UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

INTERNATIONAL NETWORK ON QUALITY INFRASTRUCTURE

SUSTAINABLE DEVELOPMENT GOALS

QI4SD

Quality Infrastructure for Sustainable Development Index

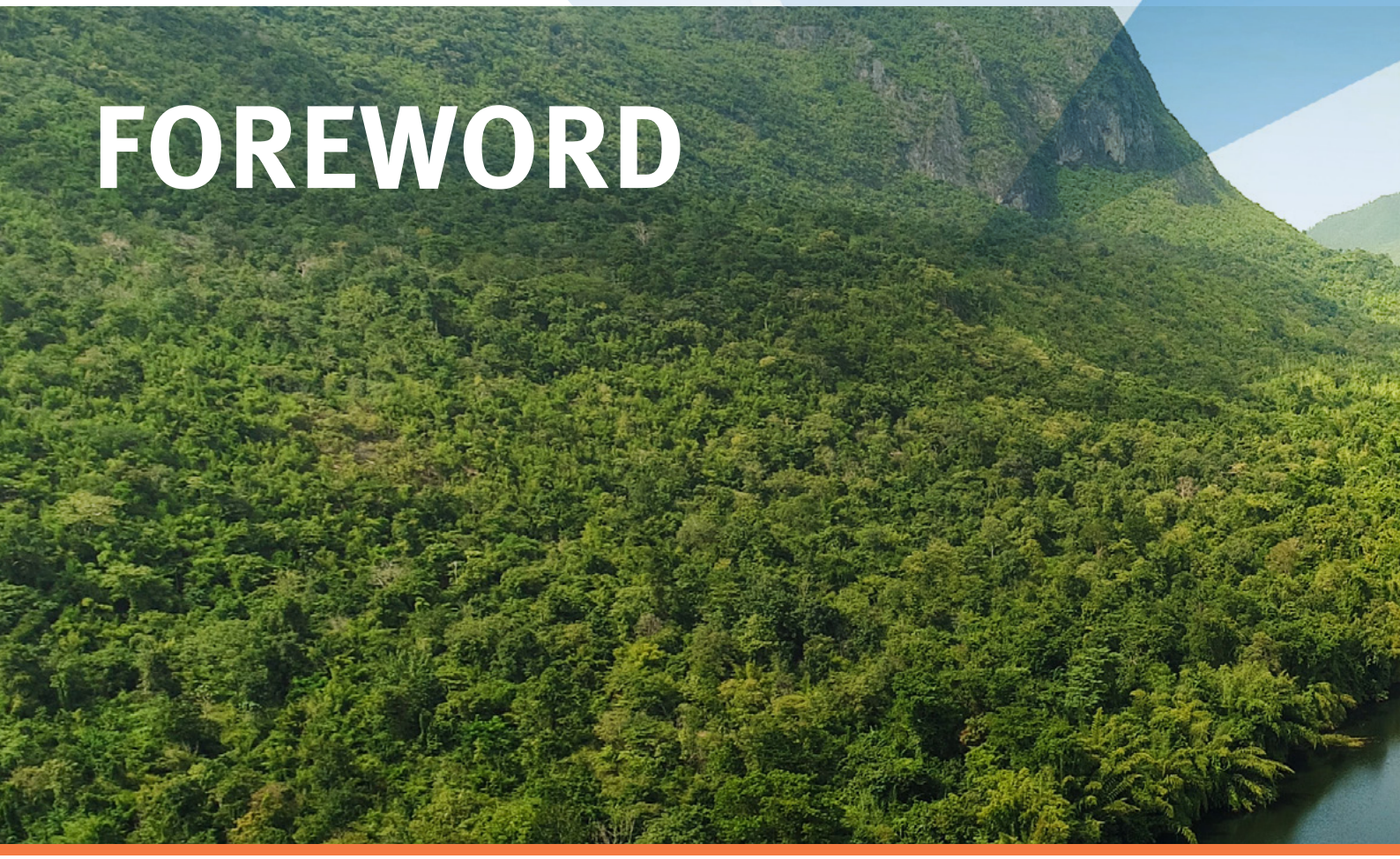
SUPPORTING SUSTAINABLE DEVELOPMENT GOALS WITH QUALITY INFRASTRUCTURE

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Quality Infrastructure for Sustainable Development Index

SUPPORTING SUSTAINABLE DEVELOPMENT GOALS WITH QUALITY INFRASTRUCTURE

Vienna, Austria 2022



FOREWORD

It is a great pleasure for me to introduce the Quality Infrastructure for Sustainable Development (QI4SD) Index. This neutral and objective tool serves to assess the readiness of a country's Quality Infrastructure (QI) to support the Sustainable Development Goals (SDGs). The Index was developed by the United Nations Industrial Development Organization (UNIDO) in collaboration with partner organizations of the International Network on Quality Infrastructure (INetQI).

For over 50 years, UNIDO has been supporting QI development to improve the industrial and economic performance of developing countries. Support to QI systems has evolved over the years, in light of rapid modernization and technological transformation. In order for QI to be effective and sustainable, QI must advance swiftly, underpinned by the paradigm of sustainable development. QI institutions and services require strengthening and expanding to meet new requirements, help consumers make informed choices, encourage innovation and good practice, and lead businesses and industries to adopt sustainable technologies and processes.

In this vein, the QI4SD Index demonstrates the value of QI as an enabler of sustainable development and the importance of investing in it. The Index aims to bridge an information gap by being the first tool to explicitly measure how fit for purpose QI is in meeting the SDGs. It also serves as a comprehensive measurement of QI in its own right. Information on the fitness of QI to meet sustainable development needs will serve as useful input to support policy processes and national implementation plans, as well as the coordination of development cooperation programmes. This information will help with strategic resource allocation and measurement of progress. As a public good for common use, this type of open-source information can allow further analysis that can, in turn, encourage and support knowledge creation.

UNIDO looks forward to the opportunities that the QI4SD Index presents to better promote QI in support of achieving the 2030 Agenda for Sustainable Development, particularly for developing and middle-income countries. I hope that this publication will help to better understand the important work being done in this area.

Gerd Müller

Director General, UNIDO

For some time now, we have been hearing that data is important. Three reasons this is the case in the QI context are that data assists with:

1. Demonstrating, with concrete evidence, the contribution of the conformity assessment sector to the market and its value. Various (predominantly local) studies demonstrate the differing contributions to productivity, workplace safety and export capacity between certified and non-certified companies;
2. Knowing (general or sectoral) market trends, including ICT sector turnover; and
3. Providing regulators with updated and complete information on the implementation of sustainability policies, so the effectiveness of the measures adopted can be measured.

In this regard, the QI4SD Index is a useful tool that analyzes QI from five dimensions—standardization, metrology, accreditation, conformity assessment and policy—and maps out indicators for each. It then links these indicators to three of the five pillars of the SDGs: "Prosperity", "People" and "Planet".

With respect to INetQI, international policies often require targeted solutions that only a regional structure can satisfy. For this reason, I welcome the idea of a Regional Network for Quality Infrastructure (RNetQI).

Moreover, as the International Accreditation Forum (IAF) Chair, I would like to highlight the launch of a new strategic Working Group on Sustainability, which aims to have an immediate impact in this area. Transitioning to its action phase, the Working Group must understand what is needed and how to get the job done, either directly or through partnerships, even outside IAF. It is an inclusive model since, now more than ever, work is best done together. It is also important to underline the worldwide database on the certification of management systems initiative.

With this in mind, I am pleased to recall the planned merging of the International Laboratory Accreditation Cooperation (ILAC) with IAF. The driving force behind this initiative is the desire to increase the ability to listen, and to provide tangible solutions in the face of the objectives set by the 2030 Agenda, thereby driving change and ease of impact through increased political weight.

It all comes full circle as each of these aforementioned initiatives contributes to a more sustainable world.

Emanuele Riva

INetQI Chair

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

The Quality Infrastructure for Sustainable Development (QI4SD) Index is a project developed by the United Nations Industrial Development Organization (UNIDO) to measure the contribution of Quality Infrastructure (QI) to the Sustainable Development Goals (SDGs), at the national level. The QI4SD Index framework aims to fill an information gap by providing the first tool for explicitly measuring how fit for purpose the QI is to achieve sustainable development. Moreover, it is a comprehensive measurement of QI in its own right.

The QI4SD Index follows a *composite indicator* approach. Both QI and sustainable development are multidimensional concepts, and are decomposed into simpler dimensions that can be more readily captured with indicators. QI is divided into the following five dimensions: Accreditation, Conformity assessment, Metrology, Policy and Standards. Sustainable development is detailed in the 17 Sustainable Development Goals (SDGs) and are divided into the "3Ps", which are People, Planet and Prosperity. Aggregating to the 3P level allows a potentially clearer analysis according to the canonical pillars of sustainable development: social (People), environmental (Planet) and economic (Prosperity).

The QI4SD Index framework was assembled by mapping the concepts of QI and SDGs and their interactions, leading to a selection of indicators. This was done in close collaboration with experts from various INetQI organisations. Indicators were grouped into the dimensions of QI and aggregated to give summary measures. Where possible, indicators are decomposed according to the 3Ps, so that the readiness of each dimension of QI for each P can be understood. The framework comprises consequently four indexes: the general QI4SD Index and the 3P-Indexes.

The QI4SD initiative has shown that QI, when linked with economic development, boosts economic output. But equally, QI costs money, so larger economies are able to have a more extensive QI. The largest economies are scoring highest on QI and are Germany, China and the USA, among others. As a result, high QI4SD Index scores mainly occur in countries that enjoy high GDP. However, the economic output is not the only enabler for an advanced QI system of a country. There seems to be a reciprocal relationship between economic prosperity and QI in a country.

Of the 17 SDGs, the People, Planet and Prosperity indexes are mostly related with SDG 9, the goal that promotes socially inclusive and environmentally sustainable economic development by enhancing infrastructure, industry and innovation. The QI institutions and services have indeed an important role in industry and infrastructure.

For the first time (to our knowledge) Quality Policy (QP) was assessed in a worldwide survey. A majority of the ranked countries (55%) has a national or regional QP, i.e. a policy for developing and sustaining effective QI, and 30% of the countries have regulations or directives that define functions and responsibilities of the different areas of QI. The survey evidenced that also smaller economies may have high QP scores.

ACKNOWLEDGEMENTS

The document is the result of a collaborative effort of UNIDO and the International Network on Quality Infrastructure (INetQI), whose members are:

BIPM	Bureau International des Poids et Mesures/International Bureau of Weights and Measures
IAF	International Accreditation Forum
IEC	International Electrotechnical Commission
IIOC	Independent International Organisation for Certification
ILAC	International Laboratory Accreditation Cooperation
IQNET	International Certification Network
ISO	International Organization for Standardization
ITC	International Trade Centre
ITU	International Telecommunication Union
OIML	Organisation Internationale de Métrologie Légale/International Organization of Legal Metrology
UNECE	United Nations Economic Commission for Europe
UNIDO	United Nations Industrial Development Organization
WBG	World Bank Group
WTO	World Trade Organization

This document has been prepared by the United Nations Industrial Development Organization (UNIDO) under the overall guidance of Dr. Bernardo Calzadilla-Sarmiento, Managing Director, Directorate of Digitalization, Technology and Agri-Business (DTA). Conceptual technical design and inputs were coordinated by Mr. Juan Pablo Davila, Industrial Development Officer (IDO), Department of Digitalization, Technology and Innovation (DTI).

UNIDO greatly acknowledges the dedicated work of Mr. William Becker and Ms. Hedvig Norlén in leading the technical work and discussions for the development of the Quality Infrastructure for Sustainable Development (QI4SD) Index Methodology and report. The contributions and coordination of Ms. Nora Dei-Anang (UNIDO) are highly appreciated.

The QI4SD Index Methodology is built from the data, inputs and feedback provided by members of INetQI during numerous Expert Group Meetings, special thanks to : Mr. Jose Alcorta (ISO), Ms. Linda Zaech (ISO), Ms. Aude Oppikofer (ISO), Mr. David Hanlon (IEC), Ms. Aristea Kyriakati (IEC), Ms. Gabriela Ehrlich (IEC), Mr. Martin Euchner (ITU), Mr. Vladimir Daigele (ITU), Mr. Andy Henson (BIPM), Mr. Chingis Kuanbayev (BIPM), Mr. Anthony Donnellan (OIML), Mr. Ian Dunmill (OIML), Mr. Brahim Houla (IAF), Mr. Mika Juha Vepsalainen (UNECE), Mr. Tauno Kangur (UNECE), Mr. Marcus Long (IIOC), Mr. Pedro Alves (IQNet) and Mr. Alex Stoichitoiu (IQNet).

We extend our grateful appreciation to members of the UNIDO team, who contributed to the development of the indicators: Mr. Steffen Kaeser, Mr. Nicola Cantore, Mr. Fernando Santiago Rodriguez, Mr. Bernard Bau, Mr. Juan Pablo Diaz-Castillo, Mr. Cong Wu, Ms. Dorina Nati, Mr. Nima Bahramalian and Mr. David Tomlinson.

This publication was developed under the Global Quality and Standards Programme (GQSP), funded by Switzerland, through the Swiss State Secretariat for Economic Affairs (SECO).

This publication was edited by Brigitt Roveti. Publication design and layout were developed by Radhika Nathwani.

DISCLAIMER

ACRONYMS

AB	Accreditation Body
BIPM	Bureau international des poids et mesures/International Bureau of Weights and Measures
CAB	Conformity Assessment Body
CAC	Codex Alimentarius Commission
CB	Certification Body
CC	Consultative Committee
CGPM	Conférence Générale des Poids et Mesures /General Conference on Weights and Measures
CI	Composite Indicator
CIMO	Commission for Instruments and Methods of Observation
CIPM	Comité international des poids et mesures International/Committee for Weights and Measures
CMC	Calibration and Measurement Capacity
CS	Certification System
DTA	Digitalization, Technology and Agri-Business
DTI	Department of Digitalization, Technology and Innovation
EU	European Union
FAO	UN Food and Agriculture Organisation
GDP	Gross Domestic Product
GFSI	Global Food Safety Initiative
GQII	Global Quality Infrastructure Index
GQSP	Global Quality and Standards Programme
IAF	International Accreditation Forum
ICH	International Council for Harmonization
ICT	Information and Communication Technology
IDO	Industrial Development Officer
IEC	International Electrotechnical Commission
IIOC	Independent International Organisation for Certification
ILAC	International Laboratory Accreditation Cooperation

INetQI	International Network on Quality Infrastructure
IPPC	International Plant Protection Convention
ISO	International Organization for Standardization
ITC	International Trade Centre
ITU	International Telecommunications Union
IQNet	International Certification Network
JRC	Joint Research Centre
MLA	Multilateral Recognition Arrangement
MRA	Mutual Recognition Arrangement
NMI	National Metrology Institute
OECD	Organisation for Economic Co-operation and Development
OIE	Organisation Mondiale de la Santé Animale/World Organisation for Animal Health
OIML	Organisation Internationale de Métrologie Légale/International Organisation of Legal Metrology)
PPP	People, Planet and Prosperity
QI	Quality Infrastructure
QI4SD	Quality Infrastructure for Sustainable Development
QP	Quality Policy
RTA	Regional Trade Agreement
SAFA	Sustainability Assessment of Food and Agriculture systems
SAN	Sustainable Agriculture Network
SDGs	Sustainable Development Goals
SECO	Swiss State Secretariat for Economic Affairs
SPS	Agreement on the Application of Sanitary and Phytosanitary Measures
TBTs	Technical Barriers to Trade
TC	Technical Committee
UN	United Nations
UNECE	United Nations Economic Commission for Europe
UNFSS	United Nations Forum on Sustainability Standards
UNIDO	United Nations Industrial Development Organization
WBG	World Bank Group
WMO	World Meteorological Organization
WTO	World Trade Organization

1. Background

The United Nations (UN) Sustainable Development Goals (SDGs) have, since their inception in 2015, become a major political focus for international organisations and governments around the world.

SDGs are being pursued in many ways. One contribution, which is the subject of this work, is *Quality Infrastructure (QI)*. Briefly, QI is the national system of standards, regulation and oversight which ensures that products and services are produced to an internationally-recognised level of quality (full definition is found below in Section 1.1). QI is important for SDGs in many ways, but its most relevant contributions include enabling international trade and boosting innovation; raising standards for consumers in terms of health, food and water quality; and effectively implementing and monitoring environmental sustainability.

The United Nations Industrial Development Organization (UNIDO) aims, among other things, to promote QI, particularly for developing countries. However, to better direct resources and interventions, more data is needed to understand the state of QI in each country, in particular with regard to its suitability for working towards SDGs.

In this context, the *Quality Infrastructure for Sustainable Development Index* (QI4SD Index) aims to provide a framework of indicators that summarises the overall state of development of a country's and/or region's QI readiness to support the SDGs, providing comparable information to measure progress over time and develop targeted interventions. The QI4SD Index is therefore not a measurement of sustainable development but rather a measure of QI and how it contributes to SDGs.

1.1 QUALITY INFRASTRUCTURE

Quality Infrastructure is defined by INetQI[1] as follows:

> *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.*
>
> *The QI is required for the effective operation of domestic markets, and its international recognition is important to enable access to foreign markets. It is a critical element in promoting and sustaining economic development, as well as environmental and social wellbeing.*
>
> *It relies on metrology, standardisation, accreditation, conformity assessment, and market surveillance.*

Note that **QI does not include most physical infrastructure**, e.g. related to transport, energy, and information and communication technology (ICT).

The nature of QI is more evident when examining its specific dimensions. These dimensions may vary slightly depending on the source; for example, the World Bank has published an extensive QI Diagnostics and Reform Toolkit (Kellermann et al., 2019[2]), which points out that some aspects of QI ("building blocks") are more essential than others, and has classified these into "fundamental", "major" and "minor" considerations. For the purposes of this work, however, the INetQI definition is adopted. UNIDO's report on Rebooting Quality Infrastructure for a Sustainable Future suggests that QI can be divided into five main dimensions (UNIDO, 2020), which are listed as follows in Table 1.

[1] https://www.inetqi.net/documentation/quality-infrastructure-definition/

[2] https://www.worldbank.org/en/topic/competitiveness/brief/qi

TABLE 1: UNIDO DIMENSIONS OF QI

METROLOGY

Metrology is the science of measurement and its application. It underpins the quality of manufactured goods and processes through accurate and reliable measurement. Metrology plays a key role in the adoption of scientific and technological innovations, the design and efficient manufacture of products that comply with the needs of the marketplace, and the detection and avoidance of non-conformities. It provides fundamental support for health and safety testing, environmental monitoring, and food processing. Metrology also provides the basis for fair trading in a domestic economy and international trading in the global market place, and has a particular role to play when there is a societal need to protect both the buyer and seller in a commercial exchange of a commodity or a service provided, or where measurements are used to apply a sanction, and virtually all countries provide such protections through their legal systems. The global aspect of many of these areas involving measurement is increasingly important and needs to be taken into account as far as possible. Scientific and industrial metrology are managed by the International Bureau of Weights and Measures (BIPM), whereas legal metrology is the domain of the International Organization of Legal Metrology (OIML).

STANDARDISATION

This distils and makes available international expertise and knowledge regarding usability, quality, safety, performance or any other characteristics required by users, buyers and producers. Standards contain technical specifications for products or product components (e.g. dimensions, sizes, formats, tolerances, performances and interfaces). They are also repositories of knowledge for product testing; for requirements for services, processes and systems; for guidance on how to conduct activities; for descriptions of best practices applied by experienced professionals in a given field; and for other specific information. The World Trade Organization's Agreement on Technical Barriers to Trade (WTO/TBT) defines a standard as a voluntary document to which compliance is not mandatory, as opposed to a technical regulation, to which compliance is mandatory.

CONFORMITY ASSESSMENT

This provides scientific and technical evidence of whether or not products meet standards or other requirements; are fit and safe for humans, animals, and the environment; and whether or not processes are organized and managed in conformity with accepted good practices. Conformity assessment services are performed by organisations—conformity assessment bodies (CABs)—that specialize in testing, inspection and certification.

ACCREDITATION

This supports the correct functioning of conformity assessment systems. Accreditation bodies (ABs) are responsible for providing a formal attestation of the integrity of conformity assessment bodies and their competence to perform specific conformity assessment activities, using criteria that are contained in international standards.

MARKET SURVEILLANCE

This verifies whether products and services on the market comply with applicable regulations. Market surveillance authorities are usually under government responsibility. The purpose of these regulations is usually to ensure that products and services do not endanger health, safety, or the environment, and to strengthen trust between businesses and their clients. The difference with conformity assessment is that the former regard *voluntary standards*, whereas market surveillance regards *mandatory regulations*.

These five components are deeply interconnected. For example, conformity assessment assesses whether standards are being achieved, and is supported by metrology. Accreditation ensures that conformity assessment is performed correctly. Market surveillance is based on regulations which often derive from standards.

A final dimension of QI that is of interest to the QI4SD Index is **Policy**. That is, what policies does the national government have in place to promote and support QI? This can include a roadmap to develop and promote QI, governmental support and funding, stakeholder engagement, laws and monitoring/evaluation mechanisms.

1.1.1

INetQI

QI is by its nature a highly-connected international network, in that it involves internationally-agreed standards and reference points, as well as international accreditation mechanisms. As such, QI is promoted, coordinated and implemented by a number of international QI organisations.

The International Network on Quality Infrastructure (INetQI) is a group of 14 international organisations which "seek to bring together all specialised organisations that operate at an international level and that are active in promoting and implementing QI activities (metrology, accreditation, standardization and conformity assessment) as a tool for sustainable economic development".[3] These organisations are roughly mapped to the relevant dimensions of QI in Figure 1.

Figure 1 is in fact a simplification of reality, in that many INetQI organisations operate in more than one dimension of QI. For example, the IEC also operates in conformity assessment, as well as developing standards.

INetQI organisations arguably represent the main hub for global QI development, and are used as the main source of expertise to guide the development of the QI4SD Index, as well as data sources in their own right. This is explained in more detail in Section 2.

1.2 SUSTAINABLE DEVELOPMENT

Sustainable development is encapsulated in the Sustainable Development Goals (SDGs) outlined in the United Nation's **2030 Agenda for Sustainable Development**. The SDGs are a set of 17 global goals designed to achieve a 'better and more sustainable future for everybody', which were adopted in a UN General Assembly in 2015, and to be achieved by the year 2030 (United Nations General Assembly, 2015).

The SDGs were accompanied by an official global set of 231 indicators which were agreed on in a UN resolution (United Nations General Assembly, 2017); since then the number has increased to 247, due to some repetitions. These indicators were intended to be a basis for regional and national systems of monitoring, and in practice, national and regional statistical offices have adopted a streamlined subset, with modifications appropriate to the national/regional context.

The SDGs have often been referred to as a plan for People, Planet and Prosperity, as well as Peace and Partnership. How the 17 SDGs relate to these five dimensions is somewhat debatable. While some are clear-cut (climate action = planet), others could fit in more than one category (for example, SDG 6 (Ensure availability and sustainable management of water and sanitation for all) sometimes appears in either People or Planet). Nevertheless, this "PPPPP distinction" (often simply "PPP" or "3Ps", excluding the "Peace" and "Partnership" dimensions) is useful in analysing sustainable development because depending on the context, analysis at the level of individual goals can be impractical due to data limitations and the considerable overlap between one goal and another. Aggregating to the PPP level allows a potentially clearer analysis according to the canonical dimensions of sustainable development: social (People), environmental (Planet) and economic (Prosperity).

The division of SDGs used in this work is shown in Figure 2.

FIGURE 1: INetQI organizations mapped to dimensions of QI

INSTITUTIONS BELONG TO THE INTERNATIONAL NETWORK ON QUALITY INFRASTRUCTURE (INETQI)			
Standards	Accreditation	Metrology	Conformity assessment
• International Organization for Standardization (ISO) • International Electrotechnical Commission (IEC) • International Telecommunication Union (ITU)	• International Accreditation Forum (IAF) • International Laboratory Accreditation Cooperation (ILAC)	• International Bureau of Weights and Measures (BIPM; scientific and industrial metrology) • International Organization of Legal Metrology (OIML; legal metrology)	• Independent International Organisation for Certification (IIOC) • International Certification Network (IQNET)
Cross-cutting			
International Trade Centre (ITC) | United Nations Commission for Europe (UNECE) United Nations International Development Organisation (UNIDO) | World Bank Group (WBG) | World Trade Organization (WTO)			

[3] https://www.inetqi.net/

FIGURE 2: Grouping of SDGs into "P" dimensions

While the Peace and Partnerships dimensions are also mapped here, the focus will be exclusively on the People/Planet/Prosperity goals. From here, the "3Ps" refers to this latter group only.

1.3 QI FOR SDGS

How does QI contribute to and support sustainable development? Here, some pathways are described. This section is largely derived from UNIDO's report on **Rebooting Quality Infrastructure for a Sustainable Future** (UNIDO, 2020), which describes in detail how QI can help to achieve sustainable development goals, and is divided into each P according to the mapping in Figure 2.

In general, it is important to realise that QI is an *enabler* of sustainable development, rather than a sustainable development outcome in itself. General benefits of QI for businesses, many of which touch on the Prosperity dimension, can be found in case studies on the *Business Benefits* site.[4] Further examples of QI contributing to the public sector, with topics corresponding to many SDGs, can be found in the *Public Sector Assurance* website.[5] Both of these resources are developed by INetQI as a way of showing the positive impacts of QI.

[4] https://business-benefits.org/

[5] https://publicsectorassurance.org/

1.3.1 Prosperity

QI contributes to Prosperity in at least two main ways: the first is international trade. A QI system ensures that products are of a known and sufficient quality, meet safety standards, and comply with the standards and requirements of the destination market. Trade is known to improve the overall economic situation of a country, and indeed a number of sustainable development goals make explicit reference to trade or exports (e.g. SDGs 2 and 17). Global value chains account for at least two thirds of international trade (Kaplinsky, 2016). Deeper international connections have also been shown to be strongly related to greater social sustainability (Becker et al., 2019).

Trade is enabled and facilitated by QI through Mutual Recognition Arrangements (MRAs) and global/regional accreditation agreements which ensure that certificates issued in one country are recognised in another. Using international standards as the basis for trade regulations (as recommended by the World Trade Organization Agreement on Technical Barriers to Trade[6]) helps ensure that countries are placed on a level playing field, and that

regulations are consistent and do not act as a barrier to international trade.

A second pathway is through industrial development and innovation, which leads to economic development. Innovation, which is supported by QI by disseminating new technologies and products, has a clear positive relationship with prosperity (Cornell University et al., 2020). QI brings standards and metrology in high-tech sectors such as 5G, artificial intelligence, big data and additive manufacturing. Moreover, specific management standards exist for innovation management (e.g. ISO 56000 series) and tools and methods for innovation partnerships. QI helps effectively regulate new technologies, helping to ensure that they are developed safely and securely and with an even benefit across society.

Overall, international standards, MRAs and trade agreements should embed requirements of sustainability, in social, economic and environmental dimensions. The United Nations Forum on Sustainability Standards[7](UNFSS) provides an intergovernmental platform to promote voluntary sustainability standards.

1.3.2 People

One of the principal contributions of QI in terms of social sustainability is the promotion of high-quality food that is safe and fit for consumption, and facilitates imports and exports of food with other countries. This is driven by the World Trade Organization's Agreement on the Application of Sanitary and Phytosanitary Measures (SPS agreement), which states that food standards adopted into measures should come from recognised sources, in order to not create barriers to trade. Countries are encouraged to adopt legislation from the *Codex Alimentarius Commission* (CAC, who have a collection of standards and guidelines called the "Food Code"), the *International Plant Protection Convention* (IPPC, developing standards for protecting plant resources), and the *World Organisation for Animal Health* (OIE, developing standards aiming to improve animal health). The Organisation for Economic Co-operation and Development (OECD) also provides international codes and schemes that help to raise standards but facilitate international trade, as do ISO and the Global Food Safety Initiative (GFSI).

Sustainable agriculture is also promoted by organisations such as the UN Food and Agriculture Organisation (FAO), in particular the FAO's "Sustainability Assessment of Food and Agriculture systems (SAFA) Guidelines", the Sustainable Agriculture Network (SAN) "Sustainable Agriculture Framework", and the Rainforest Alliance "Sustainable Agriculture Standard" (UNIDO, 2020).

Healthcare is underpinned by good metrology, to provide accurate doses and biological measurements, as well as standards and calibration of instruments. The World Health Organisation (WHO) issues guidelines and lists of medicines. Standards exist for medical laboratories, and organisations such as the International Council for Harmonization (ICH) of Technical Requirements for Pharmaceuticals for Human Use attempt to harmonise national drug registration systems around the world, in order to streamline the availability of medicines.

Targeted standards can also contribute to gender equality. In particular, the development of gender-sensitive standards can push for gender equality as they ensure that gender considerations are sufficiently taken into account.

QI, in terms of standards, conformity assessment and market surveillance, enables clean energy generation, and protects consumers from unsafe or environmentally damaging products. Finally, QI helps to ensure that water and sanitation is of a high standard and fit for purpose, and that water reserves and consumption are reliably measured. ISO alone has around 300 standards addressing water quality.

1.3.3 Planet

In order to reduce material consumption, QI provides reliable measurements and controls of the impacts of producing various products, and can monitor a transition towards a more sustainable society. This may include:

- Measurement and certification of emissions in industry, via accredited labs
- Standards and conformity assessment to ensure that
- Environmental footprint of products is reduced
    - Products are designed with re-use and recycling in mind
    - Buildings, vehicles, industry and appliances are energy efficient

The World Meteorological Organisation (WMO) has a Global Observing System and Global Climate Observing System, which are used to monitor climate change. ISO has standards for measuring emissions (ISO14064 and ISO14065, as well as for promoting sustainable culture in organisations (ISO14001)). The WMO also engages with the Commission for Instruments and Methods of Observation (CIMO), the BIPM and the National Metrology Institutes (NMIs) to address standards, conformity assessment for measurement.

Regarding oceans, the Global Benchmark Tool, developed by the Global Sustainable Seafood Initiative, is a common benchmark for fishery certification schemes.

[6] https://www.wto.org/english/docs_e/legal_e/17-tbt_e.htm

[7] https://unfss.org/

1.4 MEASURING AND MONITORING

While the contribution of QI to SDGs is evident from the linkages described in the previous section, data is needed to better understand the interaction between the two concepts. Moreover, the state of QI in each country, particularly with regard to specific dimensions of QI (Ps), is not well-known, or at best data is scattered over many different sources.

1.4.1

Existing tools

Existing tools for measuring QI are relatively few. A paper published by the German NMI, the Physikalisch Technische Bundesanstalt (PTB) on Measurement of Quality Infrastructure gives a proposal for measuring QI, using a composite indicator that covers 53 countries (Harmes-Liedtke and Oteiza Di Matteo, 2011). The 53 countries are chosen as those belonging to the BIPM (International Bureau of Weights and Measures) at the time the paper was published.

The methodology in this report was subsequently updated and converted into the Global Quality Infrastructure Index (GQII) published by the consulting firms Mesopartner (Germany) and Analyticar (Argentina), and covers 70 countries (Harmes-Liedtke and Oteiza Di Matteo, 2019). The GQII measures various aspects of metrology, accreditation, standardisation and certification of products and services, both on the supply side (the international QI system) and on the demand side (companies and other users of QI services). The present version of the GQII covers 184 economies (Harmes-Liedtke and Oteiza Di Matteo 2021) and includes eleven indicators from three QI areas, accreditation, metrology and standards, as illustrated in Figure 3.

Notably, the GQII does not include policy, and bundles conformity assessment and standards into the same dimension. It also ignores legal metrology, other than membership of the OIML. Moreover, it does not explicitly consider SDGs. The underlying data for the GQII is also not publicly available at the time of writing this report, although in the GQII report the data is declared to be downloadable from their website.[8]

From a different angle, the World Bank's Quality Infrastructure Toolkit (Kellermann et al., 2019) is a tool to "help countries to develop or strengthen their own quality and standards ecosystems—to diagnose, build, and reform the complex elements of an effective, modern QI".

[8] https://gqii.org/

The toolkit breaks the assessment of QI down into "elements" (dimensions) of QI, each of which is composed of building blocks (equivalent to indicators). Each block can be considered using a degree of implementation (implemented/mostly implemented/partially implemented/not implemented), and also by a degree of importance (fundamental/major/minor). The data for this toolkit is expected to be collected by the countries themselves. Therefore, it is not designed as a self-diagnostic tool but rather a central comparison/benchmarking framework.

1.4.2

A new approach

The Quality Infrastructure for Sustainable Development (QI4SD) Index aims to fill an information gap by providing the first tool for explicitly measuring how fit for purpose the QI is to meet sustainable development. Moreover, it is a comprehensive measurement of QI in its own right.

The QI4SD Index follows a *composite indicator* approach. Composite indicators and scoreboards are pragmatic and systematic approaches to capturing multidimensional concepts that cannot otherwise be measured. A *scoreboard* is a structured system of indicators that aim to measure a common concept. A *composite indicator* is a mathematical aggregation of a set of indicators into a single score—in this sense it is like a summary measure of a scoreboard.

Composite indicators are often used to complement scoreboards rather than substitute for them, and are usually assembled using a hierarchical system of indicators. Used properly, they can serve as an access point to a complex set of underlying data, allow global comparisons, and be an effective communication tool to raise awareness about an issue.

The QI4SD Index was assembled by mapping the concepts of QI and SDGs and their interactions, leading to a selection of indicators. This was done in close collaboration with experts from various INetQI organisations. Indicators were grouped into the dimensions of QI and aggregated to give summary measures. Where possible, indicators are decomposed according to the 3Ps (People, Planet and Prosperity), so that the readiness of each dimension of QI for each P can be understood. The methodology behind the QI4SD Index is described in Section 2, and in more detail in the accompanying Methodological Annex.

1.4.3

Objectives

The QI4SD Index and its framework of indicators aim for:

a) Rapid assessment of the QI system in a country and/or region in meeting sustainable development needs.

FIGURE 3: Framework of the Global Quality Infrastructure Index 2020

GQII 2020 FRAMEWORK		
1. Accreditation	**2. Metrology**	**3. Standards**
• Membership of ILAC, IAF , AFRAC, APAC, ARAC, EA, IAAC, SADCA • Coverage of internationally recognized accreditation schemes • No. of accredited conformity assessment bodies for ISO 17065, ISO 17021 and ISO 17025	• No. of accredited conformity assessment bodies for ISO 17065, ISO 17021 and ISO 17025 • Membership of CIPM Consultative Committees • Coverage of Calibration and Measurement Capabilities areas • Number of Key & Supplementary Comparisons • Number of accredited calibration laboratories	• Membership of ISO, IEC • Participation in ISO Technical Committees • No. of companies certified for management standards

b) Making comparisons between countries, taking into consideration socio-economic and other factors.

c) Analysis of the strong and weak points in any given country and a direction on what to address in order to achieve next milestones in terms of developing a national QI system that is fit for purpose to meet sustainable development needs.

d) A dynamic perspective over time on the national and/or regional QI system in order to measure and improve the impact of interventions and identify good practices of quality governance.

e) Benchmarking of individual QI components which allows for continual improvement and mutual learning.

The target users of the index are:

» **QI institutions/service providers**—they can use the QI4SD scorecard to see how QI can address new challenges.

» **National governments and policymakers** who are involved in developing national implementation plans for the SDGs.

» **Industries, business associations/entities**—to build consumer confidence, to make informed and most advantageous procurement or investment decisions regarding certification, and to ensure good and sustainable employment conditions.

» **Regional QI bodies, economic commissions**, etc.—to measure progress of the region, and to develop and coordinate regional QI development strategies that are aligned with the SDGs.

» **QI international organisations, development agencies, donors**—to make informed decisions on where to target investments and monitor progress/impact of technical assistance provided with the overall aim of achieving the SDGs.

Notably, this is not an advocacy tool and is not primarily intended to attract public or media attention.

2. Methodology

The QI4SD Index mostly follows the internationally-recognised methodology for constructing composite indicators, as detailed in the Joint Research Centre (JRC) and OECD Handbook of Composite Indicators (JRC and OECD, 2008). This section gives an overview of the main conceptual steps, indicator selection, and the numerical steps to aggregate the indicators into a single index. A much more detailed description of the methodology, including details for individual indicators, is available in the accompanying Methodological Annex.

2.1 CONCEPTUAL FRAMEWORK

As explained in Section 1.1.1, the main dimensions of QI are as follows:

1. Standards (also include technical regulations)
2. Accreditation
3. Metrology (scientific, industrial and legal)
4. Conformity assessment (management system, product and personnel certification bodies, testing and calibration laboratories, and inspection bodies)
5. Market surveillance (for technical regulations only)

After consultation with QI organisations, a sixth dimension was identified:

6. Policy measures

Finally, after further consultation with INetQI organisations, in particular the United Nations Economic Commission for Europe (UNECE), the market surveillance dimension was removed. This was because there was no feasible way, in the time frame of the project, to gather any data on this dimension.

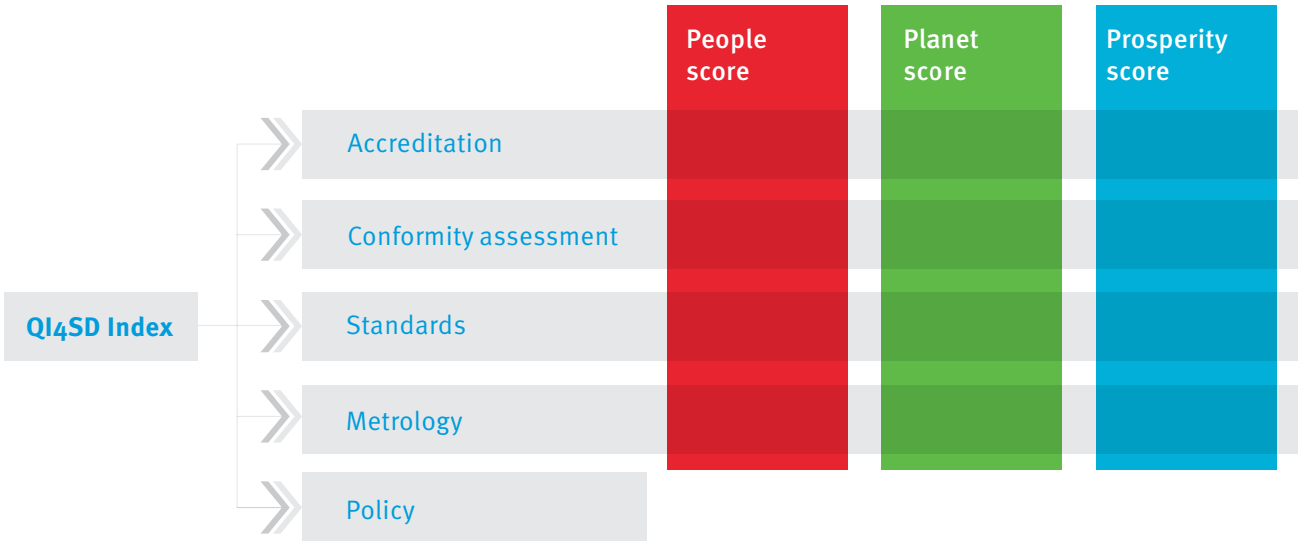
As a result, and combined with the three P-dimensions of sustainable development, the QI4SD Index can be viewed as a matrix, as shown in Figure 4.

The conceptual framework can be better explained by considering that in measuring the intersection of QI4SD to SDGs, two types of indicators arise.

1. "P-indicators" that measure specific intersections between QI dimensions and the SDGs. An example would be adopted environmental standards: this maps a QI dimension (standardisation), to an SDG dimension (Planet). These are the most desirable indicators but this kind of data is not always possible to obtain, although it is available in some cases.
2. "General indicators" that measure aspects of QI but have no explicit link to SDGs. This could be the number of accredited labs in a country, or the membership of international QI organisations. Such indicators are very relevant to QI, and these activities no doubt contribute to SDGs, but there is way to decompose or link them to specific dimensions of sustainable development.

In practice, the QI4SD Index is a mixture of these two types of indicators. Ideally, it would only be populated by P-indicators since this would give the best measurement of QI readiness for SDGs, but in practice a mixture is required to avoid omitting important aspects of QI.

FIGURE 4: Conceptual framework/matrix of the QI4SD Index



Note that P-indicators can also be used as general indicators (see Section 2.5).

Referring back to Figure 4, all dimensions except Policy have a mixture of P-indicators and general indicators. In the Policy dimension, no data was available for mapping QI to specific Ps. Importantly, **this does not mean that Policy does not contribute to SDGs**. It simply means that data is not available to measure the interaction.

The "matrix" framework here is somewhat unconventional in composite indicators, in that it attempts to merge two multidimensional concepts (QI and sustainable development). This presents challenges in data collection and processing, as well as how the index is eventually presented and communicated.

2.2 INDICATORS

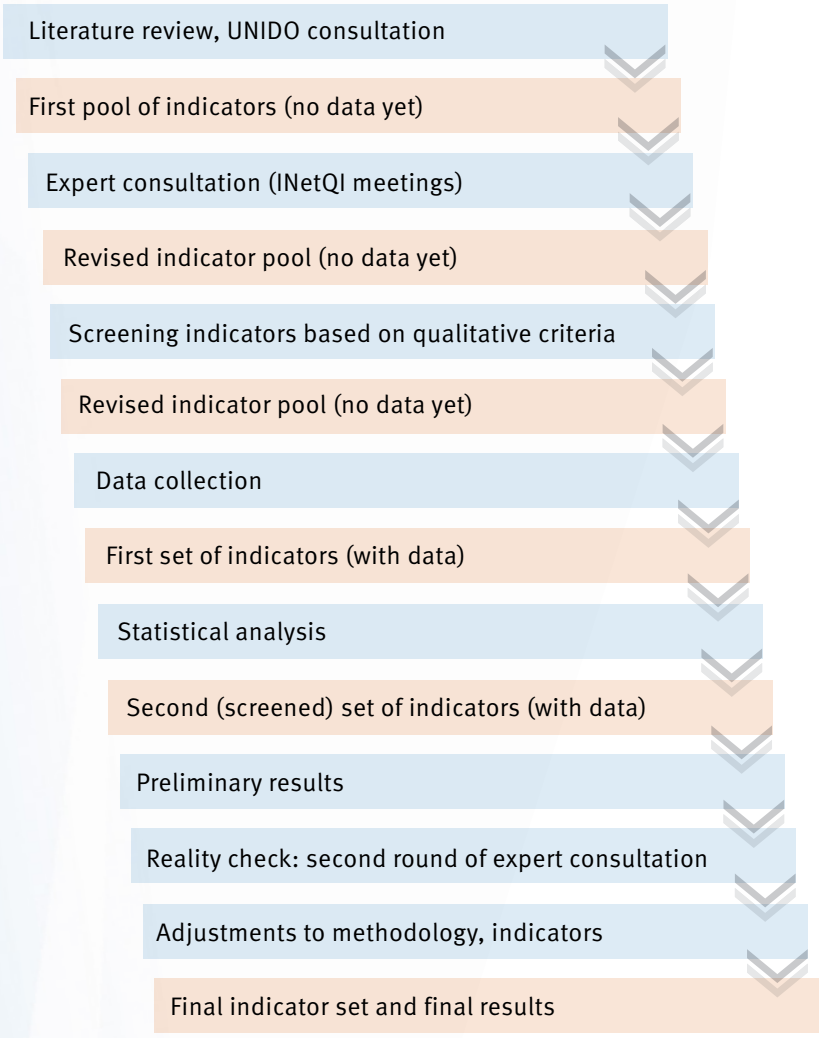
Given the framework proposed in the previous section, indicators were selected, and data collected/analysed, according to the iterative process shown in Figure 5.

The starting point was a first list of possible indicators, which was drawn up based on UNIDO expertise and previous surveys and other work, as well as the literature review. This list was used as a basis for discussions with international QI organisations, to gain further input and further suggestions for indicators. This resulted in a second pool of indicators. At this point, data had not yet been collected.

Following these meetings, potential indicators were considered against a set of (initially qualitative) selection criteria. Essentially the objective was to screen out any indicators for which it was impossible or impractical to collect data, or that represented obvious overlaps or duplicates, so as to focus on data collection of relevant indicators.

Data was then collected, with the large majority coming from INetQI organisations, since no centralised statistics exist on QI (e.g. through the World Bank, OECD, or other typical sources of indicators). While this adds to the complexity of the task, it also ensures that the QI4SD Index is not a repetition of existing indexes, and provides a unique and valuable contribution to QI and sustainable data. The data from the INetQI organizations was collected from February to June 2021. However, the

FIGURE 5: The indicator selection process



data year might differ from the year of collection as these organizations have different timeframes to update their own information.. Data is generally collected from the following sources:

1. Publicly available lists and databases provided by INetQI organisations or associates
2. Non-public data provided by INetQI organisations
3. UNIDO survey data where no existing data can be found

The survey was used only for key indicators for which no other source is available—this includes indicators for the Policy dimension, and the national adoption of ISO standards. Full details of the survey and data collection process can be found in the accompanying Methodological Annex.

Data was then analysed using the **R** statistical programming language. The statistical analysis, which examined correlations, missing data and unique values, led to a further screening of indicators. The outcome of this was a set of indicators that could be used to build preliminary results.

Finally, the preliminary results were presented to QI experts as a reality check. Following feedback, the methodology and indicators were refined as necessary, resulting in a final set of indicators and final results.

2.3

INDEX CONSTRUCTION

With the final set of indicators, the index was constructed following the statistical methodology found in the JRC and OECD Handbook on Constructing Composite Indicators, which is the main reference for composite indicator construction (JRC and OECD, 2008). This consists of the following main steps:

1. Outlier treatment (treating any outlying/extreme values that may have negative effects on the aggregation)
2. Normalisation (bringing indicators onto a common scale)
3. Weighting and aggregation

Outlier treatment consisted of a standard procedure based on ***Winsorisation*** which is used to adjust values solely for the purposes of aggregation.

Normalisation is the operation of bringing indicators onto a common scale. This is done so that indicators with very different units and scales can be aggregated and bring relatively equal contributions.

The QI4SD Index adopts a standard approach called the *min-max* method. This scales each indicator so that it lies inside the [1, 100] interval, as follows:

$$\tilde{x}_i = 1 + \frac{x_i - \min(x_i)}{\max(x_i) - \min(x_i)} \times 99$$

The reason that indicators are normalised with a minimum value of 1 (and not 0) is that assigning a zero score to a country can give the misleading impression that it has no capacity in given dimension of QI (this is discussed further in the Methodological Annex).

Finally, indicators are aggregated to give QI dimension scores (e.g. standards and metrology), and these scores are aggregated to give the overall QI4SD Index score. The aggregation method is the weighted arithmetic mean, i.e.

$$y = w_1\tilde{x}_1 + w_2\tilde{x}_2 + \cdots + w_n\tilde{x}_n; \quad \sum w_i = 1$$

Where the are the weights assigned to the indicators inside each aggregation group. In general, equal weighting is used, implying that indicators are more or less equally important. This is a common approach in composite indicators because although in principle unequal weights could be used, different stakeholders will have different perceptions of how indicators could be weighted. Some exceptions for which indicators were half-weighted are explained in detail in the Methodological Annex.

Finally, when aggregating the index, a data requirement rule is invoked. For any QI dimension, a country's score is only calculated if it has at least 60% data availability. This is also true at the index level: the index score is only calculated if 60% of the QI dimensions (3 out of 5) have a score.

2.4

COVERAGE

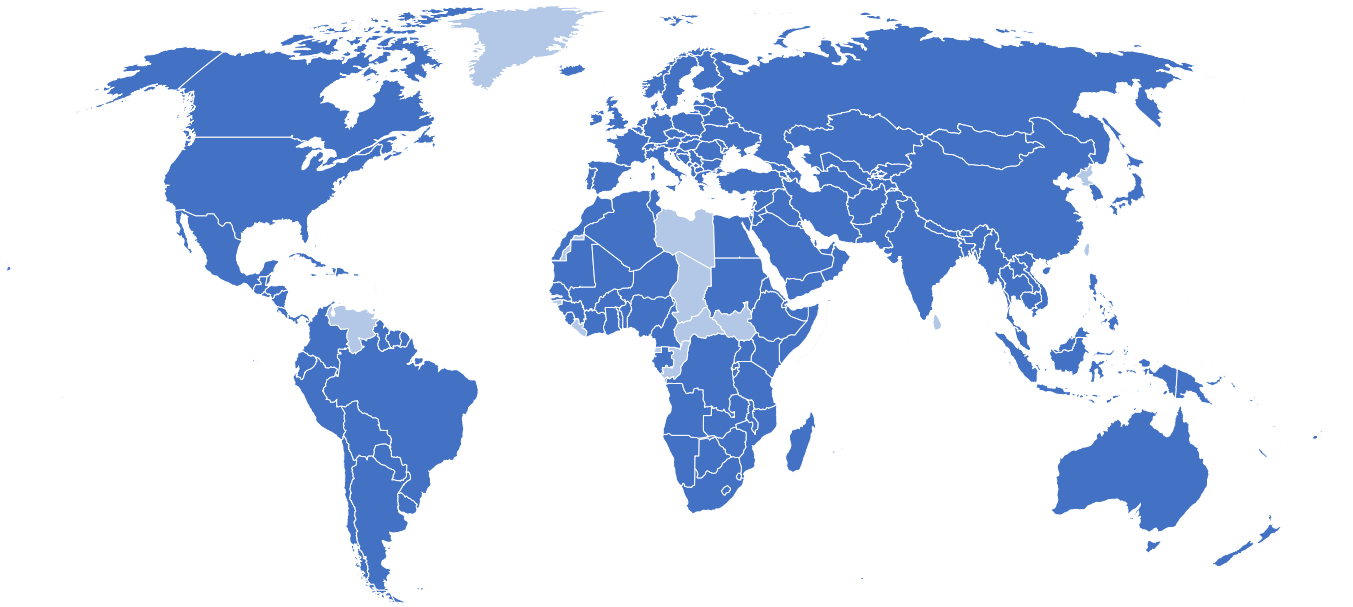
The QI4SD Index covers 137 countries. These countries were selected based on data availability rules. Countries were excluded if they have:

» Less than 60% data availability over all indicators, OR

» More than 66% zero values across all indicators

This excludes mostly very small countries but retains a wide coverage (see Figure 6 below), and has the effect of improving data availability for indicators.

FIGURE 6: Country coverage of the QI4SD Index



2.5

P-DIMENSIONS

A key feature and a unique challenge of the QI4SD Index is to break down the QI readiness of a country into specific dimensions of sustainable development:

» People

» Planet

» Prosperity

As explained in Section 2.1, the indicator framework consists of P-indicators (those that can be decomposed into the three Ps listed above), and general indicators which cannot be explicitly decomposed to the 3Ps. Notably, due to the way the P-indicators are constructed, they can be "merged" to give general indicators, by summing over the three Ps. This is explained in the Methodological Annex.

With these considerations in mind, the approach to measuring QI "by P" involves assembling four indexes.

1. A General index, which includes all indicators, both general and P-indicators. Here, the P-indicators are merged to give an overall contribution.
2. A People index, which only includes P-indicators, and only uses the *People* scores of those indicators.
3. A Planet index, which only includes P-indicators, and only uses the *Planet* scores of those indicators.
4. A Prosperity index, which only includes P-indicators, and only uses the *Prosperity* scores of those indicators.

Importantly, this means that the three P-indexes (items 2–4 above) do not include the general indicators. The reason for this is to isolate the "P-contribution" of these indicators. An alternative would be to also include general indicators in the P-indexes, but this was found to "dilute" the effect of the P-indicators and the results were too similar to the general index.

Overall, the P-indexes should be viewed as a somewhat separate measure to the general index, in that the set of indicators is not the same. Nevertheless, the P-indexes include many important indicators, such as adopted standards, participation in technical committees, and others. The indicators included in the general index, and the three P-indexes, are listed in the Appendix: List of indicators, at the end of this document.

3. Results and analysis

The QI4SD Index is a rich data set aggregated into four composite indicators, each of which can be used to look at specific dimensions of QI. This section begins to unpack the data, in order to bring out some initial messages from the study.

3.1 MAIN OUTCOMES

- QI, as measured here, is strongly linked to the economic size of a country: bigger economies have higher QI scores. This is true for all dimensions of QI, except Policy.
- High QI4SD Index scores mainly occur in countries that enjoy high GDP and there is reciprocal relationship between economic prosperity and QI.
- Germany has the strongest QI in the world, both in the main QI4SD Index and in the "3P"-indexes; People, Planet and Prosperity indexes.

3.2 QI TRENDS

QI is inextricably linked with economic development in the first place because QI boosts economic output. But equally, QI costs money, so larger economies are able to have a more extensive QI. This is intuitively clear from Figure 7, which shows the largest economies scoring highest on QI: Germany, China and the USA, among others.

More relevant is to present scores that gather together countries into peer groups. Four GDP groups are identified based on 2020 GDP values:

S	Below USD 10 Bn
M	Between USD 10–100 Bn
L	Between USD 100 Bn–1 Tn
XL	Above USD 1 Tn

The results for the XL group are presented in Table 2. According to the QI4SD Index, Germany is ranked as having the highest level of QI in the world, followed by the China, France, the USA and the UK. Five of the top ten countries are European (Germany, France, UK, Spain and Italy), with three from the East Asia and Pacific region (China, Japan and South Korea), one from South Asia (India), and the USA from the North America region.

FIGURE 7: QI4SD Index scores

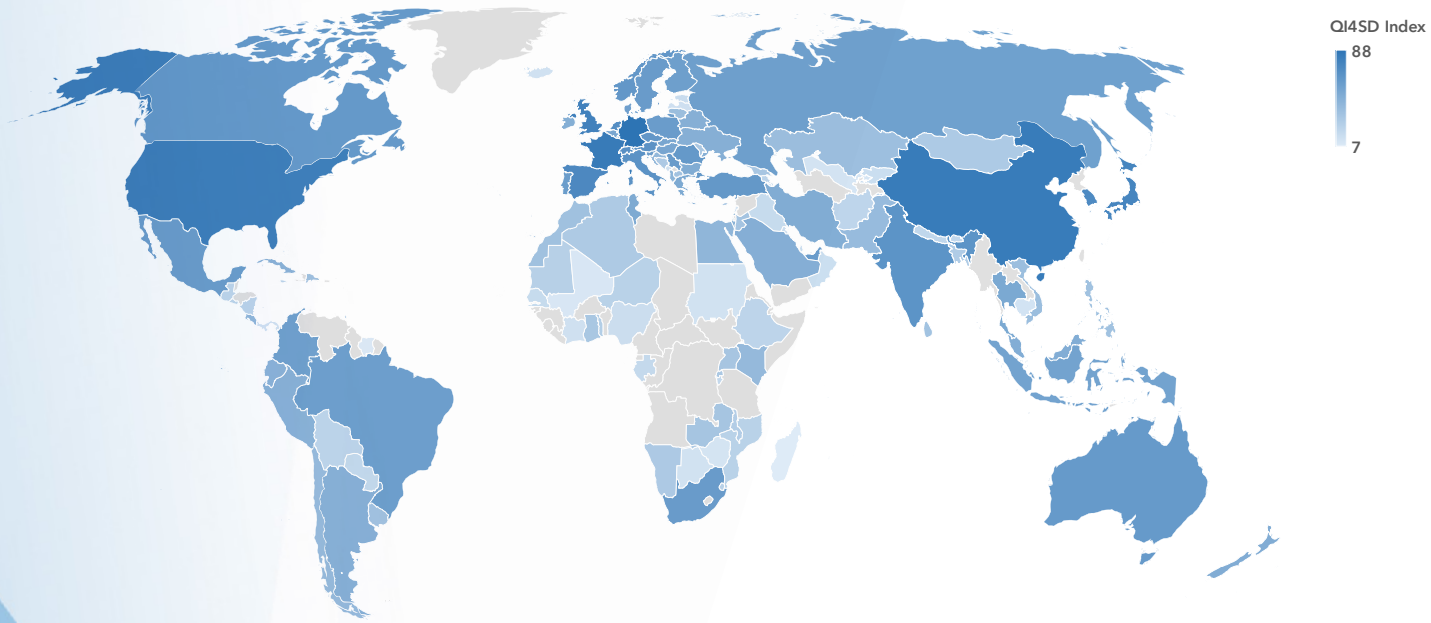


TABLE 2: QI4SD scores for countries in XL group (grey boxes indicate missing data)

Country	Region	Rank	Index	Standards	Conformity	Metrology	Accreditation	Policy
Germany	Europe & Central Asia	1	88	83	77	92	97	90
China	East Asia & Pacific	2	83	84	74	83	92	82
France	Europe & Central Asia	3	83	82	66	83	91	91
United States of America	North America	4	80	84	51	84	100	
United Kingdom	Europe & Central Asia	5	78	89	41	86	95	
Japan	East Asia & Pacific	6	76	79	56	83	87	
Spain	Europe & Central Asia	7	73	67	57	62	95	84
South Korea	East Asia & Pacific	8	73	75	59	77	73	82
India	South Asia	9	67	79	42	52	93	
Italy	Europe & Central Asia	10	67	80	52	61	98	41
Australia	East Asia & Pacific	11	62	61	25	68	93	
Canada	North America	12	62	60	17	64	74	93
Mexico	Latin America & Caribbean	13	59	55	16	53	89	80
Brazil	Latin America & Caribbean	14	58	51	40	63	79	
Russian Federation	Europe & Central Asia	15	58	73	33	82	42	
Indonesia	East Asia & Pacific	16	56	54	13	35	83	95

Germany has the highest scores in the world in metrology and conformity assessment. This is due, among other things, to having some of highest numbers of certified management certificates, a wide network of certification bodies, heavy involvement in both the BIPM (including the largest number of key and supplementary comparisons of any country, however this is partly due to active engagement in two Regional Metrology Organisations) and OIML (highest involvement in OIML Project Groups).

China closely follows, with broadly similar scores, but with a slightly lower value in metrology due to a slightly lesser involvement in OIML project groups, and a slightly lower involvement in key and supplementary comparisons. Nevertheless, China still scores very highly in all five dimensions of QI.

Some countries shown have missing data values in the Policy dimension. The Policy score is only calculated when at least 60% of its indicators have data available, and since the Policy dimension was based on the UNIDO/ISO survey, missing data occurs for countries that did not respond to the survey, or did not respond to the Policy questions in the survey. The index-level ranks of these countries should be treated with a little caution since they are based on scores of four dimensions rather than five. This includes countries such as the UK, the USA, India and Australia. Still, these countries score highly on the other four dimensions.

In the L group of countries (GDP USD 100 Bn–1 Tn), Table 3 shows the scores of the top twenty countries (with the remaining countries not shown for reasons of space). This group includes many medium-sized European countries, with countries such as the Netherlands and Switzerland ranking at the top, although the Netherlands has no score in the Policy dimension due to lack of data.

Let us take Switzerland as an example of a high-QI country in the L group. In Standards, Switzerland has full membership of ISO and IEC and has strong involvement in both of these organisations' technical committees (which are responsible for defining standards, among other things), having the 12th and 14th rank worldwide,[9] which is the third highest score in both cases within the L group. According to the ISO/UNIDO survey, it has a fully-fledged Quality Policy in place covering all dimensions of QI, and with political/government support and monitoring/evaluation facilities. In Metrology, it is a full member of nine of ten CIPM Consultative Committees (the highest score in the L group) and is a full member of both BIPM and OIML. In Conformity Assessment it has the 13th and 20th highest number of recognised certificates according to the International Certification Network (IQNet) and ISO databases respectively. Finally, in Accreditation it is a signatory to both the IAF Multilateral Recognition Arrangement (MLA) and the ILAC MRA, and its accreditation body scores highly in terms of the overall scope. Overall, this shows that for its size, Switzerland has a high level of QI.

Other countries in the L group include South Africa, which is the highest-ranking African country, and the United Arab Emirates, which is the highest ranking Middle-Eastern country.

[9] Score is a weighted sum of participant and observer membership—see Methodological Annex

TABLE 3: QI4SD Scores for countries in L group (grey boxes indicate missing data; truncated to top 20)

Country	Region	Rank	Index	Standards	Conformity	Metrology	Accreditation	Policy
Netherlands	Europe & Central Asia	1	69	71	31	79	97	
Switzerland	Europe & Central Asia	2	68	67	31	65	85	90
Austria	Europe & Central Asia	3	66	69	36	54	87	84
Norway	Europe & Central Asia	4	63	65	19	39	91	100
Czechia	Europe & Central Asia	5	63	66	26	64	95	
Turkey	Europe & Central Asia	6	62	56	36	62	95	
Romania	Europe & Central Asia	7	62	64	28	44	88	84
South Africa	Sub-Saharan Africa	8	60	63	19	70	88	
Sweden	Europe & Central Asia	9	60	74	18	54	91	64
Poland	Europe & Central Asia	10	60	64	27	56	91	
United Arab Emirates	Middle East & North Africa	11	60	53	52	23	79	91
Portugal	Europe & Central Asia	12	59	59	27	42	85	82
Singapore	East Asia & Pacific	13	59	48	22	44	86	93
Finland	Europe & Central Asia	14	58	70	21	52	88	
Denmark	Europe & Central Asia	15	57	65	22	52	89	
Colombia	Latin America & Caribbean	16	57	50	32	39	80	84
Hungary	Europe & Central Asia	17	53	58	23	44	88	
Slovakia	Europe & Central Asia	18	53	53	10	60	88	
Belgium	Europe & Central Asia	19	53	71	10	43	86	
Thailand	East Asia & Pacific	20	52	52	15	43	84	69
Greece	Europe & Central Asia	21	50	50	22	35	91	
New Zealand	East Asia & Pacific	22	50	47	14	45	93	
Malaysia	East Asia & Pacific	23	49	54	39	29	79	46
Iran	Middle East & North Africa	24	49	68	6	39	32	98
Saudi Arabia	Middle East & North Africa	25	47	55	46	32	1	100
Ireland	Europe & Central Asia	26	47	57	6	36	88	
Argentina	Latin America & Caribbean	27	46	51	23	35	77	
Ukraine	Europe & Central Asia	28	46	50	18	36	82	
Peru	Latin America & Caribbean	29	45	43	6	20	62	95
Israel	Middle East & North Africa	30	45	53	41	30	56	
Cuba	Latin America & Caribbean	31	44	35	1	40	51	96
Hong Kong	East Asia & Pacific	32	44	11	3	28	87	93
Egypt	Middle East & North Africa	33	42	51	4	37	75	
Pakistan	South Asia	34	39	50	9	31	68	
Chile	Latin America & Caribbean	35	39	44	23	18	72	
Viet Nam	East Asia & Pacific	36	37	36	11	25	77	
Kazakhstan	Europe & Central Asia	37	37	38	4	34	71	
Philippines	East Asia & Pacific	38	35	46	5	16	72	
Morocco	Middle East & North Africa	39	34	44	3	30	1	94
Bangladesh	South Asia	40	28	38	2	15	56	
Algeria	Middle East & North Africa	41	28	43	2	15	51	
Ethiopia	Sub-Saharan Africa	42	21	36	2	8	38	
Iraq	Middle East & North Africa	43	17	42	2	22	1	
Qatar	Middle East & North Africa	44	16	43	3	15	1	
Nigeria	Sub-Saharan Africa	45	15	41	8	9	1	
Kuwait	Middle East & North Africa	46	15	42	1	15	1	

TABLE 4: QI4SD scores for countries in M group, (grey boxes indicate missing data, truncated to top 20)

Country	Region	Rank	Index	Standards	Conformity	Metrology	Accreditation	Policy
Serbia	Europe & Central Asia	1	60	61	25	41	80	93
Slovenia	Europe & Central Asia	2	59	51	18	43	82	100
Tunisia	Middle East & North Africa	3	50	43	4	35	75	93
Bulgaria	Europe & Central Asia	4	48	58	16	40	80	
Belarus	Europe & Central Asia	5	46	48	13	38	86	
Ecuador	Latin America & Caribbean	6	44	39	4	23	68	88
Albania	Europe & Central Asia	7	43	35	2	23	70	87
Costa Rica	Latin America & Caribbean	8	42	35	3	18	69	82
Croatia	Europe & Central Asia	9	41	51	18	37	56	
Kenya	Sub-Saharan Africa	10	39	40	8	38	72	
Lithuania	Europe & Central Asia	11	37	40	2	26	79	
Dominican Republic	Latin America & Caribbean	12	35	25	2	8	51	89
Sri Lanka	South Asia	13	34	38	2	23	75	
Uruguay	Latin America & Caribbean	14	34	35	2	29	70	35
Luxembourg	Europe & Central Asia	15	34	44	1	16	75	
North Macedonia	Europe & Central Asia	16	33	35	2	23	74	
Jordan	Middle East & North Africa	17	32	31	1	8	51	69
Zambia	Sub-Saharan Africa	18	31	28	1	27	1	100
Uganda	Sub-Saharan Africa	19	31	44	2	9	1	100
Georgia	Europe & Central Asia	20	31	31	4	18	1	100
Ghana	Sub-Saharan Africa	21	30	44	2	15	1	88
Moldova	Europe & Central Asia	22	30	29	1	17	72	
Rwanda	Sub-Saharan Africa	23	29	41	1	14	1	89
Mongolia	East Asia & Pacific	24	29	30	1	16	69	
Namibia	Sub-Saharan Africa	25	28	25	3	22	1	91
Bosnia and Herzegovina	Europe & Central Asia	26	28	42	3	18	51	
Malta	Middle East & North Africa	27	28	36	1	15	1	88
Mauritius	Sub-Saharan Africa	28	28	32	2	15	62	
Trinidad and Tobago	Latin America & Caribbean	29	27	27	2	16	1	89
Cyprus	Europe & Central Asia	30	26	36	7	15	45	
Malawi	Sub-Saharan Africa	31	26	34	1	8	1	84
Palestine, State of	Middle East & North Africa	32	24	25	1	1	1	93
Mozambique	Sub-Saharan Africa	33	23	21	2	8	1	82
Niger	Sub-Saharan Africa	34	23	18	1	1	1	92
Bolivia	Latin America & Caribbean	35	22	31	2	17	1	60
Armenia	Europe & Central Asia	36	22	29	1	1	1	78
Nicaragua	Latin America & Caribbean	37	22	21	1	1	45	42
Afghanistan	South Asia	38	22	30	1	1	1	75
Jamaica	Latin America & Caribbean	39	21	25	1	9	51	
Tanzania, the United Republic c	Sub-Saharan Africa	40	21	32	1	24	1	47
Nepal	South Asia	41	21	28	1	8	45	
El Salvador	Latin America & Caribbean	42	20	28	3	1	51	
Guatemala	Latin America & Caribbean	43	20	15	2	8	56	
Paraguay	Latin America & Caribbean	44	19	18	1	16	40	
Gabon	Sub-Saharan Africa	45	18	42	1	1	1	44
Senegal	Sub-Saharan Africa	46	17	24	2	1	1	55
Estonia	Europe & Central Asia	47	16	36	2	24	1	
Oman	Middle East & North Africa	48	15	44	1	15	1	

The scores for the M group are shown in Table 4. While the scores are generally less than in the L and XL groups, the Policy scores are similar and, in some cases, rather high, with Slovenia, Zambia, Uganda and Georgia having a top score of 100. In practice, this means that they received the highest value in all Policy indicators.

The higher ranking countries in this group include many Eastern European countries such as Serbia, Slovenia and Bulgaria. These countries are typically full members of many QI organisations such as IAF, ILAC, BIPM, and OIML, but have slightly lower scores on indicators such as the number of recognised certificates—perhaps simply because they are smaller countries. Serbia, however, has a large proportion of ISO standards adopted (18 of the 22 standards surveyed), and is also rather deeply integrated in the IQNet network of conformity assessment bodies, having a head office and four hosted offices within its borders. Indeed, this higher score in conformity assessment distinguishes five Eastern European countries in this group: Serbia, Slovenia, Bulgaria, Belarus and Croatia. Further down in the rankings in this group we find that the conformity assessment scores become lower. Typically, this seems to be due to a lack of involvement in the IEC's conformity assessment systems, among other things.

Finally, the scores in the S group (GDP below USD 10 Bn) are shown in Table 5. As expected, the overall scores are lower, with the exception of the Policy dimension. Here Mauritania has the highest score. Otherwise, conformity assessment scores are generally low, as are metrology scores, with a few exceptions including Montenegro. Montenegro is a small country but is in the upper middle-income group, and has a high breadth and number of calibration and measurement capacities—in both cases mid-ranked worldwide which is quite high given its size.

In the Accreditation dimension, Kyrgyzstan stands out as having a much higher score than the other countries in the group. This is because, unlike many of its peers, it has a signatory to the ILAC MRA. We recall that having a score of 1 in accreditation does not mean that the country has no capacity in accreditation. Indeed, some of these countries have other membership types with ILAC or IAF but are not signatories to the MRA or MLA.

3.2.1

Quality Infrastructure and economic development

Prosperity in a country is highly linked to its economic development, which is fuelled by the development of its industry and infrastructure. Today in developing countries industrialisation is indeed acknowledged as a key driver for economic development, as it was for developed countries in the past. Figure 8 shows the relationship between GDP on the X-axis and the overall QI4SD Index scores on the Y-axis, revealing a strong linear association (the regression line in light blue) between QI and log-GDP for the 137 countries under consideration. The choice of the logarithm transformation is justified by the greater simplicity of the line of fit (the light blue straight line), compared to the curve that the original information would produce, and by the possibility to further understand the information behind the data by looking at the residuals.

The correlation coefficient ($r = 0.81$) shows a strong association between the two variables, confirmed by the high coefficient of determination ($R^2 = 0.66$) indicating that two thirds of the variation of the QI4SD Index scores may be explained by the variation of the GDP. High QI4SD Index scores mainly occur in countries that enjoy high GDP but this does not tell the full story, otherwise the data dots would coincide with the straight line, which is not the case. The analysis of residuals (a residual being

TABLE 5: QI4SD scores for countries in S group (grey boxes indicate missing data)

Country	Region	Rank	Index	Standards	Conformity	Metrology	Accreditation	Policy
Togo	Sub-Saharan Africa	1	26	40	1	1	1	85
Mauritania	Sub-Saharan Africa	2	24	15	1	1	1	100
Eswatini	Sub-Saharan Africa	3	23	22	2	1	1	92
Seychelles	Sub-Saharan Africa	4	21	21	1	16	1	68
Bhutan	South Asia	5	20	19	1	1	1	75
Burundi	Sub-Saharan Africa	6	18	22	1	1	1	66
Barbados	Latin America & Caribbean	7	17	24	1	15	1	42
Antigua and Barbuda	Latin America & Caribbean	8	17	6	1	8	1	67
Kyrgyzstan	Europe & Central Asia	9	16	15	1	8	40	
Montenegro	Europe & Central Asia	10	13	25	2	23	1	
Suriname	Latin America & Caribbean	11	8	21	1	8	1	

the difference between the actual QI4SD Index score and the corresponding value of the line of fit) shows some exceptions. A set of countries score higher on QI than with respect to their GDP. In descending order, the top ten countries are: Serbia, Slovenia, Seychelles, Albania, Tunisia, Germany, Czechia, France, Romania and Austria (QI overperformers are marked in blue in Figure 8). At the opposite end, countries with higher GDP levels compared to their QI are found in Nigeria, Kuwait, Qatar, Iraq, Uzbekistan, Côte d'Ivoire, Oman, Bangladesh, Panama and Azerbaijan (QI underperformers are marked in red in Figure 8). While most of the QI overperforming countries are situated in Europe, the QI underperformers are mainly found in the Middle East, Central Asia and Africa. The top QI overperformers span the whole GDP range, but the QI underperformers are mainly concentrated in the GDP middle range. Further investigating Figure 8 shows that Austria and Nigeria have similar GDP levels but have very diverse QI4SD scores, 66.0 for Austria (ranked 13th) compared to 14.9 for Nigeria (118th ranked country). Another striking example is Serbia and Panama with GDP of the same range but with very distinct QI4SD scores, 60.0 for Serbia (ranked as the 22nd country) and 12.4 for Panama (ranked as the 126th country). The economic level is thus not the only enabler for an advanced QI system of the country.

One might speculate what the significance of these over- and underperformers actually is. On the one hand, countries with higher GDP have a greater capacity to build many aspects of QI: they simply have more resources. In this context, "overperformers" have laudably developed a higher level of QI than their GDP suggests. From another angle, one could argue that GDP ought to be boosted by QI. This could imply that the "overperformers" in QI could actually be seen as having a lower GDP than their level of QI would predict. This chicken and egg discussion (whether GDP leads to QI or vice versa) is resolved by acknowledging that the relationship very likely goes both ways: there is a reciprocal relationship between economic prosperity and QI.

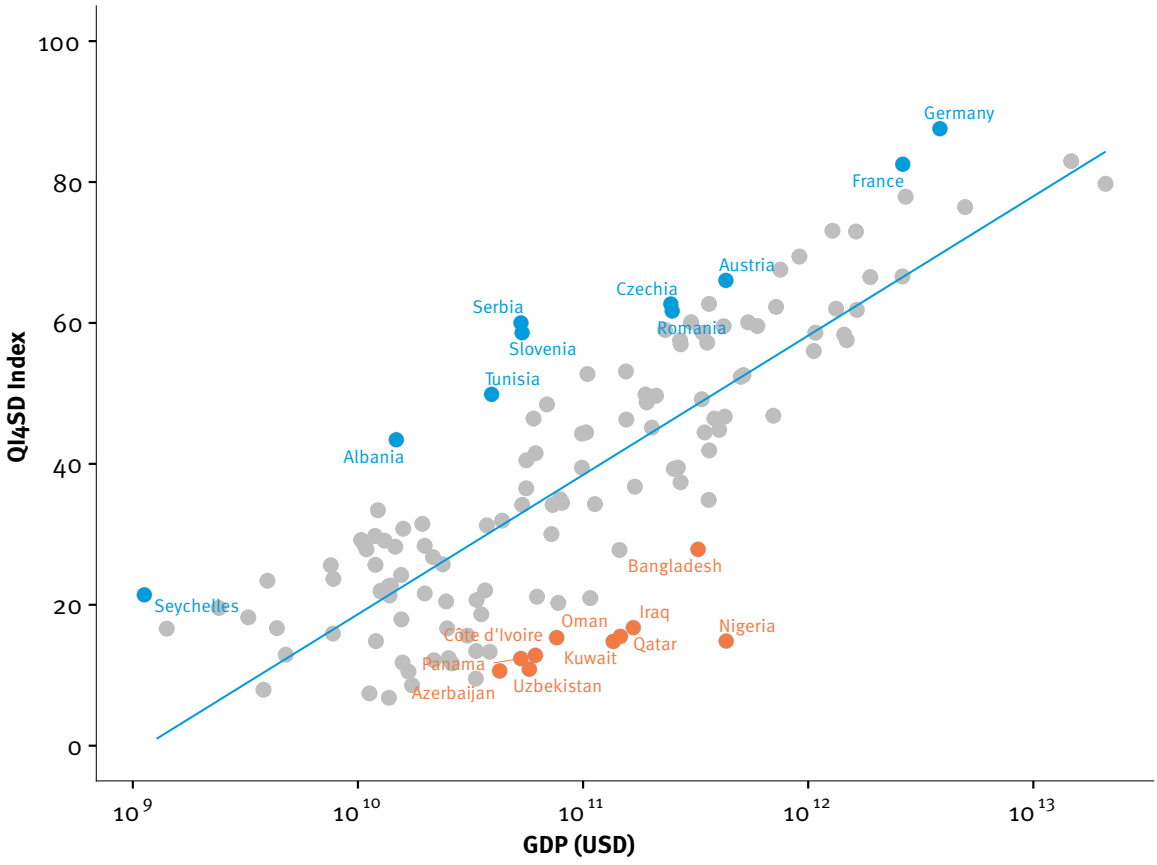
3.2.2

Relation with trade

International trade is one of the main outcomes of a QI system, and one of the main motivations in developing QI capacity. Moreover, trade is essential to prosperity and is directly relevant to SDGs 8[11] and 9[12], and indirectly relevant to many others.

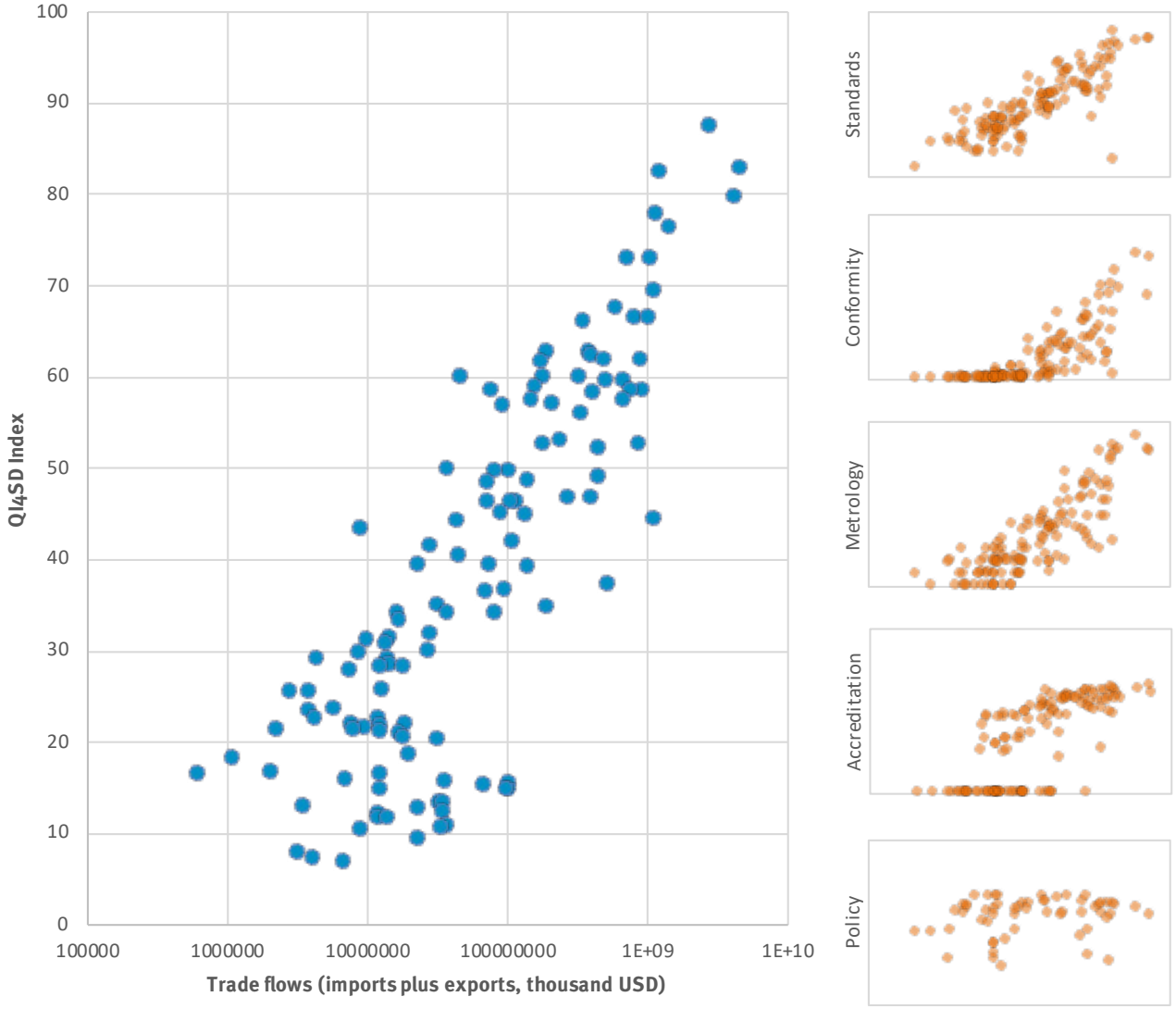
Figure 9 shows the relation between the overall QI4SD Index and the sum of imports and exports of each country. There is a clear positive relationship between trade and QI, although this does imply that one causes the other. Intuitively, there is a complex relationship between QI,

FIGURE 8: QI4SD Index scores vs GDP (current USD, 2018-2020 latest value). The regression line is in light blue. QI overperformers are in blue and QI underperformers are in red.



[11] Promote inclusive and sustainable economic growth, employment and decent work for all
[12] Build resilient infrastructure, promote sustainable industrialization and foster innovation

FIGURE 9: QI4SD Index scores vs annual international trade (2018-2019 latest value). Smaller panels are QI dimensions against international trade.



trade and the economic output of a country, where each stimulates the other. Nevertheless, the strong correlation between trade and QI (0.83[13]) adds weight to the necessity of a strong QI system underpinning a healthy global economy. These figures are similar when imports or exports are considered individually, with exports showing a slightly stronger trend in all cases.

The dimension plots of Figure 9 show in more detail the relationship of trade with specific dimensions of QI. The positive relationship holds in particular for Standards, Conformity Assessment and Metrology, and a little less for Accreditation. QI Policy does not seem to have a noticeable relation with trade. Analysis indicates that Policy does not have a strong relationship with trade as percentage of GDP either.

3.2.3

Comparing results with existing tools

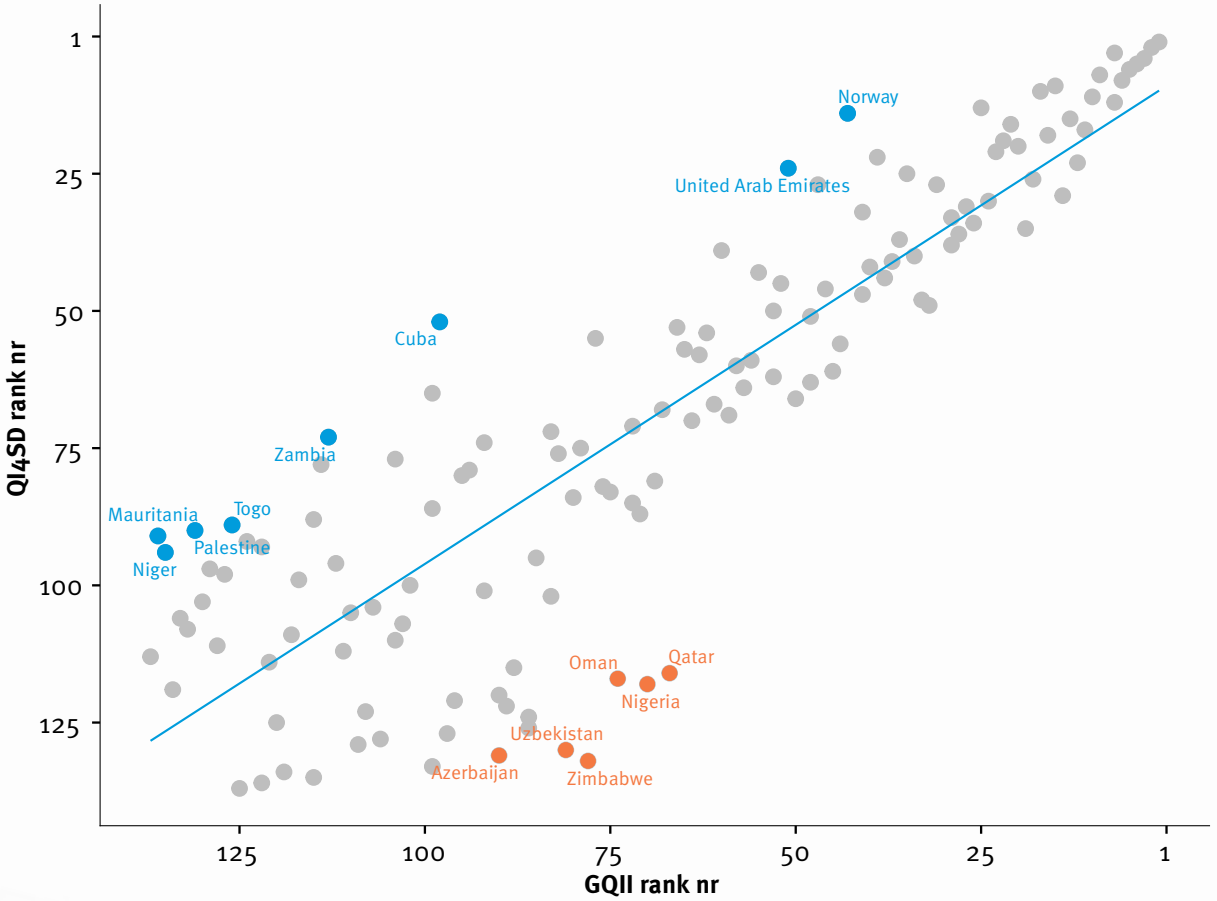
As introduced in section 1.4.1 there are only a few tools for measuring QI. The Global Quality Infrastructure Index (GQII) (Harmes-Liedtke and Oteiza Di Matteo 2021) is one composite indicator that measures various aspects of metrology, accreditation, standardisation and certification of products and services. The present version of the GQII[14] includes eleven indicators from three QI areas, accreditation, metrology and standards. There is a positive relationship (correlation 0.87) between the ranks[15] of the two indexes. Both indexes clearly converge to the better scoring countries while on the other end there is a larger spread. Countries highlighted in blue in Figure 10 are ranked better in the QI4SD Index than the GQII. For example, Norway in the QI4SD framework is ranked in 14th place but only in 43rd place in the GQII. Cuba is

[13]Correlation between log(imports + exports) and QI score

[14] Compared to the QI4SD Index, the GQII does not include a policy dimension and the conformity assessment and standards dimensions are put into the same standards dimension. Another difference between the frameworks is that the GQII does not explicitly consider SDGs.

[15] Comparing the ranks of the two indices is more relevant than comparing their scores. Since a score is interesting in perspective to its range (the GQII scores range from 30 to100 and the QI4SD Index scores from 7 to 88) while a rank is a more objective measure. A lower rank means a better score.

FIGURE 10: QI4SD Index ranks vs GQII ranks. The regression line is in light blue. QI4SD Index better scored countries are in blue and GQII better scored countries are in orange.



ranked in 52nd place in the first framework compared to 98th place in the second. Countries highlighted in orange in Figure 10 are on the other hand ranked better in the GQII framework. Zimbabwe is ranked on the 78th place in the GQII framework compared to 54 places below in the QI4SD Index (132nd place).

There is even more agreement between the Standards and Metrology dimensions[16] of the two frameworks (Figure 11 and Figure 12). In the figures, highlighted countries in blue are better ranked in the QI4SD Index framework and countries in orange are better in the GQII framework. The relation between the Accreditation dimensions is less strong.[17] Unfortunately, it is not possible to compare the different indicators of the two frameworks since underlying data for the GQII is also not publicly available at the time of writing this report.

[16] Correlation coefficients of 0.94 for the Standards and 0.95 for the Metrology dimensions.

[17] Correlation coefficient of 0.86 for the Accreditation dimensions. Figure not presented.

FIGURE 11: QI4SD standards dimension ranks vs GQII standards dimension ranks.

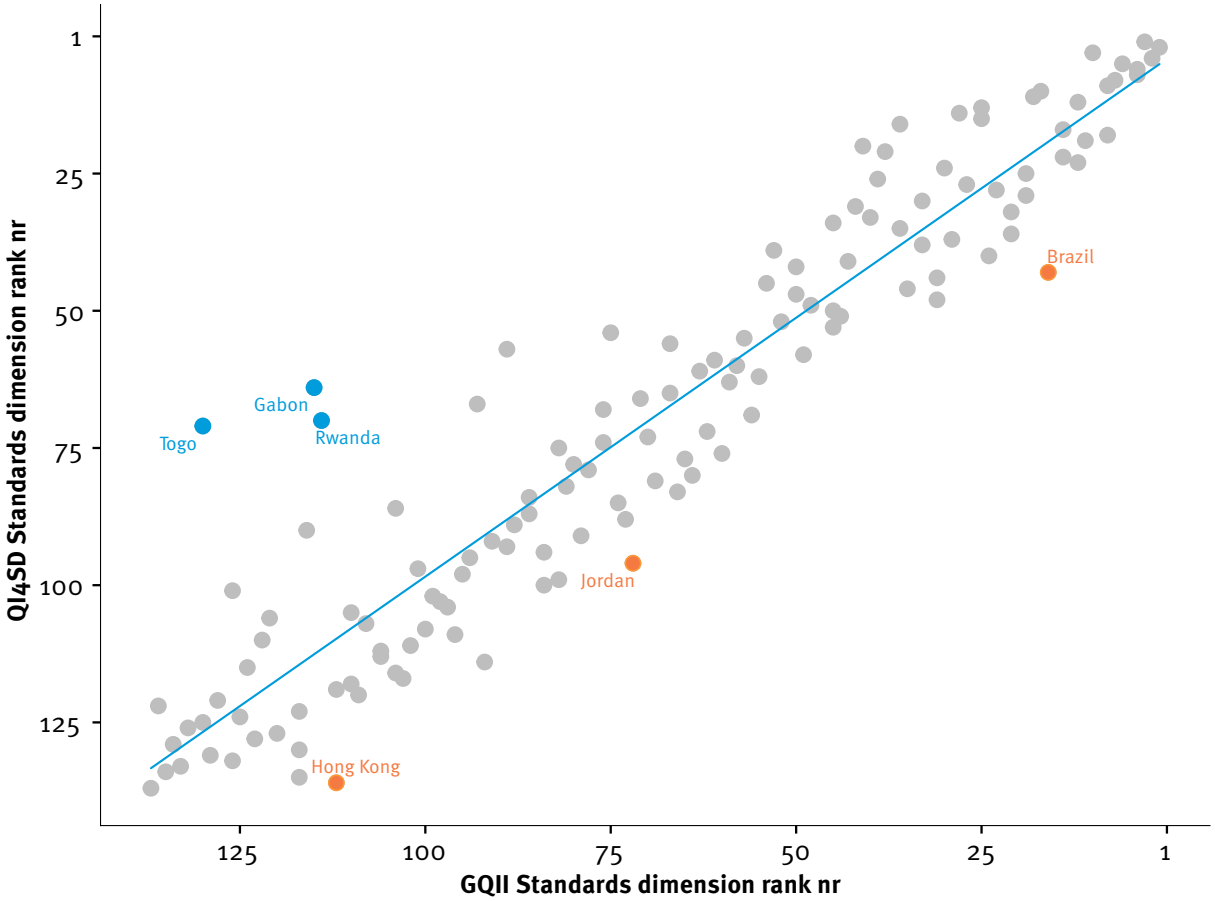
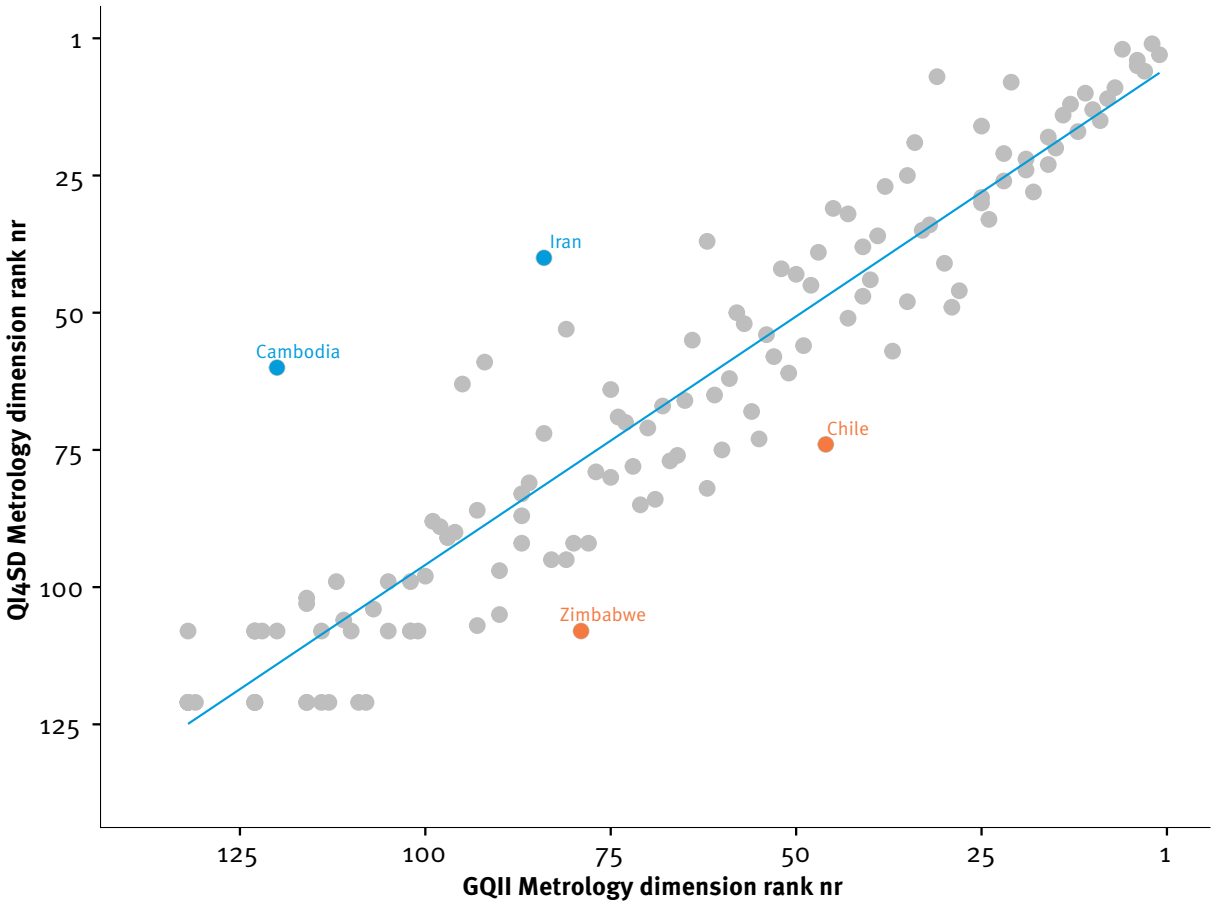


FIGURE 12: QI4SD metrology dimension ranks vs GQII metrology dimension ranks.



3.2.4

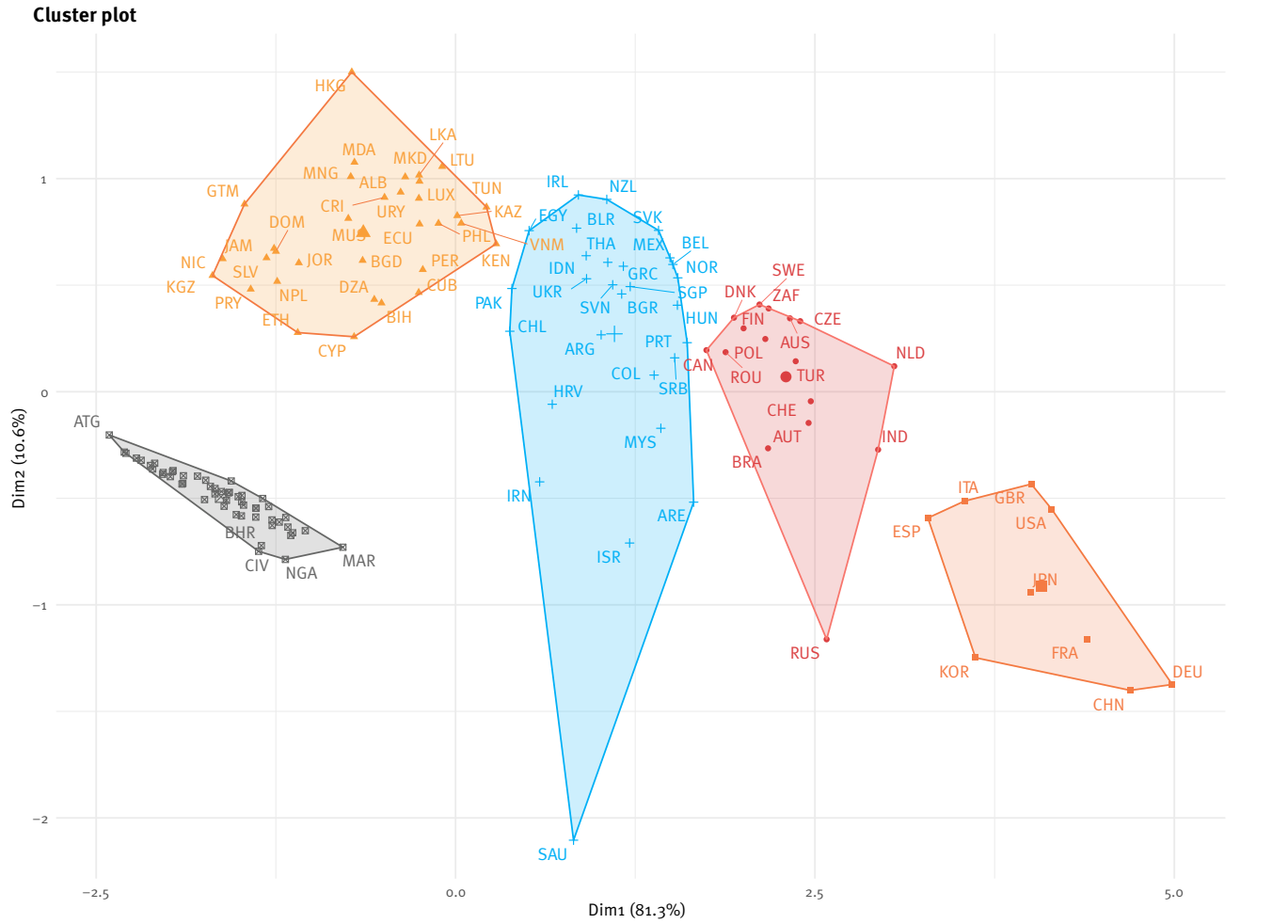
Cluster analysis

Using the QI4SD scores at the dimension level, it is possible to perform a cluster analysis which can help to group countries based on these scores. Clustering is performed by a k-means clustering algorithm[18] which is a form of unsupervised machine learning.

The results of this exercise, shown in Figure 13, indicate that five clusters can be identified. In fact, the countries could be clustered into other groups, but it is evident that there is a distinct group of countries in the lower left (grey group). A deeper investigation of the data reveals that this cluster is composed of countries with a minimum accreditation score because they are not signatories of either the MRA or the MLA. This does not mean that they have no capacity for accreditation, and many of these countries have accreditation bodies that are members that are not signatories to the MRA or MLA. This group is composed of a mixture of countries, ranging from low to high-income groups, and GDP groups from S to L (no XL countries are present).

The orange cluster on the far right also identifies the group of countries that have high scores in all four dimensions of QI. These are uniquely countries in the XL GDP group, and all in the high-income group (with the exception of China, which is classed as upper middle-income).

FIGURE 14: Countries grouped into clusters using the k-means clustering algorithm. Axes represent the first two principal components of the four dimensions of the QI4SD Index: Accreditation, Conformity Assessment, Metrology and Standards (Policy is excluded due to lower data availability).



3.3

LINKING TO SDGS

Breaking down QI into components that relate to specific aspects of sustainable development is challenging. As described in Section 2.5, the approach adopted here was to create specific "P-indexes", one each for People, Planet and Prosperity. These indexes consist of a subset of the indicators in the general index—corresponding to those for which it was practically possible to map to each of the 3Ps. The resulting indicators are given in Table 6, showing that nine indicators were able to be mapped to Ps in this way.

[18] https://doi.org/10.2307/2346830

TABLE 6: Indicators included in each of the P-indexes

Dimension	Name	Organization
Accreditation	Scopes of IAF accreditation bodies	IAF
	Scopes of ILAC accreditation bodies	ILAC
Conformity	Number of recognised certificates (IQNet)	IQNet
	Number of recognised certificates (ISO)	ISO
Metrology	Number of CMCs	BIPM
	Breadth of CMCs	BIPM
Standards	Adopted ISO standards	ISO
	Adopted IEC standards	IEC
	Participation in IEC technical committees	IEC

It is important to be clear that the P-indexes are not strictly comparable with the general index described in the previous section, simply because the indicators in the P-indexes are a ***subset*** of the indicators in the general index. More details on this are given Section 2 and the Methodological Annex.

With that said, let us examine the results of the P indexes in more detail. Table 7—Table 10 show the P-ranks for the top ten countries in each GDP group (other countries have been excluded for brevity, but full ranks can be found in the Appendix: Results tables). One thing is immediately evident—the data shows that countries have very similar ranks/scores in each of the 3Ps. This means that if a country is doing well in People, for example, it is probably doing well in Planet and Prosperity. To take the XL group of countries as a first example (see Table 7), Germany has the highest rank in all three P-indexes. However, France ranks second in People and Planet, and fourth in Prosperity. Differences of this magnitude are likely not to be very significant.

Let us examine a case where P-ranks are somewhat different. Japan ranks fifth in People, fourth in Planet, but ninth in Prosperity. What is causing this difference? When we look into the underlying data, we find that Japan has, in particular, a slightly lower score on metrology relating to the Prosperity pillar, compared to People and Planet—due to a slightly lower number and breadth of calibration and measurement capacities (CMCs) relating to Prosperity—whereas in People and Planet, Japan ranks joint number one for these indicators—in People, it ranks 12th (for number of CMCs). This is in contrast to Germany, for example, which ranks number one in these indicators, for all 3Ps. We recall that in any case, Japan scores very highly in these indicators, but it can be helpful to compare against its peers to see where perhaps improvements could be made. This also demonstrates that while the P-scores and ranks are not a strict measurement in themselves, they lead to asking further questions and exploring the underlying data.

TABLE 7: P-index ranks for XL GDP group countries (top 10)

Country	Region	People	Planet	Prosperity
Germany	Europe & Central Asia	1	1	1
France	Europe & Central Asia	2	2	4
China	East Asia & Pacific	3	3	3
United Kingdom	Europe & Central Asia	4	6	6
Japan	East Asia & Pacific	5	4	9
United States of America	North America	6	5	5
Italy	Europe & Central Asia	7	8	2
Spain	Europe & Central Asia	8	7	7
South Korea	East Asia & Pacific	9	13	12
India	South Asia	10	12	8

TABLE 8: P-index ranks for L GDP group countries (top 10)

Country	Region	People	Planet	Prosperity
Netherlands	Europe & Central Asia	1	4	5
Turkey	Europe & Central Asia	2	3	1
Romania	Europe & Central Asia	3	1	3
Czechia	Europe & Central Asia	4	2	2
Austria	Europe & Central Asia	5	8	9
Switzerland	Europe & Central Asia	6	6	4
Finland	Europe & Central Asia	7	10	6
South Africa	Sub-Saharan Africa	8	9	10
Poland	Europe & Central Asia	9	5	8
Greece	Europe & Central Asia	10	20	20
Sweden	Europe & Central Asia	11	12	7
Hungary	Europe & Central Asia	12	7	11
Norway	Europe & Central Asia	13	18	16

In the L group (Table 8), we see the same pattern in that the rankings in the 3Ps are broadly similar. This table is similar to the general index scores of the L group in Table 3, although Turkey ranks highly in all of the 3Ps. Strictly, in this sense, Turkey is the leader in this group (using on the P-indicators) since it ranks the highest on average across the 3Ps.

Greece is an interesting case here in that it ranks higher in People (10th) than in Planet and Prosperity (both 20th). One reason for this is that Greece has a lower score in the Planet dimension for Standards, and this is because no data is available on its adopted ISO or IEC standards, so its scores are based uniquely on the participation in IEC technical committees, which is the only indicator with available data. Here we find that Greece has a slightly lesser participation in technical committees related to Planet and Prosperity, as opposed to People (using an IEC mapping of its technical committees to SDGs).

Turning now to the M and S groups of countries shown in Table 9 and Table 10, similar patterns are evident. Ranks in each of the 3Ps are broadly similar, with some particular differences. Let us take Bhutan as an example here. It has a notably higher rank in People than in Planet and Prosperity. Closer inspection suggests that this is due to higher scores in standards, particularly for adopted ISO standards and involvement in IEC TCs.

Overall, the intersections of QI and sustainable development are fairly indicative and rely on mappings between, e.g. standards and technical committees, and detailed information on each country's involvement in these indicators. However, taking the example of standards, adoption data is only available for a small subset of international standards, and the same is true for the numbers of recognised certificates in each country. On the other hand, these indicators represent the first attempt to try to explicitly measure the intersections of QI and sustainable development. The raw data should also provide useful insights by unpacking individual indicators.

3.3.1

Relating the P-Indexes to existing SDG tools

The Bertelsmann Stiftung and the United Nations Sustainable Development Solutions Network (SDSN) has developed the Sustainable Development Goals Index and Dashboards (SDG Index), an indicator framework for measuring countries' progress towards the SDGs. Since 2016, the SDG Index has been annually updated and presently covers 165 countries in the seventh edition (Sachs, et al. 2021). The last edition has a special focus on the recovery from the COVID-19 pandemic. For the first time since the SDGs were adopted in 2015, the world lost ground on the SDGs in 2020. The COVID-19 pandemic has created not only a global health emergency, but also a sustainable development crisis.

The conceptual framework of the SDG Index mirrors the 17 SDGs agreed by all UN Member States. It includes 92 indicators grouped into 17 goals, which are subsequently aggregated into the SDG Index. The overall index is calculated as a simple arithmetic average of the 17 goals.

The People, Planet and Prosperity indexes are correlating moderately and positively with the SDG Index (0.61-0.62[19]), as illustrated in Table 11. It is interesting to discover that of the 17 SDGs (dimensions within the SDG Index), the goal that is correlating the most with the 3P-Indexes is SDG 9. This is the goal that promotes socially inclusive and environmentally sustainable economic development by enhancing infrastructure, industry and innovation. QI institutions and services have indeed an important role

TABLE 9: P-index ranks for M GDP group countries (top 10)

Country	Region	People	Planet	Prosperity
Serbia	Europe & Central Asia	1	4	2
Slovenia	Europe & Central Asia	2	2	4
Bulgaria	Europe & Central Asia	3	1	1
Belarus	Europe & Central Asia	4	3	3
Croatia	Europe & Central Asia	5	9	6
Tunisia	Middle East & North Africa	6	10	8
Lithuania	Europe & Central Asia	7	8	9
Moldova	Europe & Central Asia	8	11	14
Uruguay	Latin America & Caribbean	9	5	5
Ecuador	Latin America & Caribbean	10	6	12

TABLE 10: P-index ranks for S GDP group countries (top 10)

Country	Region	People	Planet	Prosperity
Togo	Sub-Saharan Africa	1	1	1
Bhutan	South Asia	2	5	7
Suriname	Latin America & Caribbean	3	3	3
Seychelles	Sub-Saharan Africa	4	4	4
Eswatini	Sub-Saharan Africa	5	2	2
Barbados	Latin America & Caribbean	6	7	8
Kyrgyzstan	Europe & Central Asia	7	6	6
Montenegro	Europe & Central Asia	8	8	5
Antigua and Barbuda	Latin America & Caribbean	9	10	11
Mauritania	Sub-Saharan Africa	10	11	10

in industry and infrastructure. Under the guidance of a Quality Policy (QP), QI institutions need to catch up with the increasing interconnectivity and smart automation to support the development of sustainable industry and infrastructure. Metrology, standards, accreditation, and conformity assessment procedures for testing, inspection and certification are needed to embed sustainability requirements within projects and are required to support the sustainable management of organisations, global supply chains, and associated environmental and social responsibility aspects. The correlation coefficients for this goal (dimension within the SDG Index) are a bit higher[20] than compared to the general SDG Index. The highest correlations[21] are found for the 3P-Indexes' Conformity dimension and SDG 9 (0.70-0.75).

The moderate relationships here underline a basic difference between the SDG Index and the QI4SD Indexes; while the former aims to capture each country's progress towards SDGs, the QI4SD P-indexes aim to measure *QI that contributes to SDGs*, not sustainable development itself. In this sense, QI can be viewed as an enabler of sustainable development, rather than an outcome in itself. The results here support the idea that QI is indeed contributing to a country's progress towards SDGs.

3.4

RESULTS BY DIMENSIONS

Figure 14 shows the distributions of the five dimensions of the general QI4SD Index, in a so-called "raincloud plot" which combines the raw data (the "rain"), probability density (the "cloud"), and key summary statistics in the boxes (boxplots). As seen in the plot, the distributions of the five dimensions are very diverse. For example, the Conformity dimension is right-skewed while the Policy dimension is left-skewed. What do the shapes of the distributions tell us about the underlaying data behind the QI dimensions? The Conformity dimension is right-skewed (most data falls to the right, or positive side, of the peak) because it depends on the recognised certificates that are related to the size of the country (GDP), which is itself very skewed (Section 3.4.2). The Policy dimension is entirely derived from a UNIDO/ISO designed survey, which aimed to ask questions as clearly and precisely as possible but different countries may have also interpreted questions in different ways. The survey showed that QP is not only linked to economic development. The survey suggested in fact that smaller economies may also have high or the highest policy scores and hence the left-skewed dimension (Section 3.4.4).

All the dimensions apart from the Policy dimension are highly correlated with the general QI4SD Index. Especially the Metrology and the Standards dimensions are correlating highly with the index, with correlating coefficients of 0.90 and 0.87, respectively.

TABLE 11: Correlation coefficients between the ranks of the 3P-Indexes and the SDG Index with its 17 dimensions (SDGs).

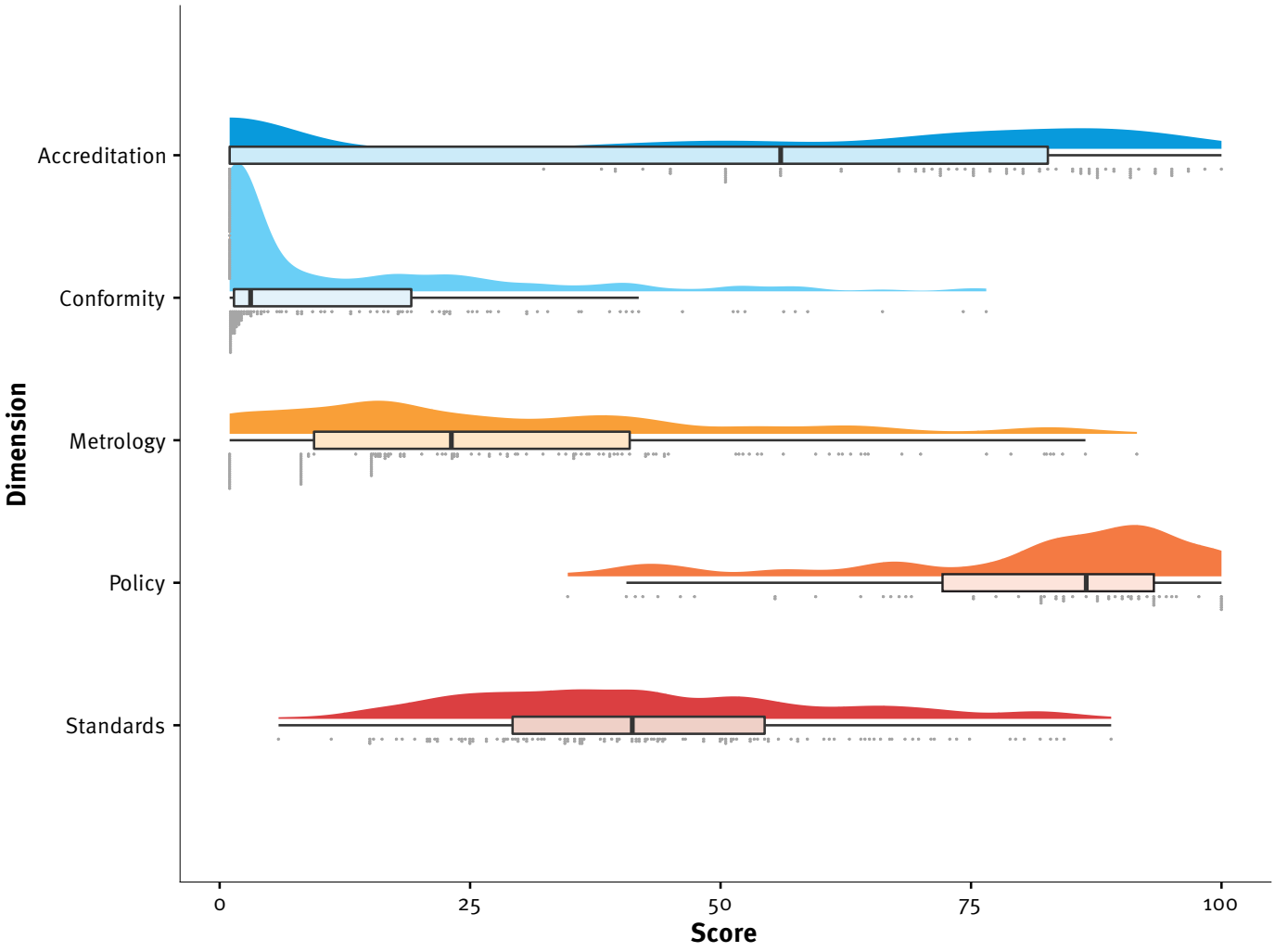
	People Index	Planet Index	Prosperity Index
SDG Index	0,62	0,61	0,62
SDG 1	0,50	0,48	0,50
SDG 2	0,48	0,49	0,47
SDG 3	0,54	0,52	0,52
SDG 4	0,52	0,50	0,49
SDG 5	0,41	0,42	0,42
SDG 6	0,57	0,57	0,58
SDG 7	0,48	0,47	0,46
SDG 8	0,46	0,46	0,46
SDG 9	0,66	0,63	0,65
SDG 10	0,23	0,19	0,21
SDG 11	0,46	0,45	0,44
SDG 12	-0,36	-0,34	-0,35
SDG 13	-0,36	-0,33	-0,34
SDG 14	-0,10	-0,09	-0,07
SDG 15	0,13	0,17	0,15
SDG 16	0,40	0,35	0,37
SDG 17	0,24	0,26	0,26

[19] Correlations between People, Planet and Prosperity indexes and the SDG Index. Correlations above 0.22 are significant, significance level 0.01.

[20] Correlations between People, Planet and Prosperity indexes and SDG 9 are respectively: 0.66, 0.63 and 0.65.

[21] Correlations between the Conformity dimension in the People, Planet and Prosperity indexes and SDG 9 are: 0.72, 0.75 and 0.70.

FIGURE 14: Distribution plot of the five dimensions in the QI4SD Index.



If the rankings of the general index are compared with the rankings of the different dimensions, it is clear that the shifts in rank positions are very comparable over the five dimensions, as illustrated in Table 12. Instead, if one dimension is excluded at a time and the rankings are compared over the index comprising the four remaining dimensions, it is apparent that excluding the Accreditation or the Policy dimensions has the biggest impact on the shifts in ranks, Table 13. These differences are most probably due to the discrete indicators in these dimensions (further discussed in Sections 3.4.1 and 3.4.4).

TABLE 12: Distribution in differences between general QI4SD Index and its dimension rankings.

Shifts with respect to QI4SD Index	Accreditation Dimension	Conformity Dimension	Metrology Dimension	Policy Dimension	Standards Dimension
0 position	3%	7%	2%	6%	3%
Less than 5 positions	16%	19%	22%	16%	22%
5 to 9 positions	18%	20%	21%	22%	15%
More than 10 positions	66%	61%	57%	62%	63%
10 to 19 positions	28%	28%	31%	24%	28%
20 to 29 positions	15%	14%	13%	19%	17%
More than 30 positions	23%	20%	12%	19%	18%

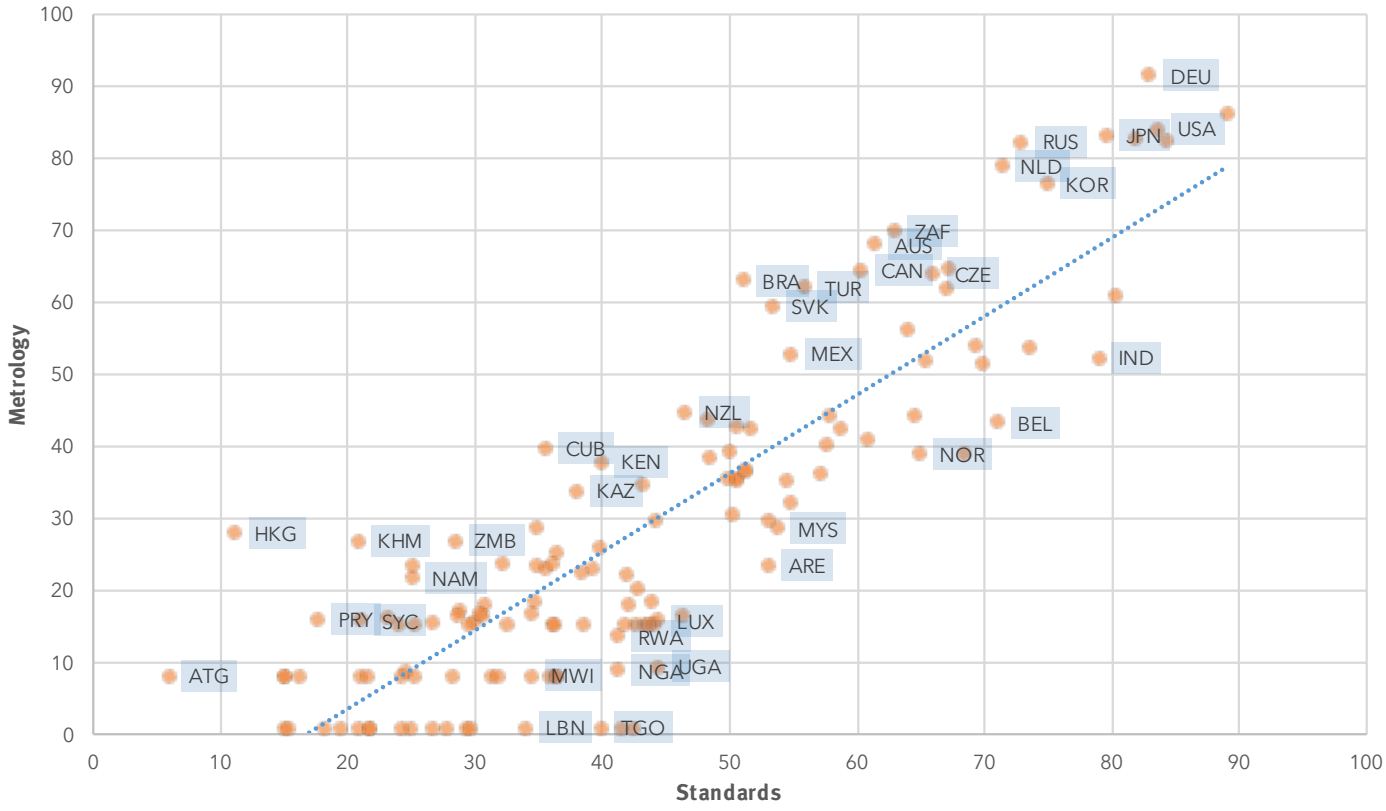
TABLE 13: Distribution in differences between general QI4SD Index and the Index comprising four dimensions.

Shifts with respect to QI4SD Index	Omission of Accreditation Dimension	Omission of Conformity Dimension	Omission of Metrology Dimension	Omission of Policy Dimension	Omission of Standards Dimension
0 position	3%	18%	15%	6%	12%
Less than 5 positions	26%	81%	70%	20%	64%
5 to 9 positions	14%	15%	25%	27%	31%
More than 10 positions	60%	4%	5%	53%	4%
10 to 19 positions	34%	4%	4%	27%	4%
20 to 29 positions	20%	0%	1%	22%	0%
More than 30 positions	7%	0%	0%	4%	0%

At the dimension level, it is interesting to examine relationships between the various dimensions of QI. In the first place, all dimensions of QI except Policy are positively correlated with one another. This means that higher scores in one dimension generally imply higher scores in the other.

Figure 15 shows an example of Metrology scores plotted against Standards scores. There is a strong linear relationship between the two, and this is likely partly due to the fact that both are related to the size of the economy (GDP). However, we can also pick out exceptions—India, for example, has a relatively high score in Standards but a somewhat lower score in its Metrology capacity. This fact can also be seen from India's country profile,[22] in which one of its lowest ranking indicators is its involvement in OIML Project Groups, as well as its number and breadth of CMCs. On the other hand, in the Standards dimension, India is strongly integrated in the ITU and has adopted all 22 of the ISO standards surveyed in the ISO/UNIDO survey.

FIGURE 15: Metrology scores against Standards scores - full index. Selected countries labelled.



[22] See accompanying Country Profiles document

These strong positive relationships between QI dimensions hold especially for Standards, Metrology and Conformity Assessment but a little less for Accreditation. This may be simply due to the nature of the Accreditation indicators which take more discrete values.

The clear exception in terms of inter-dimension correlation is Policy, which is not strongly correlated with any of the other dimensions of QI. This could be due to a number of reasons, and should not be interpreted that QP has no impact on QI. First, the indicators used for QP are mostly discrete yes/no questions. Second, policies of any nature take time for the impacts to materialise. More analysis on QP is provided in Section 3.4.4.

At the dimension level, we can also check for any dimension scores that do not follow the general pattern of high scores in one dimension implying high scores in the other. Excluding the policy dimension, we take the average rank across the four remaining dimensions of QI for each country. Then we check the difference between the average rank and individual dimension ranks. This should highlight any dimension scores, for a given country, that stand out—either as being much higher than the other dimensions, or much lower.

Table 14 shows this "rank discrepancy" measure for each dimension, with the highest 20 rank discrepancies shown. To take Hong Kong here as an example: it ranks 69th, 58th and 26th in Conformity, Metrology and Accreditation, but only 136th in Standards. Digging into the data, this is because it is not a member of IEC or ITU and is an ISO correspondent member with no adopted ISO surveyed standards (from the survey).

Clearly, this is a rough analysis that does not take into account the individual circumstances of countries, and uses only the available indicator data. However, it can perhaps highlight some areas where countries may be "unbalanced" in their QI capacity.

3.4.1

Accreditation

Accreditation is the independent evaluation of conformity assessment bodies against recognised standards to carry out specific activities to ensure their independence and competence. The Accreditation dimension of the QI4SD Index contains four indicators and the dimension behaves somewhat differently compared to the other dimensions because of its discrete indicators. Two of the indicators referring to the signatories of IAF and ILAC arrangements have binary (yes/no) values and the other two referring to the scopes of IAF and ILAC accreditation bodies are also rather discrete in nature.[23] Many of the low or lower middle-income countries do not have signatories or scopes of IAF and ILAC, meaning that they have the lowest scores for these indicators. Figure 16 shows the countries that have signatories to ILAC MRA. Many countries in Sub-Saharan Africa, the Middle East and North Africa do not have signatories. In fact, 53 countries out of the 137 QI4SD Index countries do not have ILAC arrangements in place.[24] For the IAF MLAs there are even less in place—70 countries do not have IAF arrangements in place. Eighteen countries have ILAC MRA signatories but not IAF MLA signatories

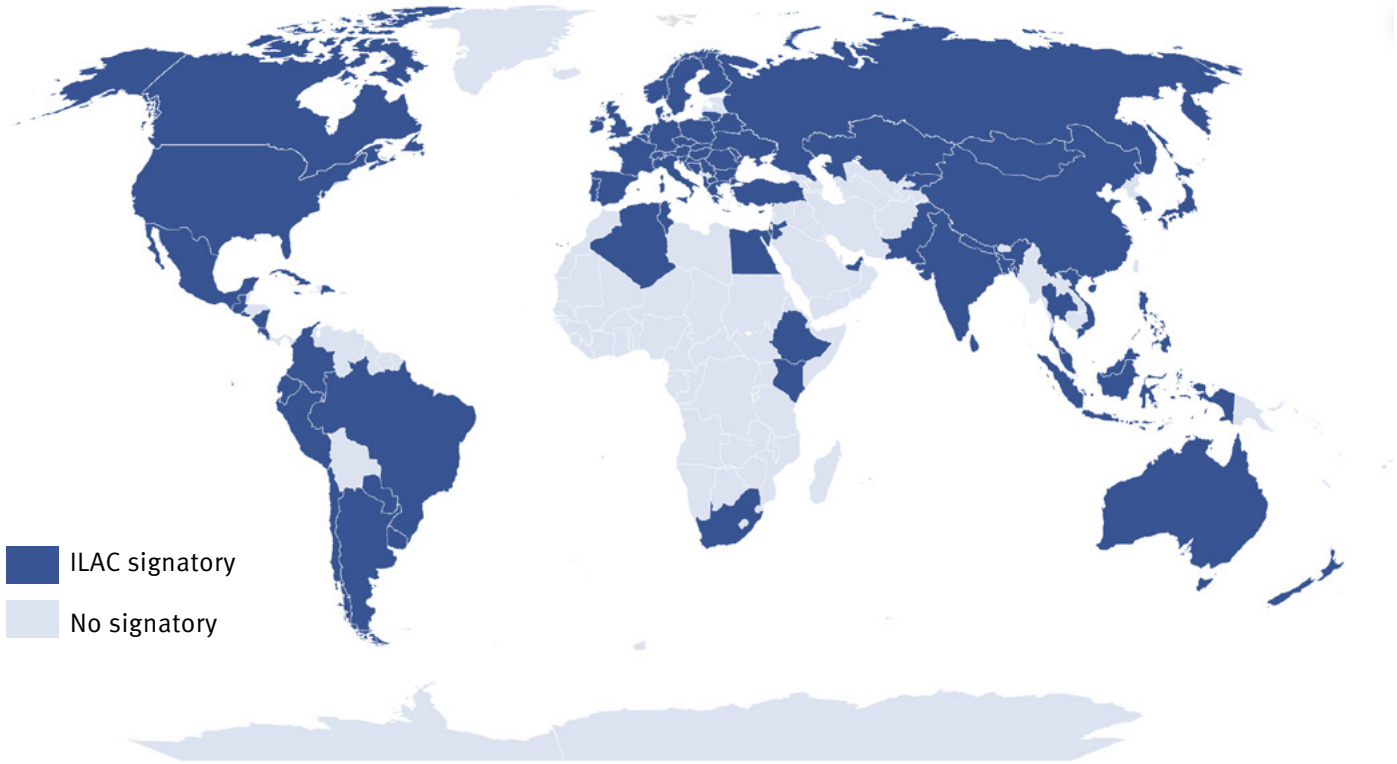
TABLE 14: : Rank discrepancies for QI dimensions (difference between dimension rank and average dimension rank, rounded to the nearest whole number). Sorted by highest discrepancies.

	Standards	Conformity	Metrology	Accreditation
Hong Kong	64	3	14	46
Russian Federation	18	11	22	52
Cuba	7	40	41	7
Saudi Arabia	12	36	7	41
Cambodia	27	28	40	14
Côte d'Ivoire	15	28	39	4
Luxembourg	21	38	11	29
Guatemala	37	17	10	31
Iran	34	8	10	36
Zambia	12	32	35	8
South Korea	10	15	10	34
Moldova	16	27	10	34
Nicaragua	15	7	10	33
Togo	33	33	18	18
Kyrgyzstan	21	17	6	32
Uganda	31	12	18	1
Bhutan	11	16	4	31
United Arab Emirates	1	31	27	4
Paraguay	31	2	15	18
Burundi	5	21	5	30

[23] The maximum number of IAF scopes is 15 and 6 for ILAC scopes.

[24] While multi-economy accreditation bodies were included in data provided by IAF, they are not noted as signatories, and as a result were excluded. Additionally, they do not have any scopes listed, and so received scope scores of zero. In the data provided by ILAC, multi-economy accreditation bodies were overlooked, and will be taken into due consideration in the next edition of the index.

FIGURE 16: Signatories of ILAC Mutual Recognition Arrangements (MRAs).[25]



(Algeria, Bangladesh, Bosnia and Herzegovina, Croatia, Cuba, Cyprus, Dominican Republic, Ethiopia, Guatemala, Israel, Jamaica, Jordan, Kyrgyzstan, Nicaragua, Nepal, Paraguay, Russian Federation, El Salvador) and only Iran has the IAF MLA signatory in place but not the ILAC MRA signatory.

3.4.2

Conformity assessment

In the Conformity Assessment dimension, there are five indicators. Three of these are general, and two are P-indicators, concerning recognised certificates from the IQNet and ISO databases. Figure 17 illustrates these two P-indicators. The values for five countries with the highest number of recognised certificates have been omitted from the figure, due to their very high numbers that would interfere with the visualisation of the rest of the countries. These five countries are China, Italy, Germany, Spain and France and their values are shown in Figure 17 below. Apart from the top five countries, most other countries in this GDP-group (XL) have many certificates in both databases. Countries in the L GDP-group also have many certificates in the IQNet database but not necessary in the ISO database. The average contribution of the 3Ps for the 137-ranked countries are quite equally distributed. 37% for Planet, 27% for People and 36% for Prosperity for certificates from the IQNet database. The figure is similar for certificates from the ISO database.[26]

3.4.3

Metrology

Metrology is the dimension that is most related to the overall QI4SD Index with a correlation coefficient of 0.90. The Metrology dimension includes nine indicators, of which two are P-indicators, concerning the number and breadth (coverage) of calibration and measurement capacities (CMCs). The BIPM has detailed data on the number CMCs of each country and has mapped them to the 3Ps. These two indicators have therefore been calculated as P-indicators. These indicators are correlated with a value of 0.85, which suggests that they are similar but still capture marginally different aspects of CMCs in the country, as shown in Figure 18. As seen in Figure 18 larger economies tend to have more capacities both in number and coverage. When the distribution of the 3Ps over the CMCs are analysed, it is evident that Prosperity has the largest contribution of the 3Ps. Figure 19 and Figure 20 show the distributions for the top 20 countries in number and breadth of CMCs. For Italy, Switzerland and Sweden as much as 99%, 91% and 94% of the number of CMCs can be attributed to Prosperity. Germany is the top ranked country when it comes to breadth of CMC types. It covers 46 out of 47 types with only the Thermophysical Quantity type (ThQ) missing in Thermometry (T).

[25] Multi-economy accreditation bodies excluded.

[26] 37% for Planet, 29% for People and 34% for Prosperity for certificates from the ISO database.

FIGURE 17: Number of recognised certificates from IQNet vs ISO databases.

Top 5 countries	IQNET certificates	Recognized certificates (ISO)
China	127435	434099
Italy	47295	120693
Germany	27992	56348
Spain	18264	43762
France	16424	28104

FIGURE 18: Number of CMCs vs total breadth of CMC types.

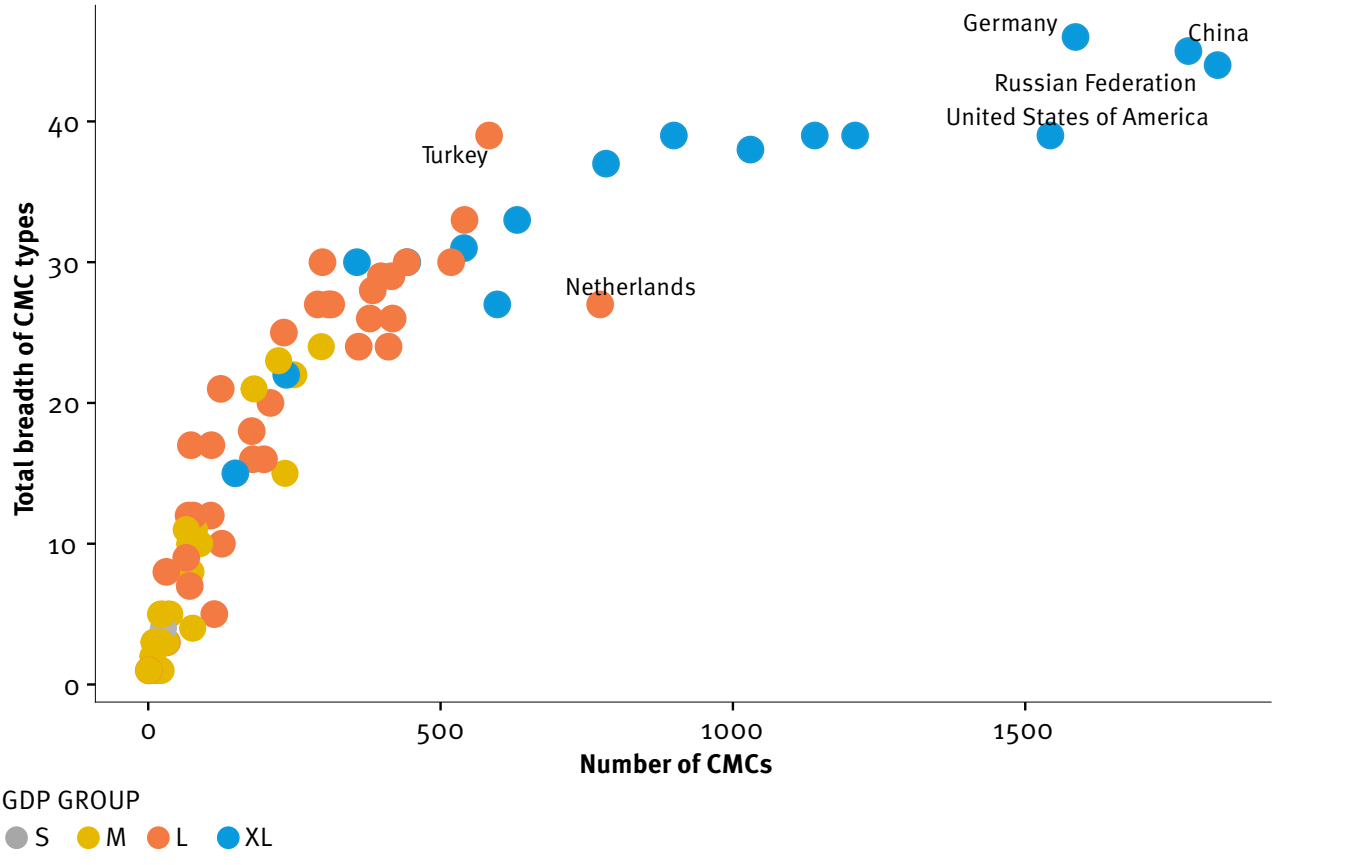


FIGURE 19: Number of CMCs mapped to 3Ps for top 20 countries.

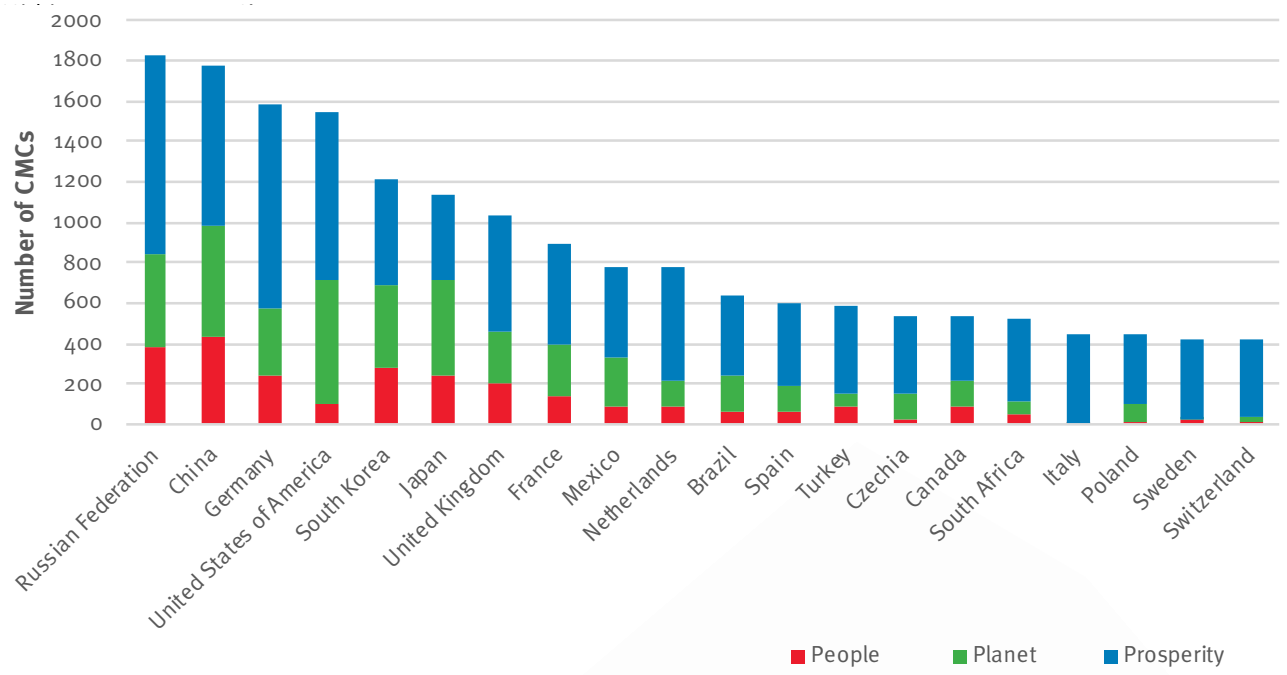
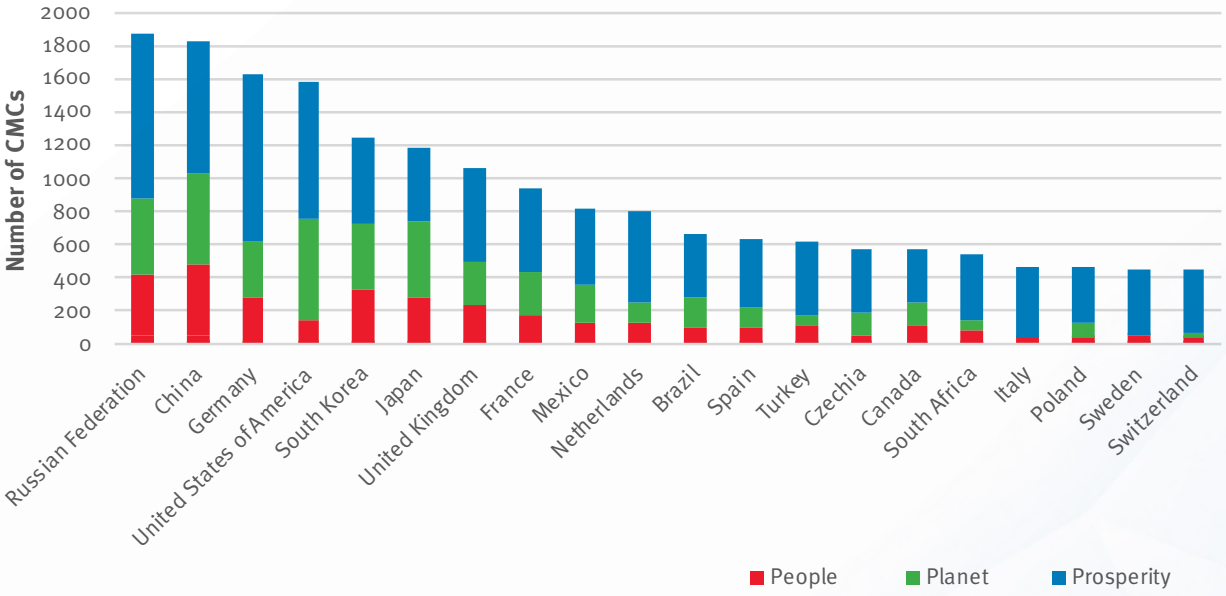


FIGURE 20: Total breadth of CMC types mapped to 3Ps for top 20 countries.



3.4.3
Policy

The Policy dimension was based exclusively on the UNIDO/ISO survey[27] since no data was available elsewhere. Figure 21 shows the countries having a Quality Policy (QP) in place or having regulations or directives that define functions and responsibilities of the different areas of QI. A majority of the QI4SD ranked countries (55%[28]) has a national or regional QP, i.e. a policy for developing and sustaining effective QI. 30%[29] of the countries have regulations or directives that define functions and responsibilities of the different areas of QI. Four countries (Bosnia and Herzegovina, Nigeria, Panama and Turkey) answered they do not have a QP in place and nine[30] countries answered they do not know. For the vast majority of countries with a QP in place, the four QI dimensions (Accreditation, Conformity Assessment, Metrology and Standards) are all addressed within the policy framework.

FIGURE 21: Countries having a Quality Policy (QP) in place or regulations which define functions and responsibilities of the different areas of QI.

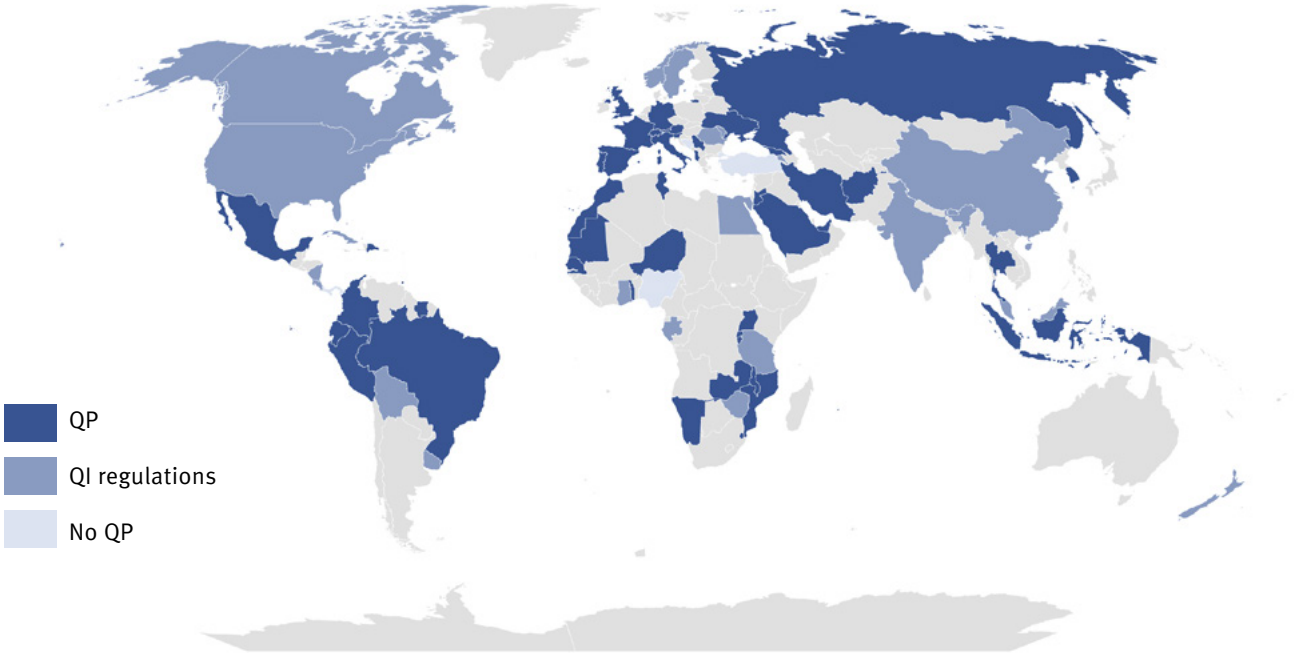
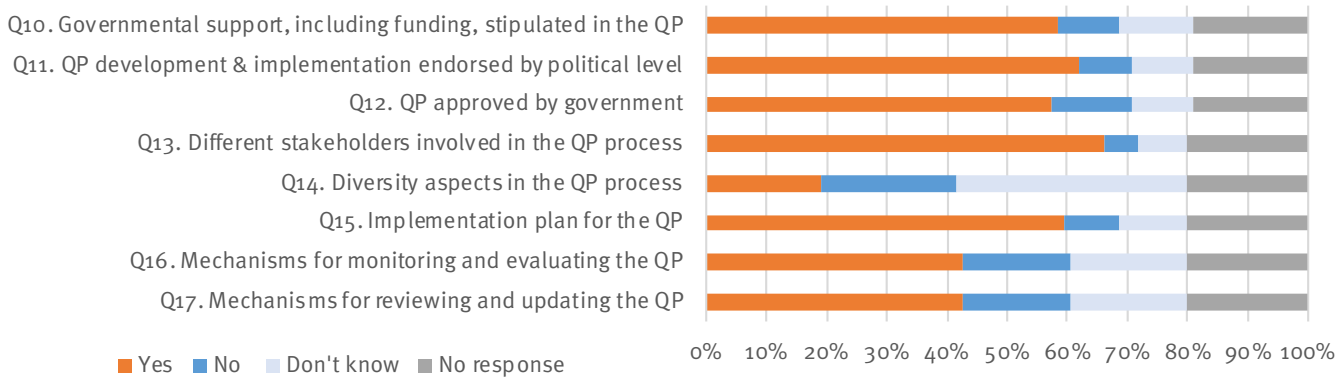


FIGURE 22: Results from QP questions in the UNIDO/ISO survey.



[27] Full details of the survey and data collection process can be found in the accompanying Methodological Annex.

[28] 49 of 89 countries

[29] 27 of 89 countries

[30] Bulgaria, Bahrain, Croatia, Hungary, Israel, Japan, Lithuania, the Netherlands and Poland

The remaining questions in the survey, are illustrated in Figure 22 and show that a majority of the countries have:

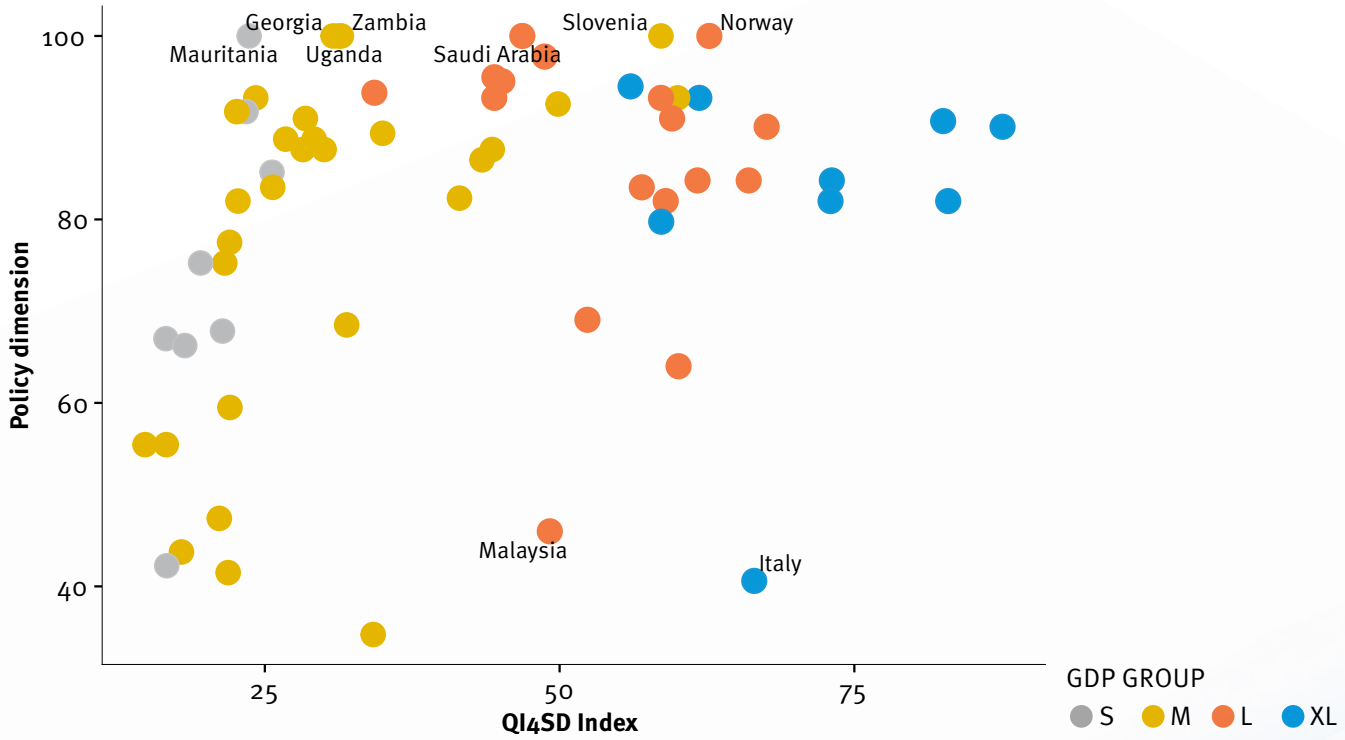
- Different stakeholders (private and public sectors, consumers, producers) involved in the QP process (Q13. 66%)
- QP development and implementation endorsed by the political level or led by the highest level of government (Q12. 62%)
- Existence of implementation plan for the QP, i.e. a plan that sets out the steps for achieving the policy objectives (Q15. 60%)
- Governmental support, including funding, stipulated in the QP (Q10. 58%)
- QP approved by government or regional country grouping (Q11. 57%)

Gender balance and other diversity aspects have been considered in the QP process only in 19% of the countries.

We have earlier learnt that larger economies (generally) have higher QI scores since QI is linked to economic development but this is not necessarily true for the QP scores. Figure 23 shows the relationship between scores in the Policy dimension versus scores of the general QI4SD Index. The figure shows that smaller economies may also have high QP scores. Mauritania, belonging to the smallest GDP group (S), even has one of the highest scores. Italy, on the other end, belonging to the largest GDP group (XL), has one of the lowest QP scores of the countries who responded to the survey.

We note that while the survey aimed to ask questions as clearly and precisely as possible, different countries may have also interpreted questions in different ways. Nevertheless, this survey is the first attempt of its kind to gather data on QP and could perhaps be refined in the future.

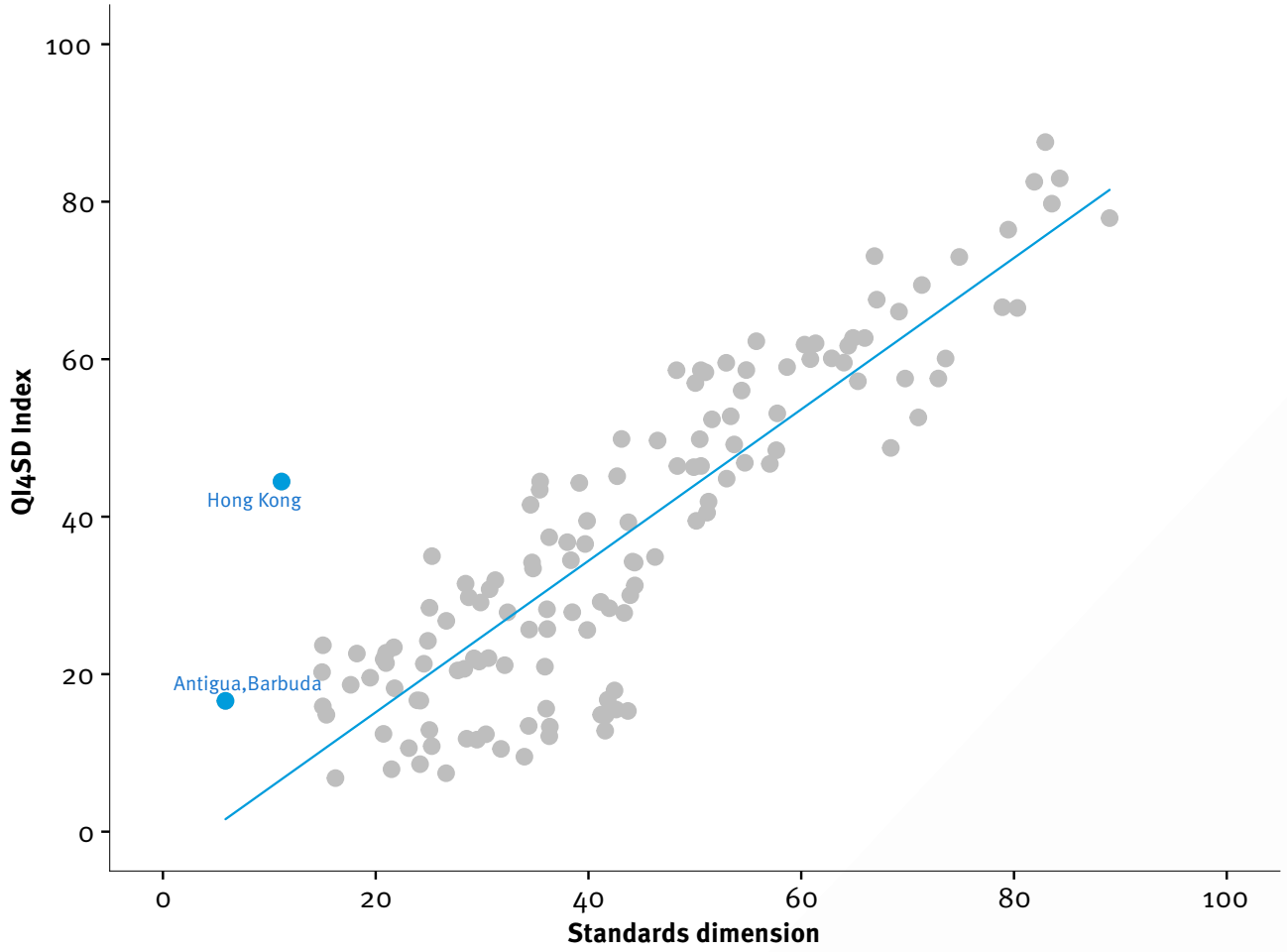
FIGURE 23: Policy dimension scores vs QI4SD Index scores.



3.4.5
Standards

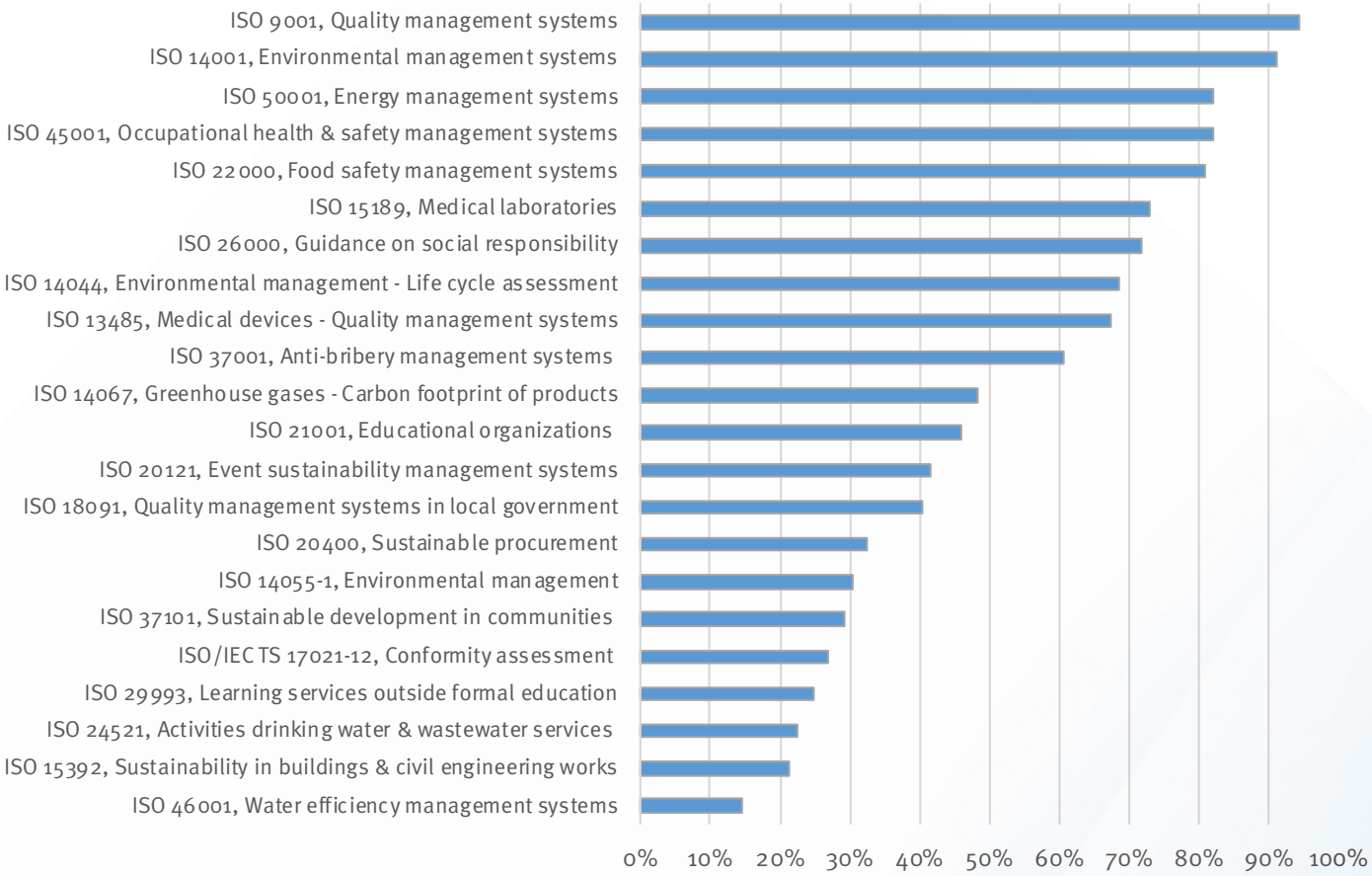
The Standards dimension is highly related to the overall QI4SD Index. There is indeed a strong linear relationship (correlation 0.87), as illustrated in Figure 24.

FIGURE 24: Standards dimension scores vs QI4SD Index scores.



The indicator about adopted ISO standards comes from the survey launched by ISO and UNIDO in 2021 (see more information in the Methodological Annex). The aim of the survey was to see which ISO standards had been adopted as national standards, for each country. However, since there are a very large number of ISO standards, a small subset of 22 standards that were deemed to especially relevant to sustainable development were selected. Ten of those standards are adopted in more than half of the countries that replied to the survey, as shown in Figure 25. The two management systems, ISO 9001 and ISO 14001, for quality and environment, are adopted in 90% or more of the countries. The result may not come as a surprise since the ISO 9001 is probably the world's most best-known quality management standard for companies and organisations. While on the other end, the water efficiency management system (ISO 46001) is only adopted as a national standard in 15% of the countries. It should be noted that some of the standards may not have had time to be adopted by some countries since they are relatively "new". Take for example ISO 46001 and ISO 15392, which were both published in 2019, while ISO 9001 and ISO 14001 have been on the market longer (both published in 2015). Both the UK and India have adopted all of the 22 surveyed standards. Gabon (ranked 109 in the overall QI4SD Index) has adopted 21, and Togo (ranked 89) has adopted 20 standards. The top ranked country Germany has adopted 16, while China (2nd ranked country) has adopted less than half of the standards (10).

FIGURE 25: Percentage of adopted ISO standards as national standards in surveyed countries.



4. Conclusions

This work has outlined the methodology and results for a Quality Infrastructure for Sustainable Development Index. The objective (among others) was to see the extent to which QI in each country is able to contribute to SDGs.

The framework is composed of four indexes: the general QI4SD Index and three "P-indexes" (People, Planet and Prosperity). The "P-indexes" measure specific intersections between QI dimensions and the SDGs.

The work has yielded a number of conclusions, including:

» Quality Infrastructure is linked with economic development, in the first place because QI boosts economic output. But equally, QI costs money, so larger economies are able to have a more extensive QI. The largest economies scoring highest on QI are Germany, China and the USA, among others.

» As a result, high QI4SD Index scores mainly occur in countries that enjoy high GDP, but the economic output is not the only enabler for an advanced QI system of the country. There seems to be a reciprocal relationship between economic prosperity and Quality Infrastructure in a country.

» Some countries score higher regarding QI in respect to their GDP and these QI over performers are mainly found in Europe. On the other end, countries with higher GDP levels compared to their QI are the so-called QI underperformers and they are mostly situated the Middle East, Central Asia and Africa.

» Countries have similar ranks/scores in each of the three "P-indexes". If a country is doing well in the People index, for example, it is likely to do well in the other two "P-indexes", Planet and Prosperity.

» Of the 17 SDGs, the People, Planet and Prosperity indexes correlate the most with SDG 9, the goal that promotes socially inclusive and environmentally sustainable economic development by enhancing infrastructure, industry and innovation. The QI institutions and services have an important role in industry and infrastructure, as they are needed to embed sustainability requirements within projects and are required to support the sustainable management of organizations, global supply chains, and associated environmental and social responsibility aspects.

» All the dimensions apart from the Policy dimension are highly correlated with the general QI4SD Index. Further, all dimensions of QI except Policy are positively correlated with one another. This means that higher scores in one dimension generally imply higher scores in the other.

» For the first time (to our knowledge) QP was assessed in a worldwide survey. A majority of the ranked countries (55%) has a national or regional QP, i.e. a policy for developing and sustaining effective QI, and 30% of the countries have regulations or directives that define functions and responsibilities of the different areas of QI. The survey also evidenced that smaller economies may have high QP scores.

A number of challenges were faced along the way. In the first place, data is not readily available and indicators had to generally be created from scratch, sometimes using data downloaded from websites, and in other cases scraping from documents and tables. This is in contrast to many composite indicators for which data is taken from central statistical sources, such as the OECD, World Bank, and the UN. As a consequence, indicators were created using the best interpretations of the data by the authors, with the methodology cross-checked by INetQI experts. A positive implication of this is that the QI4SD data set represents a unique centralised resource which can be used to examine the state of QI and its relations to SDGs, for individual countries, and to investigate global trends.

A further challenge was the incorporation of sustainable development into the index. As mentioned in Section 2.1, this results in a "matrix" framework which is quite unusual in composite indicator construction, and four separate indexes. This again adds value, but care is needed in interpreting the resulting rankings and scores. In this respect, the Country Profiles (available in an accompanying document and in the online data portal) help to zoom in a little on the individual scores of each country.

All in all, the QI4SD Index represents a first iteration of an index for measuring the intersection of QI and SDGs, and could probably be improved using further feedback after its launch, and its intended use by stakeholders. This is a natural process for any analytical tool – though experts and stakeholders were closely involved at every step of its construction,

At the heart of this work is the aim for transparency and reproducibility. As such, the methodology is described in considerable detail in the accompanying Methodological Annex, and data will be made publicly available online[31].

[31] https://hub.unido.org/qi4sd

References

Becker, W., Dominguez-Torreiro, M., Neves, A.R., Tacao Moura, C.J., Saisana, M., European Commission, Joint Research Centre, 2019. Exploring ASEM sustainable connectivity: what brings Asia and Europe together?.

Cornell University, INSEAD, WIPO, 2020. The Global Innovation Index 2020: Who Will Finance Innovation? Cornell University, INSEAD, and the World Intellectual Property Organization, Ithaca, Fontainebleau, and Geneva.

Harmes-Liedtke, U., and J.J. Oteiza Di Matteo. 2021. "Global Quality Infrastructure Index Report 2020." https://gqii.org/programme/.

Sachs, J., C. Kroll, G. Lafortune, G. Fuller, and F. Woelm. 2021. *The Decade of Action for the Sustainable Development Goals: Sustainable Development Report 2021*. Cambridge: Cambridge University Press.

Harmes-Liedtke, U., Oteiza Di Matteo, J.J., 2019. Measurement and Performance of Quality Infrastructure -A proposal for a Global Quality Infrastructure Index. Preprint. https://doi.org/10.13140/RG.2.2.29254.83526

Harmes-Liedtke, U., Oteiza Di Matteo, J.J., 2011. Measurement of Quality Infrastructure (Discussion paper No. 5/2011). Physikalisch-Technische Bundesanstalt, Braunschweig, Germany.

JRC, OECD, 2008. JRC/OECD Handbook on constructing composite indicators: methodology and user guide. OECD publishing.

Kaplinsky, R., 2016. Inclusive and Sustainable Growth: The SDG Value Chains Nexus, Framework paper: Development and LDCs. International Centre for Trade and Sustainable Development (ICTSD), Geneva, Switzerland.

Kellermann, M., World Bank Group, Physikalisch-Technische Bundesanstalt (Germany), 2019. Ensuring quality to gain access to global markets: a reform toolkit.

UNIDO, 2020. Rebooting Quality Infrastructure for a Sustainable Future. United Nations Industrial Development Organization, Vienna, Austria.

United Nations General Assembly, 2017. Work of the Statistical Commission pertaining to the 2030 Agenda for Sustainable Development, A/RES/71/313.

United Nations General Assembly, 2015. Transforming our world: the 2030 Agenda for Sustainable Development, A/RES/70/1.

Appendix: Results tables

Here, the full results tables (up to the dimension level) are given for each country, as well as P-ranks for each country. The full data set is available online https://hub.unido.org/qi4sd

GENERAL INDEX

FIGURE 26: Index and dimension scores for XL group

Country	Region	Rank	Index	Standards	Conformity	Metrology	Accreditation	Policy
Germany	Europe & Central Asia	1	88	83	77	92	97	90
China	East Asia & Pacific	2	83	84	74	83	92	82
France	Europe & Central Asia	3	83	82	66	83	91	91
United States of America	North America	4	80	84	51	84	100	
United Kingdom	Europe & Central Asia	5	78	89	41	86	95	
Japan	East Asia & Pacific	6	76	79	56	83	87	
Spain	Europe & Central Asia	7	73	67	57	62	95	84
South Korea	East Asia & Pacific	8	73	75	59	77	73	82
India	South Asia	9	67	79	42	52	93	
Italy	Europe & Central Asia	10	67	80	52	61	98	41
Australia	East Asia & Pacific	11	62	61	25	68	93	
Canada	North America	12	62	60	17	64	74	93
Mexico	Latin America & Caribbean	13	59	55	16	53	89	80
Brazil	Latin America & Caribbean	14	58	51	40	63	79	
Russian Federation	Europe & Central Asia	15	58	73	33	82	42	
Indonesia	East Asia & Pacific	16	56	54	13	35	83	95


12:00PM
5G
75%
/INSURANCE
/WARRANTY
/OWNERSHIP
50%
/BUSINESS
/TECHNOLOGY
/FINANCIAL
/INSURANCE
/INVESTMENT
/INFORMATION
/ECONOMY

FIGURE 27: Index and dimension scores for L group

Country	Region	Rank	Index	Standards	Conformity	Metrology	Accreditation	Policy
Netherlands	Europe & Central Asia	1	69	71	31	79	97	
Switzerland	Europe & Central Asia	2	68	67	31	65	85	90
Austria	Europe & Central Asia	3	66	69	36	54	87	84
Norway	Europe & Central Asia	4	63	65	19	39	91	100
Czechia	Europe & Central Asia	5	63	66	26	64	95	
Turkey	Europe & Central Asia	6	62	56	36	62	95	
Romania	Europe & Central Asia	7	62	64	28	44	88	84
South Africa	Sub-Saharan Africa	8	60	63	19	70	88	
Sweden	Europe & Central Asia	9	60	74	18	54	91	64
Poland	Europe & Central Asia	10	60	64	27	56	91	
United Arab Emirates	Middle East & North Africa	11	60	53	52	23	79	91
Portugal	Europe & Central Asia	12	59	59	27	42	85	82
Singapore	East Asia & Pacific	13	59	48	22	44	86	93
Finland	Europe & Central Asia	14	58	70	21	52	88	
Denmark	Europe & Central Asia	15	57	65	22	52	89	
Colombia	Latin America & Caribbean	16	57	50	32	39	80	84
Hungary	Europe & Central Asia	17	53	58	23	44	88	
Slovakia	Europe & Central Asia	18	53	53	10	60	88	
Belgium	Europe & Central Asia	19	53	71	10	43	86	
Thailand	East Asia & Pacific	20	52	52	15	43	84	69
Greece	Europe & Central Asia	21	50	50	22	35	91	
New Zealand	East Asia & Pacific	22	50	47	14	45	93	
Malaysia	East Asia & Pacific	23	49	54	39	29	79	46
Iran	Middle East & North Africa	24	49	68	6	39	32	98
Saudi Arabia	Middle East & North Africa	25	47	55	46	32	1	100
Ireland	Europe & Central Asia	26	47	57	6	36	88	
Argentina	Latin America & Caribbean	27	46	51	23	35	77	
Ukraine	Europe & Central Asia	28	46	50	18	36	82	
Peru	Latin America & Caribbean	29	45	43	6	20	62	95
Israel	Middle East & North Africa	30	45	53	41	30	56	
Cuba	Latin America & Caribbean	31	44	35	1	40	51	96
Hong Kong	East Asia & Pacific	32	44	11	3	28	87	93
Egypt	Middle East & North Africa	33	42	51	4	37	75	
Pakistan	South Asia	34	39	50	9	31	68	
Chile	Latin America & Caribbean	35	39	44	23	18	72	
Viet Nam	East Asia & Pacific	36	37	36	11	25	77	
Kazakhstan	Europe & Central Asia	37	37	38	4	34	71	
Philippines	East Asia & Pacific	38	35	46	5	16	72	
Morocco	Middle East & North Africa	39	34	44	3	30	1	94
Bangladesh	South Asia	40	28	38	2	15	56	
Algeria	Middle East & North Africa	41	28	43	2	15	51	
Ethiopia	Sub-Saharan Africa	42	21	36	2	8	38	
Iraq	Middle East & North Africa	43	17	42	2	22	1	
Qatar	Middle East & North Africa	44	16	43	3	15	1	
Nigeria	Sub-Saharan Africa	45	15	41	8	9	1	
Kuwait	Middle East & North Africa	46	15	42	1	15	1	

FIGURE 28: Index and dimension scores for M group (ranks 1-35)

Country	Region	Rank	Index	Standards	Conformity	Metrology	Accreditation	Policy
Serbia	Europe & Central Asia	1	60	61	25	41	80	93
Slovenia	Europe & Central Asia	2	59	51	18	43	82	100
Tunisia	Middle East & North Africa	3	50	43	4	35	75	93
Bulgaria	Europe & Central Asia	4	48	58	16	40	80	
Belarus	Europe & Central Asia	5	46	48	13	38	86	
Ecuador	Latin America & Caribbean	6	44	39	4	23	68	88
Albania	Europe & Central Asia	7	43	35	2	23	70	87
Costa Rica	Latin America & Caribbean	8	42	35	3	18	69	82
Croatia	Europe & Central Asia	9	41	51	18	37	56	
Kenya	Sub-Saharan Africa	10	39	40	8	38	72	
Lithuania	Europe & Central Asia	11	37	40	2	26	79	
Dominican Republic	Latin America & Caribbean	12	35	25	2	8	51	89
Sri Lanka	South Asia	13	34	38	2	23	75	
Uruguay	Latin America & Caribbean	14	34	35	2	29	70	35
Luxembourg	Europe & Central Asia	15	34	44	1	16	75	
North Macedonia	Europe & Central Asia	16	33	35	2	23	74	
Jordan	Middle East & North Africa	17	32	31	1	8	51	69
Zambia	Sub-Saharan Africa	18	31	28	1	27	1	100
Uganda	Sub-Saharan Africa	19	31	44	2	9	1	100
Georgia	Europe & Central Asia	20	31	31	4	18	1	100
Ghana	Sub-Saharan Africa	21	30	44	2	15	1	88
Moldova	Europe & Central Asia	22	30	29	1	17	72	
Rwanda	Sub-Saharan Africa	23	29	41	1	14	1	89
Mongolia	East Asia & Pacific	24	29	30	1	16	69	
Namibia	Sub-Saharan Africa	25	28	25	3	22	1	91
Bosnia and Herzegovina	Europe & Central Asia	26	28	42	3	18	51	
Malta	Middle East & North Africa	27	28	36	1	15	1	88
Mauritius	Sub-Saharan Africa	28	28	32	2	15	62	
Trinidad and Tobago	Latin America & Caribbean	29	27	27	2	16	1	89
Cyprus	Europe & Central Asia	30	26	36	7	15	45	
Malawi	Sub-Saharan Africa	31	26	34	1	8	1	84
Palestine, State of	Middle East & North Africa	32	24	25	1	1	1	93
Mozambique	Sub-Saharan Africa	33	23	21	2	8	1	82
Niger	Sub-Saharan Africa	34	23	18	1	1	1	92
Bolivia	Latin America & Caribbean	35	22	31	2	17	1	60

FIGURE 29: Index and dimension scores for M group (ranks 36-64)

Country	Region	Rank	Index	Standards	Conformity	Metrology	Accreditation	Policy
Armenia	Europe & Central Asia	36	22	29	1	1	1	78
Nicaragua	Latin America & Caribbean	37	22	21	1	1	45	42
Afghanistan	South Asia	38	22	30	1	1	1	75
Jamaica	Latin America & Caribbean	39	21	25	1	9	51	
Tanzania, the United Republic c	Sub-Saharan Africa	40	21	32	1	24	1	47
Nepal	South Asia	41	21	28	1	8	45	
El Salvador	Latin America & Caribbean	42	20	28	3	1	51	
Guatemala	Latin America & Caribbean	43	20	15	2	8	56	
Paraguay	Latin America & Caribbean	44	19	18	1	16	40	
Gabon	Sub-Saharan Africa	45	18	42	1	1	1	44
Senegal	Sub-Saharan Africa	46	17	24	2	1	1	55
Estonia	Europe & Central Asia	47	16	36	2	24	1	
Oman	Middle East & North Africa	48	15	44	1	15	1	
Brunei Darussalam	East Asia & Pacific	49	15	15	1	1	1	55
Latvia	Europe & Central Asia	50	13	34	2	17	1	
Bahrain	Middle East & North Africa	51	13	36	8	8	1	
Côte d'Ivoire	Sub-Saharan Africa	52	13	42	8	1	1	
Cambodia	East Asia & Pacific	53	12	21	1	27	1	
Panama	Latin America & Caribbean	54	12	30	1	17	1	
Iceland	Europe & Central Asia	55	12	36	3	8	1	
Botswana	Sub-Saharan Africa	56	12	29	1	16	1	
Sudan	Sub-Saharan Africa	57	12	30	1	15	1	
Uzbekistan	Europe & Central Asia	58	11	25	2	15	1	
Azerbaijan	Europe & Central Asia	59	11	23	2	16	1	
Zimbabwe	Sub-Saharan Africa	60	11	32	1	8	1	
Lebanon	Middle East & North Africa	61	10	34	2	1	1	
Mali	Sub-Saharan Africa	62	9	24	1	8	1	
Bahamas	Latin America & Caribbean	63	7	27	1	1	1	
Madagascar	Sub-Saharan Africa	64	7	16	2	8	1	

FIGURE 30: : Index and dimension scores for S group

Country	Region	Rank	Index	Standards	Conformity	Metrology	Accreditation	Policy
Togo	Sub-Saharan Africa	1	26	40	1	1	1	85
Mauritania	Sub-Saharan Africa	2	24	15	1	1	1	100
Eswatini	Sub-Saharan Africa	3	23	22	2	1	1	92
Seychelles	Sub-Saharan Africa	4	21	21	1	16	1	68
Bhutan	South Asia	5	20	19	1	1	1	75
Burundi	Sub-Saharan Africa	6	18	22	1	1	1	66
Barbados	Latin America & Caribbean	7	17	24	1	15	1	42
Antigua and Barbuda	Latin America & Caribbean	8	17	6	1	8	1	67
Kyrgyzstan	Europe & Central Asia	9	16	15	1	8	40	
Montenegro	Europe & Central Asia	10	13	25	2	23	1	
Suriname	Latin America & Caribbean	11	8	21	1	8	1	

P-INDEXES

The following tables are the ranks from the P-indexes.

FIGURE 31: P-index ranks for countries in XL group (sorted by People score)

Country	Region	People	Planet	Prosperity
Germany	Europe & Central Asia	1	1	1
France	Europe & Central Asia	2	2	4
China	East Asia & Pacific	3	3	3
United Kingdom	Europe & Central Asia	4	6	6
Japan	East Asia & Pacific	5	4	9
United States of America	North America	6	5	5
Italy	Europe & Central Asia	7	8	2
Spain	Europe & Central Asia	8	7	7
South Korea	East Asia & Pacific	9	13	12
India	South Asia	10	12	8
Brazil	Latin America & Caribbean	11	9	11
Australia	East Asia & Pacific	12	14	14
Mexico	Latin America & Caribbean	13	10	13
Russian Federation	Europe & Central Asia	14	11	10
Canada	North America	15	15	16
Indonesia	East Asia & Pacific	16	16	15

FIGURE 32: P-index ranks for countries in L group (sorted by People score)

Country	Region	People	Planet	Prosperity
Netherlands	Europe & Central Asia	1	4	5
Turkey	Europe & Central Asia	2	3	1
Romania	Europe & Central Asia	3	1	3
Czechia	Europe & Central Asia	4	2	2
Austria	Europe & Central Asia	5	8	9
Switzerland	Europe & Central Asia	6	6	4
Finland	Europe & Central Asia	7	10	6
South Africa	Sub-Saharan Africa	8	9	10
Poland	Europe & Central Asia	9	5	8
Greece	Europe & Central Asia	10	20	20
Sweden	Europe & Central Asia	11	12	7
Hungary	Europe & Central Asia	12	7	11
Norway	Europe & Central Asia	13	18	16
Denmark	Europe & Central Asia	14	13	12
Malaysia	East Asia & Pacific	15	19	13
Portugal	Europe & Central Asia	16	16	14
Belgium	Europe & Central Asia	17	17	18
Singapore	East Asia & Pacific	18	24	23
Slovakia	Europe & Central Asia	19	15	24
Colombia	Latin America & Caribbean	20	11	15
Thailand	East Asia & Pacific	21	14	22
Ireland	Europe & Central Asia	22	26	17
Israel	Middle East & North Africa	23	23	19
United Arab Emirates	Middle East & North Africa	24	27	25
New Zealand	East Asia & Pacific	25	30	26
Hong Kong	East Asia & Pacific	26	25	28
Ukraine	Europe & Central Asia	27	22	20
Argentina	Latin America & Caribbean	28	21	27
Egypt	Middle East & North Africa	29	28	29
Iran	Middle East & North Africa	30	31	31
Chile	Latin America & Caribbean	31	32	30
Philippines	East Asia & Pacific	32	35	35
Pakistan	South Asia	33	33	34
Peru	Latin America & Caribbean	34	29	32
Viet Nam	East Asia & Pacific	35	36	33
Kazakhstan	Europe & Central Asia	36	37	37
Saudi Arabia	Middle East & North Africa	37	40	39
Cuba	Latin America & Caribbean	38	34	38
Bangladesh	South Asia	39	38	36
Morocco	Middle East & North Africa	40	39	41
Ethiopia	Sub-Saharan Africa	41	41	40
Nigeria	Sub-Saharan Africa	42	43	43
Algeria	Middle East & North Africa	43	42	42
Qatar	Middle East & North Africa	44	44	45
Iraq	Middle East & North Africa	45	46	44
Kuwait	Middle East & North Africa	46	45	46

FIGURE 33: P-index ranks for countries in M group (sorted by People score, ranks 1-35)

Country	Region	People	Planet	Prosperity
Serbia	Europe & Central Asia	1	4	2
Slovenia	Europe & Central Asia	2	2	4
Bulgaria	Europe & Central Asia	3	1	1
Belarus	Europe & Central Asia	4	3	3
Croatia	Europe & Central Asia	5	9	6
Tunisia	Middle East & North Africa	6	10	8
Lithuania	Europe & Central Asia	7	8	9
Moldova	Europe & Central Asia	8	11	14
Uruguay	Latin America & Caribbean	9	5	5
Ecuador	Latin America & Caribbean	10	6	12
Costa Rica	Latin America & Caribbean	11	7	11
Albania	Europe & Central Asia	12	12	7
Kenya	Sub-Saharan Africa	13	20	17
Bosnia and Herzegovina	Europe & Central Asia	14	13	10
Sri Lanka	South Asia	15	15	23
Luxembourg	Europe & Central Asia	16	19	15
North Macedonia	Europe & Central Asia	17	18	19
Mauritius	Sub-Saharan Africa	18	14	21
Ghana	Sub-Saharan Africa	19	26	22
Georgia	Europe & Central Asia	20	29	13
Uganda	Sub-Saharan Africa	21	22	25
Jordan	Middle East & North Africa	22	28	34
Mongolia	East Asia & Pacific	23	16	18
Cyprus	Europe & Central Asia	24	38	37
Gabon	Sub-Saharan Africa	25	23	16
Lebanon	Middle East & North Africa	26	39	29
Rwanda	Sub-Saharan Africa	27	17	20
Guatemala	Latin America & Caribbean	27	32	32
Jamaica	Latin America & Caribbean	29	40	36
Nicaragua	Latin America & Caribbean	30	25	28
Zambia	Sub-Saharan Africa	31	21	31
Malawi	Sub-Saharan Africa	32	37	27
Sudan	Sub-Saharan Africa	33	51	48
Dominican Republic	Latin America & Caribbean	34	24	24
Cambodia	East Asia & Pacific	35	46	49

FIGURE 34: P-index ranks for countries in M group (sorted by People score, ranks 36-64)

Country	Region	People	Planet	Prosperity
Bolivia	Latin America & Caribbean	36	27	35
Zimbabwe	Sub-Saharan Africa	37	30	43
Malta	Middle East & North Africa	38	36	56
Tanzania, the United Republic of	Sub-Saharan Africa	39	33	41
Bahrain	Middle East & North Africa	40	31	50
Armenia	Europe & Central Asia	41	44	54
Nepal	South Asia	42	53	53
Panama	Latin America & Caribbean	43	47	38
Mozambique	Sub-Saharan Africa	44	48	47
Palestine, State of	Middle East & North Africa	45	41	30
Botswana	Sub-Saharan Africa	46	49	45
Afghanistan	South Asia	47	45	39
El Salvador	Latin America & Caribbean	48	34	33
Namibia	Sub-Saharan Africa	49	43	40
Trinidad and Tobago	Latin America & Caribbean	50	42	44
Côte d'Ivoire	Sub-Saharan Africa	51	35	26
Bahamas	Latin America & Caribbean	52	59	57
Uzbekistan	Europe & Central Asia	53	57	60
Niger	Sub-Saharan Africa	54	50	51
Iceland	Europe & Central Asia	55	61	42
Brunei Darussalam	East Asia & Pacific	56	56	62
Paraguay	Latin America & Caribbean	57	52	46
Madagascar	Sub-Saharan Africa	58	60	58
Senegal	Sub-Saharan Africa	59	54	59
Oman	Middle East & North Africa	60	55	55
Estonia	Europe & Central Asia	61	58	52
Latvia	Europe & Central Asia	62	62	63
Azerbaijan	Europe & Central Asia	63	63	60
Mali	Sub-Saharan Africa	64	64	64

FIGURE 35: P-index ranks for countries in S group (sorted by People score)

Country	Region	People	Planet	Prosperity
Togo	Sub-Saharan Africa	1	1	1
Bhutan	South Asia	2	5	7
Suriname	Latin America & Caribbean	3	3	3
Seychelles	Sub-Saharan Africa	4	4	4
Eswatini	Sub-Saharan Africa	5	2	2
Barbados	Latin America & Caribbean	6	7	8
Kyrgyzstan	Europe & Central Asia	7	6	6
Montenegro	Europe & Central Asia	8	8	5
Antigua and Barbuda	Latin America & Caribbean	9	10	11
Mauritania	Sub-Saharan Africa	10	11	10
Burundi	Sub-Saharan Africa	11	9	9


HS
OH
HN
OH
N
NH2

Appendix: List of indicators

FULL QI4SD INDEX

DIMENSION	NAME	DESCRIPTION	UNIT	ORGANISATION	TYPE	WEIGHT
ACCREDITATION	Scopes of IAF accreditation bodies	Number of scopes for the IAF Multilateral Recognition Arrangement mapped into the 3Ps.	Number	IAF	P	1
	Signatory to the IAF MLA	Existence of an accreditation body that is a signatory to the IAF Multilateral Recognition Arrangement.	Yes/no	IAF	G	1
	Scopes of ILAC accreditation bodies	Number of scopes for the ILAC Mutual Recognition Arrangement mapped into the 3Ps.	Number	ILAC	P	1
	Signatory to the ILAC MRA	Existence of an accreditation body that is a signatory to the ILAC Mutual Recognition Arrangement.	Yes/no	ILAC	G	1
CONFORMITY	Membership of IEC conformity assessment systems	Country membership in the four IEC conformity assessment systems (IECEE, IECEx, IECRE, IECQ), range 0 to 4.	Number	IEC	G	1
	Number of IECEE certificates recognised	Number of IECEE certificates present in country.	Number	IEC	G	1
	Number of recognised certificates (IQNet)	Number of recognised certificates from IQNet database mapped into 3Ps.	Number	IQNet	P	0.5
	Membership of IQNet	Level of involvement in IQNet, location of head, subsidiary offices and origin of Certification Bodies.	Composite score	IQNet	G	1
	Number of recognised certificates (ISO)	Number of recognised certificates from ISO database mapped into 3Ps.	Number	ISO	P	0.5
METROLOGY	Participation in CIPM Consultative Committees	Sum of overall participation in ten Consultative Committees, range 0 to 20.	Number	BIPM	G	1
	Participation in key and supplementary comparisons	Sum of the scores for the key and supplementary comparisons.	Number	BIPM	G	1
	Number of CMCs	Total number of Calibration and Measurement Capacities (CMCs) in any area mapped into 3Ps.	Number	BIPM	P	0.5
	Breadth of CMCs	Total breadth of Calibration and Measurement Capacity (CMC) types with at least one capacity mapped into 3Ps	Number of types	BIPM	P	0.5
	Membership of BIPM	Membership of BIPM, range 0 to 2.	Categorical	BIPM	G	1
	Membership of OIML	Membership of OIML, range 0 to 2.	Categorical	OIML	G	1
	OIML-CS - number of services offered	Number of OIML Certification System (CS) services offered.	Number	OIML	G	0.5
	OIML-CS - number of services recognised	Number of OIML Certification System (CS) services recognised.	Number	OIML	G	0.5
	Involvement in OIML project groups	Number of project groups for which each country is a convener (C), participating member (P) and observer (O).	Composite score	OIML	G	1

POLICY	Participation in capacity building programmes	Participated in capacity building programmes related to QI from BIPM, OIML, ISO, WTO in the last two years, range 0 to 4.	Number of types	UNIDO/ISO	G	1
	Quality Policy in place	National or regional Quality Policy in place, a policy for developing and sustaining effective QI.	Yes/no	UNIDO/ISO	G	1
	Dimensions of QI addressed by Quality Policy	QI dimensions (Metrology, Standards, Accreditation, Conformity Assessment) addressed by the Quality Policy or regulatory framework, range 0 to 4.	Number	UNIDO/ISO	G	1
	Support and funding for Quality Policy	Governmental support, including funding, stipulated in the Quality Policy or in the regulations and directions supporting QI.	Yes/no	UNIDO/ISO	G	1
	Government/political endorsement for Quality Policy	Development and implementation of the Quality Policy being endorsed by the political level or led by the highest level of government.	Yes/no	UNIDO/ISO	G	1
	Government approval of Quality Policy	Quality Policy approved by government or regional country grouping.	Yes/no	UNIDO/ISO	G	1
	Stakeholder involvement of Quality Policy	Involvement of stakeholders from the private and public sectors, consumers, producers in the Quality Policy process.	Yes/no	UNIDO/ISO	G	1
	Consideration of diversity in Quality Policy	Gender balance and other diversity aspects considered in the Quality Policy process.	Yes/no	UNIDO/ISO	G	1
	Implementation plan for Quality Policy	Presence of implementation plan for the national Quality Policy, i.e. a plan that sets out the steps for achieving the policy objectives.	Yes/no	UNIDO/ISO	G	1
	Monitoring and evaluation for Quality Policy	Mechanism(s) for monitoring and/or evaluating the implementation/outcomes of the Quality Policy.	Yes/no	UNIDO/ISO	G	1
	Reviewing and updating for Quality Policy	Mechanism(s) for periodically reviewing and updating the Quality Policy.	Yes/no	UNIDO/ISO	G	1
STANDARDS	Adopted ISO standards	ISO standards that had been adopted as national standards and mapped into the 3Ps.	Number	ISO	P	1
	Adopted IEC standards	IEC standards that have been adopted and mapped into the 3Ps.	Number	IEC	P	1
	Membership of IEC	Membership of the IEC, range 0 to 3.	Categorical	IEC	G	1
	Participation in IEC technical committees	IEC technical committees (TCs) participation mapped into the 3Ps.	Number	IEC	P	1
	Membership of ISO	Membership of the ISO, range 0 to 3.	Categorical	ISO	G	1
	Participation in ISO technical committees	ISO technical committees (TCs) participation.	Number	ISO	G	1
	Membership of ITU	Composite score of membership of ITU.	Composite score	ITU	G	1

P-INDEXES

The following table shows the indicators included in the P-indexes. For each of these indexes, components of the indicators are only included that are relevant to the respective P. For example, for the People index, only the "People" component of adopted standards is included (i.e. the weighting of each standard that is relevant to People).

DIMENSION	NAME	DESCRIPTION	UNIT	ORGANISATION	TYPE	WEIGHT
ACCREDITATION	Scopes of IAF accreditation bodies	Number of scopes for the IAF Multilateral Recognition Arrangement mapped into the 3Ps.	Number	IAF	P	1
	Scopes of ILAC accreditation bodies	Number of scopes for the ILAC Mutual Recognition Arrangement mapped into the 3Ps.	Number	ILAC	P	1
CONFORMITY	Number of recognised certificates (IQNet)	Number of recognised certificates from IQNet database mapped into 3Ps.	Number	IQNet	P	0.5
	Number of recognised certificates (ISO)	Number of recognised certificates from ISO database mapped into 3Ps.	Number	ISO	P	0.5
METROLOGY	Number of CMCs	Total number of Calibration and Measurement Capacities (CMCs) in any area mapped into 3Ps.	Number	BIPM	P	0.5
	Breadth of CMCs	Total breadth of Calibration and Measurement Capacity (CMC) types with at least one capacity mapped into 3Ps.	Number of types	BIPM	P	0.5
STANDARDS	Adopted ISO standards	ISO standards that had been adopted as national standards and mapped into the 3Ps.	Number	ISO	P	1
	Adopted IEC standards	IEC standards that have been adopted and mapped into the 3Ps.	Number	IEC	P	1
	Participation in IEC technical committees	IEC technical committees (TCs) participation mapped into the 3Ps.	Number	IEC	P	1

Department of Digitalization, Technology and Innovation (DTI)
Vienna International Centre
Wagramer Str. 5, P.O. Box 300,
A-1400 Vienna, Austria

+43 1 26026-0

www.unido.org

dti@unido.org

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION