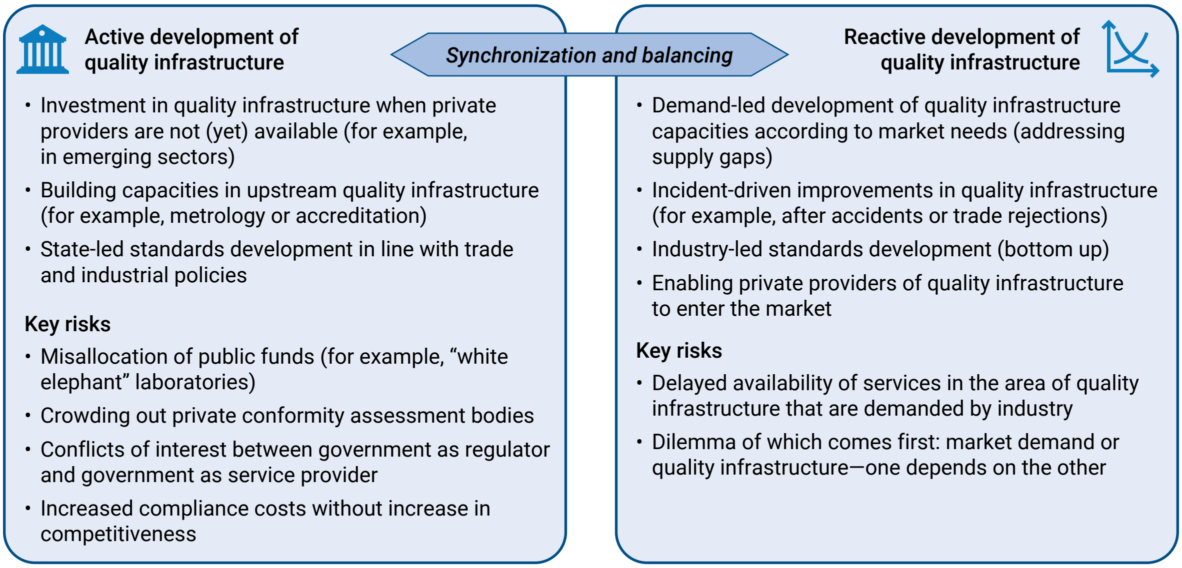
Source: WDR 2025 team, based on data from the International Accreditation Forum.

Note: The figure shows the scope of certification services to which national accreditation bodies are signatory under the Multilateral Recognition Arrangement of the International Accreditation Forum (IAF). If a national accreditation body that is a member of this arrangement accredits a certification body under a given scope, that accreditation can be recognized by other countries internationally. For example, a national accreditation body's scope might include that its accreditation of conformity assessment bodies in the area of systems for managing food safety (International Organization for Standardization [ISO] 22000) is internationally recognized. The sample includes 71 economies. For the economy labels used in the figure, refer to ISO, https://www.iso.org/obp/ui/#search (select "country codes").

following consumer complaints, safety failures, or export rejections. Moreover, a reactive approach may leave exporting and innovative companies no other choice but to rely on foreign conformity assessment bodies, potentially creating a path dependency, because it may be difficult for local conformity assessment bodies, once they develop, to get a share of the market at a later stage.

Both the active and reactive approaches involve trade-offs. If the government invests in public laboratories that are poorly aligned with industry needs, it creates "white elephant" facilities that are underused and expensive to maintain. These often fall into disuse on account of lack of funding for consumables, spare parts, and similar items. Importantly, a strong government role in providing services in the area of conformity assessment risks crowding out private providers of such services. As a rule of thumb, it is better for governments to give demand-side support to firms to enable them to access conformity assessment services provided by private bodies (for example, through certification vouchers), rather than for governments to invest in providing conformity assessment services themselves.[62]

Figure 3.12 Active and reactive development of quality infrastructure should be synchronized and balanced



Source: WDR 2025 team.

A reactive investment strategy, in which infrastructure is developed only after demand for it becomes clear, risks unavailability of services when firms initially need them, such as when they enter or attempt to enter export markets, which can delay growth and innovation. Additionally, core functions of quality infrastructure like metrology and accreditation might stay underdeveloped because their value is systemic and not directly reflected in market signals, increasing the risk of delays in providing them. Likewise, without targeted government support to build foundational capacity, both the supply of and demand for quality infrastructure can become trapped in a low-level equilibrium.[63]

In short, sequencing reforms to quality infrastructure systems requires an iterative approach aligned with the maturity of public and private institutions, market conditions, and national priorities regarding development. To better bridge the demand and supply sides, public-private dialogue is essential, consistent with "new industrial policy" discourse.[64] Only through such dialogue can sector-specific needs be recognized. Box 3.4 shows how different countries have adopted various paths for developing their quality infrastructure systems, ranging from an approach driven by industrial policy in Korea to a method more focused on regulation in Brazil to donor-supported upgrades to quality infrastructure in Ethiopia.

Balancing the roles of quality infrastructure for effective regulation and competitiveness

As discussed, quality infrastructure serves a dual function: ensuring competitiveness of industries and public enforcement. Although these goals may not be inherently in conflict,[65] effectively using quality infrastructure to advance both objectives requires a careful balance.

In general, standards aimed at boosting competitiveness should remain voluntary and be shaped by industry demand. In contrast, standards cited in technical regulations are typically used to achieve public policy goals such as health, safety,

Box 3.4 Quality infrastructure systems at different levels of economic development in the Republic of Korea, Brazil, and Ethiopia

The *Republic of Korea's* development of quality infrastructure is widely regarded as a model of successful catch-up industrialization, marked by strong state leadership, phased institutional development, and responsiveness to economic priorities.[a] The country made metrology a priority early in its process of developing a quality infrastructure system, joining the Treaty of the Metre in 1959[b] and establishing the Korea Research Institute of Standards and Science (KRISS) in 1975.[c] In later phases it put in place standards and accreditation bodies such as the Korean Agency for Technology and Standards (KATS, 1983), Korean Laboratory Accreditation Scheme (KOLAS, 1992), and Korea Accreditation Board (KAB, 1995). In line with the industrial policies of the 1970s and 1980s, metrology responded to the need for accurate measurements in fields like chemicals and heavy industry. In the late 1990s, policy shifted to support small and medium enterprises, leading to targeted programs and local outreach by agencies like KRISS and the Korea Testing Laboratory. Since the 2000s, Korea has become an active participant in international standards development organizations, such as the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC), with its quality infrastructure evolving to meet the demands of advanced sectors like information technology and biotechnology. Overall, Korea's experience demonstrates how developing a quality infrastructure system often aligns with a country's broader industrial policies.

Brazil has a long experience in setting up quality infrastructure and was one of the first signatories to the Treaty of the Metre.[d] However, its development of quality infrastructure was repeatedly interrupted, requiring efforts to be revisited and renewed over time. Unlike Korea, whose industrial policy regime motivated development of its quality infrastructure, regulation heavily drove development of Brazil's quality infrastructure, with an emphasis on consumer protection and compliance with national technical regulations, in addition to industrial development. This model helped consolidate multiple functions of quality infrastructure within the country's National Institute of Metrology, Standardization, and Industrial Quality (INMETRO). The resulting integrated, regulation-centered structure has enabled Brazil to build a strong and centralized quality infrastructure system. Although challenges like regulatory overlap, regional disparities in service coverage, and institutional stability still exist, Brazil's quality infrastructure is among the most advanced in Latin America.

In *Ethiopia,* the origins of quality infrastructure date to the 1950s. A major step was consolidating all functions related to quality infrastructure under one umbrella with the creation of the Quality and Standards Authority of Ethiopia (QSAE) in 1998. In 2010, Ethiopia moved toward international best practices by dividing the authority into four specialized institutions, one each for standardization, metrology, accreditation, and conformity assessment. Development partners have provided considerable support for the establishment of these

(Box continues next page)

Box 3.4 Quality infrastructure systems at different levels of economic development in the Republic of Korea, Brazil, and Ethiopia *(continued)*

institutions, including a project funded by the World Bank. Over the last 10–15 years, the technical capacity of these institutions has increased significantly through, among other things, upgraded equipment, the development of human resources, and stakeholder engagement. Ethiopia's experience shows that during earlier stages of development of quality infrastructure, government may play a greater role in providing conformity assessment services. The state-owned Ethiopian Conformity Assessment Enterprise (ECAE) offers services at subsidized rates, which supports firms' compliance but also limits the entry of private providers of quality assurance services, which have not yet developed in the country.

Source: Harmes-Liedtke et al. 2025.

Note: Harmes-Liedtke et al. (2025), a background paper prepared for *World Development Report 2025*, includes other country case studies.

a. Refer to Korea's ODA (website), Ministry of Foreign Affairs, Republic of Korea (accessed May 9, 2025), https://www.mofa.go.kr/eng/wpge/m_5447/contents.do; Seo et al. (2013).
b. Yoo (2019).
c. Choi (2013).
d. Harmes-Liedtke (2021a).

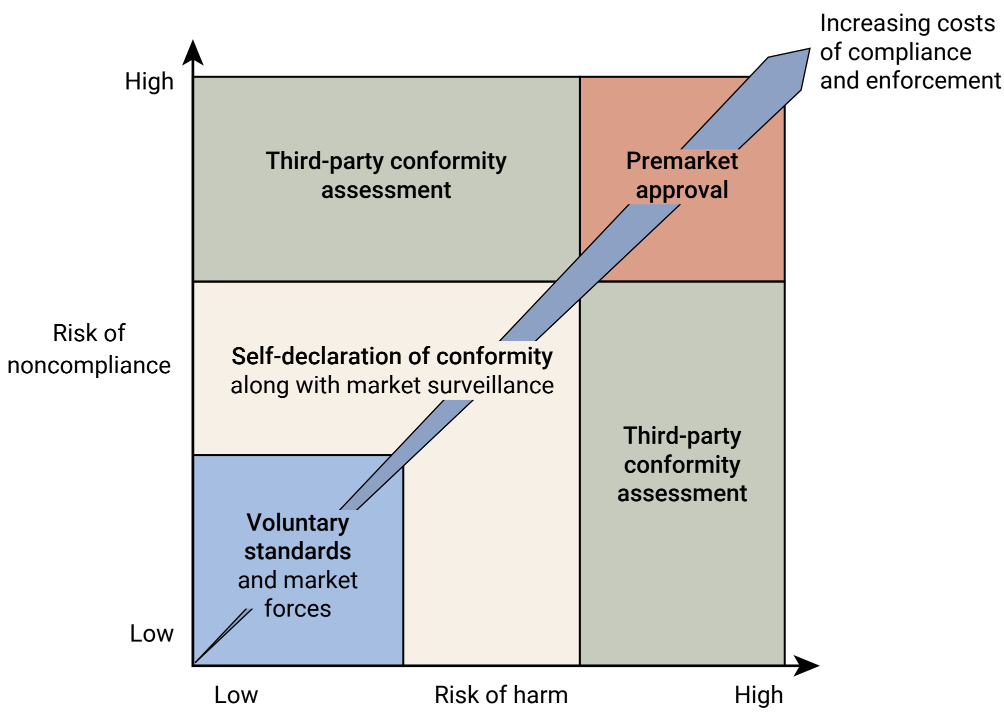
or environmental protection. Although there is greater certainty that technical regulations will achieve their objectives than that voluntary approaches will, the former carry risks like stifling innovation, raising compliance costs for firms, and imposing costs associated with enforcement on the government. Research shows that particularly in uncertain markets, such as those characterized by lack of technological maturity or volatile demand, voluntary standards outperform regulations in terms of innovation efficiency, because they provide flexibility and adaptability without locking firms into rigid requirements for compliance.[66] To use quality infrastructure effectively for regulation, policy makers should apply a risk-based approach to navigate the trade-offs involved in voluntary and regulatory methods.

Two key factors should guide the choice of the appropriate approach to compliance: (1) the level of risk, defined by the likelihood and potential severity of harm to consumers, the environment, or society; and (2) the probability of noncompliance, which is closely tied to both the capacity of the private sector to comply and that of the government to monitor and enforce requirements.[67] Although risk and the likelihood of noncompliance are often correlated, they are not always the same. Some sectors may have high potential for harm but low probability of noncompliance with standards and regulations, in particular, those in which firms have strong commercial incentives to comply because failure to do so would pose significant business or reputational risks. Moreover, risk preferences of society and policy makers may influence the appropriate approach to compliance; for example, a country may be willing to tolerate higher levels of pollution than international standards might dictate.[68]

Depending on these two factors, four different approaches can be differentiated, as illustrated in figure 3.13:

- *Voluntary standards and market forces* (illustrated in blue in figure 3.13). Controlling the quality of products presenting a low risk of harm such as (nonprotective) clothing, nonelectric household items (such as brooms), and stationery (paper, pens, and so on) can typically be left to voluntary, industry-driven standards and conformity assessment, with no government involvement. In these cases, market forces, consumer pressure, and reputation are often sufficient to drive quality.
- *Self-declaration of conformity along with market surveillance* (illustrated in ivory in figure 3.13). For areas with low to medium risks of harm, such as certain electronic products and nonstructural construction materials, governments may put regulations in place and allow firms to self-declare their compliance with the regulations. Companies will likely voluntarily use third-party conformity assessment or internal production control to mitigate the risk of noncompliance.[69] Such an approach reduces compliance burdens and leverages industry responsibility, provided it is paired with effective market surveillance (the government serves as a referee).

Figure 3.13 Risk-based approaches to compliance



Source: WDR 2025 team, adapted from data from ISO [International Organization for Standardization]/CASCO: Committee on Conformity Assessment (dashboard), https://www.iso.org/committee/54998.html.

Note: "Third-party conformity assessment" appears twice in the figure, as it may be needed either because of high risk of noncompliance or high risk of harm.

- *Third-party conformity assessment* (illustrated in green in figure 3.13). For products that present risks of harm that are too high (such as electrical safety and children's toys) or noncompliance too likely to permit self-declaration of compliance, regulators may mandate third-party conformity assessment before products are placed on the market. This still requires some form of market surveillance, but surveillance is not as essential as in the case of self-declaration of conformity.
- *Premarket approval* (illustrated in rust in figure 3.13). In high-risk sectors (such as medical devices, pharmaceuticals, or aerospace), regulatory systems often require stringent premarket controls. These typically include third-party testing, inspection, or certification, followed by formal regulatory clearance by a competent authority, such as the US Food and Drug Administration (FDA) or EU Aviation Safety Agency (EASA), before a product can be placed on the market. Premarket approval is designed to prevent harm in cases in which failures in quality or safety could have severe consequences and are difficult to detect or mitigate after a product is in circulation.

Low- and middle-income countries generally face a higher risk of noncompliance as a result of limited firm capabilities and weak legal enforceability of regulations. Informal firms in these countries are more prone to evade sanctions and have less ability to comply with regulatory or voluntary requirements. Similarly, governments in low- and middle-income countries often lack the capacity to operate effective systems for postmarket surveillance. Consequently, it is often advisable for low- and middle-income countries to depend initially more on third-party conformity assessments or premarket controls than on firms' self-declarations of conformity. However, premarket controls tend to impose greater burdens on industry and more expense on the government. Therefore, as a country's capacity grows, it becomes more justifiable for it to shift toward more flexible, postmarket systems that employ supplier declarations, market surveillance, and risk-based inspections.[70]

To address capacity constraints, low- and middle-income countries may need to implement second-best enforcement strategies and increase their use of digital tools in assessing compliance. For example, nongovernmental organizations can help inform consumers about nonconformities with applicable standards, and public digital registries can increase transparency by sharing risk-related information. A growing array of digital solutions are improving the effectiveness of quality infrastructure, especially that for risk management, as discussed in box 3.5. In Pakistan, an experiment demonstrated that providing government health inspectors with a smartphone application for sending geo-stamped reports on rural clinics to senior policy makers increased the frequency of inspections.[71]

International collaboration to share resources in the area of quality infrastructure

Not all services related to quality infrastructure need to be available domestically to serve the needs of local firms. In many cases, firms routinely send product samples abroad for testing, particularly when international buyers require certification from globally recognized conformity

Box 3.5 Leveraging digital tools for quality infrastructure

A variety of digital tools can greatly improve the effectiveness, reach, and efficiency of quality infrastructure. For example, remote audits can reduce assessment costs, and machine-readable standards can be integrated into companies' operations more smoothly. Digital systems for traceability like the European Union's Digital Product Passport can assist in verifying compliance and managing risks in supply chains. Similarly, digital certificates for calibration and automated data logging enhance the reliability and efficiency of metrology and testing services. Market surveillance can also benefit from employing digital tools, for instance, using online reviews and social media content to better target unsafe products. For low- and middle-income countries, digital tools can help overcome limitations in capacity and those imposed by geography by, for example, enabling virtual training for laboratory staff or remote conformity assessment in areas that are difficult to reach. Although digital tools in quality infrastructure require investments in digital infrastructure, they can make processes more agile and cost-effective (refer to spotlight 5).

Source: WDR 2025 team.

assessment bodies. This is often an efficient and commercially sensible approach. However, reliance on foreign laboratories can create challenges when testing is time sensitive or logistics make it impractical, especially in the cases of perishable goods or bulk commodities traded on short timelines. But such considerations need to be assessed on a case-by-case basis before policy makers take steps to provide incentives to make services relating to quality infrastructure locally available.

For many low- and middle-income and small countries, regional or bilateral cooperation offers a cost-effective alternative, particularly for expensive and specialized services like accreditation and scientific metrology.[72] Joint investments (such as regional reference laboratories or designated national responsibilities) can ensure traceability to international standards like the International System of Units, as illustrated by examples from the Caribbean and Southern Africa discussed in box 3.6. However, political, financial, and logistical barriers frequently hinder effective collaboration, with many governments preferring domestic control over shared efficiency. When cooperation is viable, it may take forms such as bilateral service agreements or jointly funded regional facilities, but even with outsourcing, governments must retain sufficient technical expertise to manage and oversee external services. Figure 3.14 presents a decision tree that can offer guidance.

Box 3.6 Sharing resources related to quality infrastructure among countries in the Caribbean and Southern Africa

Testing energy efficiency in the Caribbean

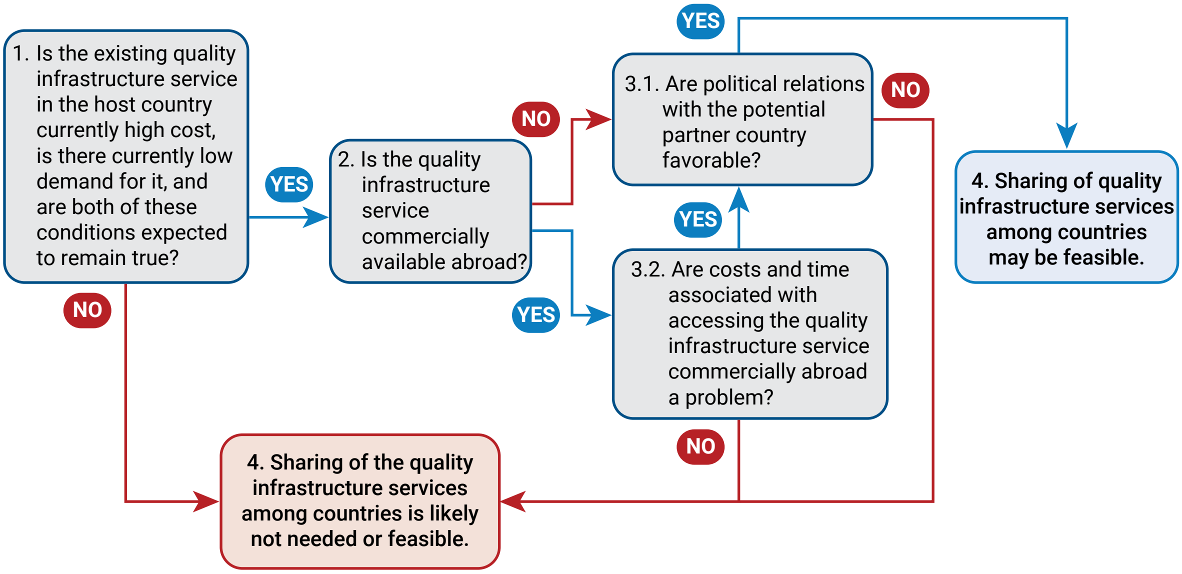
Many small island countries in the Caribbean lack the scale needed to establish cost-effective infrastructure to test the energy efficiency of appliances and equipment. Two institutions providing such infrastructure help address the region's specific challenges: the Energy Efficient Lighting Laboratory of the Trinidad and Tobago Bureau of Standards (TTBS) and the Cooling Laboratory of the Bureau of Standards Jamaica (BSJ). Each of these laboratories provides accredited testing services for different types of electric appliances to members of the Caribbean Community and beyond. A key factor in their success is that the region's program for energy efficiency labeling is coordinated at the regional level by a well-established institution, the Caribbean Community (CARICOM) Regional Organisation for Standards and Quality (CROSQ). This organization offers ongoing support to member states in developing energy efficiency standards, raising awareness of standards, and sharing results of testing through a centralized database.

Southern Africa: Regional accreditation body

When trade agreements among the member countries of the Southern African Development Community (SADC) took effect, only 2 out of 16 member countries had national accreditation bodies on account of the high fixed costs of setting up such institutions. This created a challenge in ensuring competent and mutually recognized conformity assessment across the region. Through the pooling of resources from the remaining 14 member states, the Southern African Development Community Accreditation Service (SADCAS) was established as the world's first regional, multi-economy accreditation body for verifying the competencies of conformity assessment bodies in participating countries. A key factor in this service's success has been sharing qualified assessors and technical experts. Using only 21 full-time staff but having access to nearly 100 experts in the region, SADCAS is capable of meeting the accreditation needs of the entire SADC region with support from its National Accreditation Focal Points located in member states.

Source: Physikalisch-Technische Bundesanstalt (PAB), as an input to *World Development Report 2025*.

Figure 3.14 Decision tree for assessing the feasibility of sharing resources related to quality infrastructure between countries



Source: WDR 2025 team, in collaboration with Physikalisch-Technische Bundesanstalt.

Conclusion

Quality infrastructure is often overlooked, yet it quietly supports the effective functioning of economies and governments, from enabling exports and protecting consumers to fostering innovation and environmental sustainability. For low- and middle-income countries, strengthening quality infrastructure is not just about building laboratories or metrology institutes, it is also about establishing credible institutions that can support development. That is why this Report emphasizes that the functions and principles of quality infrastructure have universal relevance. The ambition of standards must be raised along with the capacity to comply with them. Quality infrastructure is vital to this effort, ensuring that higher standards are not only set but also met. As this chapter has highlighted, quality infrastructure is an adaptive system in public-private partnership that must evolve as countries develop. Such an evolution includes defining the types of services needed within the country, how public and private roles should shift over time, and how quality infrastructure can be effectively integrated into public policy.

Notes

1. The International Network on Quality Infrastructure (InetQI) has established the following definition of quality infrastructure: "The system comprising the organizations (public and private) together with the policies, relevant legal and regulatory framework, and practices needed to support and enhance the quality, safety and environmental soundness of goods, services and processes" (Quality Infrastructure Definition [web page], International Network on Quality Infrastructure, https://www.inetqi.net/documentation/quality-infrastructure-definition/). InetQI brings together all specialized organizations that operate at an international level and are active in promoting and implementing activities related to quality infrastructure (metrology, standardization, conformity assessment, and accreditation) as a tool for sustainable economic development. For details, refer

to INetQI: International Network on Quality Infrastructure (home page), https://www.inetqi.net/.
2. The Quality Infrastructure Investment (QII) Partnership, implemented by the World Bank with funds from the government of Japan, is not related to quality infrastructure as defined in this Report. The partnership aims to raise awareness of the quality dimensions of physical infrastructure. Refer to Quality Infrastructure Investment Partnership (home page), World Bank, https://www.worldbank.org/en/programs/quality-infrastructure-investment-partnership.
3. As defined by ISO and IEC (2020).
4. BIPM (2021, 7).
5. Calibration is generally classified under metrology services, not as a conformity assessment activity. However, it can become part of a process for conformity assessment if it is performed to demonstrate that measurement equipment meets specified requirements (for example, if an accredited laboratory issues a calibration certificate that is recognized in trade or regulation). This Report therefore lists calibration under conformity assessment services.
6. Market surveillance by regulatory authorities differs from the activities of conformity assessment bodies that conduct regular audits and inspections after completion of their assessments to ensure continued compliance.
7. Guasch et al. 2007; UNIDO 2018a. The term "quality infrastructure" emerged as a comprehensive concept only in the late 1990s and early 2000s, but its components have been recognized and discussed separately for a longer time (Harmes-Liedtke et al. 2025). Before the term was coined, engagements either focused on individual elements of quality infrastructure or used abbreviations such as MSTQ (metrology, standardization, testing, and quality) and SQAM (standardization, quality assurance, and metrology).
8. Harmes-Liedtke et al. (2025).
9. Kellermann (2019a).
10. Refer also to Blind et al. (2025); Kellermann (2019a); Racine (2011).
11. WTO (2016).
12. Rab and Brown (2023).
13. Manders (2014).
14. Moreover, quality infrastructure can also be understood as a separate economic sector or high-tech cluster. This sector employs highly qualified personnel and provides corresponding jobs.
15. OECD (2025).
16. World Bank (2024).
17. The vision of "One standard, one test, accepted everywhere" has been published in different variations by different organizations, such as the European Committee for Standardization (CEN) and the European Committee for Electrotechnical Standardization (CENELEC). Refer to European Standardization: CEN and CENELEC (dashboard), European Committee for Standardization and European Committee for Electrotechnical Standardization, https://www.cencenelec.eu/european-standardization/cen-and-cenelec/. For example, it also was the theme of the International Organization for Standardization's World Standards Day in 2002 (ISO 2002).
18. Through the ISO Committee on Conformity Assessment (CASCO), ISO and the IEC have developed the ISO/IEC 17000 series of standards, which specify requirements for the competence, consistency, and impartiality of conformity assessment bodies and accreditation bodies. These documents are commonly known as the "CASCO toolbox." Using them fosters international compatibility among conformity assessment bodies and accreditation bodies and reduces technical barriers to trade. The World Trade Organization (WTO) and its Agreement on Technical Barriers to Trade formally recognize this role. For more information, refer to CASCO Toolbox (dashboard), Committee on Conformity Assessment, International Organization for Standardization, https://casco.iso.org/toolbox.html.
19. In practice, national legislation may supersede a mutual recognition arrangement based on accreditation: for example, if a regulator requires an entity to have additional recognition from conformity assessment bodies in order to conduct testing or certification in regulated areas. Accreditation is only the attestation of technical competence to conduct a conformity assessment, not an authorization for conducting assessments in regulated areas. Refer also to BMWi (2021).
20. For further discussion, refer to UNIDO and PTB (2024).
21. Harmes-Liedtke et al. (2025); Lee and Kim (2025).
22. The literature review by Blind et al. (2025) focuses on the term "quality infrastructure" and does not include the elements of quality infrastructure separately, which would have increased the number of articles substantially.
23. Refer, for example, to Blind et al. (2011).
24. de Vries et al. (2012).
25. Mirtsch et al. (2021).
26. Aba et al. (2015); Castka and Corbett (2015); Manders (2014); Sfreddo et al. (2021).
27. Clougherty and Grajek (2023); Manders et al. (2016).
28. Boiral et al. (2018); Nemati et al. (2019).
29. Arocena et al. (2021); Treacy et al. (2019); Wiegmann et al. (2023).
30. de Vries et al. (2012).
31. Blind et al. (2025).
32. Frenz and Lambert (2014); Ramkissoon and Nisi (2024); Swann (2009).
33. Clougherty and Grajek (2008, 2023); Potoski and Prakash (2009).
34. Blind et al. (2018).
35. Du et al. (2025).
36. Choudhary et al. (2013); refer also to Birch (2003).
37. Although calibration is mentioned under metrology here, it is also a type of conformity assessment. Refer to note 5.
38. Harmes-Liedtke and Oteiza Di Matteo (2011).

39. These three phases also align with the four maturity levels of quality infrastructure distinguished by Kellerman (2019a): rudimentary, basic, advanced, and mature. The simplified framework presented here mainly merges the rudimentary and basic levels.
40. Kaul (2025).
41. Harmes-Liedtke et al. (2025).
42. ILAC and the IAF will form a new organization, the Global Accreditation Cooperation Incorporated, in January 2026 (refer to "Global Accreditation Cooperation Incorporated Is Registered in New Zealand," ILAC, December 6, 2024, https://ilac.org/latest_ilac_news/global-accreditation-cooperation-incorporated-is-registered-in-new-zealand/).
43. Kellermann (2019b).
44. OECD (2025).
45. Kellermann (2019b).
46. Kellermann (2019a). Reflecting these shifts, responsibility for quality infrastructure often transitions from ministries of science and technology, in the early stages, to ministries of trade or economy, which are typically better positioned to engage with the private sector.
47. Harmes-Liedtke et al. (2025).
48. Refer to de Vries (1999); Kellermann (2019a); OECD (2018); UNIDO (2018b).
49. ISO (2019).
50. World Bank and ISO (2025).
51. Battocletti et al. (2023).
52. Bush (2022).
53. Duflo et al. (2013).
54. An example is management system certification, such as that under the popular standard ISO 9001.
55. Kellermann and Keller (2015).
56. Harmes-Liedtke (2021b).
57. Kaul (2025).
58. Refer to What Is the TIC Sector? (web page with media), TIC Council (accessed April 25, 2025), https://www.tic-council.org/about-us/what-is-the-tic-sector.
59. Kaul (2025).
60. Gong and Zhang (2025).
61. Lee and Kim (2025).
62. Kellermann (2019a).
63. It therefore is common practice for development partners to support both the supply and demand sides for quality infrastructure. For example, the Global Quality and Standards Programme implemented by the United Nations Industrial Development Organization (UNIDO) and funded by the Swiss government follows such an integrated approach, strengthening quality infrastructure institutions (supply), enhancing private sector capacities for compliance (demand), and promoting a quality culture to strengthen the links between supply and demand.
64. Juhász et al. (2023); Rodrik (2022).
65. Refer to Porter and van der Linde (1995).
66. Blind et al. (2017).
67. ISO (2012, 2023); OECD (2018).
68. Risk preferences are also affected by the extent of people's awareness of risks. With greater awareness, people may opt for lower risk preference.
69. A hybrid approach combining self-declaration of conformity with mandatory third-party assessment is also possible. For example, under the European Union's CE marking framework, legislation may require an economic operator to undergo third-party conformity assessment by an authorized body before issuing a manufacturer's declaration of conformity.
70. BMWi (2021); UNIDO (2018b).
71. Callen et al. (2020).
72. Miesner (2009).

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