GQII DATA & ANALYTICS PAPER, NO. 1

GLOBAL QUALITY INFRASTRUCTURE INDEX

REPORT 2020

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GQII
GLOBAL QUALITY INFRASTRUCTURE INDEX

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TITLE: Global Quality Infrastructure Index Report 2020

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[1] GQII Website https://gqii.org


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LIST OF ACRONYMS

AFNOR	French National Association for Standardization
AFRAC	African Accreditation Cooperation
AFRIMETS	Intra-Africa Metrology System
APAC	Asia Pacific Accreditation Cooperation
APMP	Asia Pacific Metrology Programme
ARAC	Arab Accreditation Cooperation
BIPM	International Bureau of Weights and Measures
BRICS	Brazil, Russia, India, China and South Africa
BMZ	Federal Ministry for Economic Cooperation and Development (Germany)
BSI	British Standards Institution
CAB	Conformity Assessment Body
CI	Composite Indicators
CIPM	International Committee for Weights and Measures
CMC	Calibration and Measurement Capabilities
COOMET	Euro-Asian Cooperation of National Metrological Institutions
CROSQ	CARICOM Regional Organization for Standards and Quality
CSR	Corporate Social Responsibility
DAC	Development Assistance Committee
DIN	German Institute for Standardization
DRC	Democratic Republic of Congo
EA	European Cooperation for Accreditation
ECA	National Accreditation Body of Costa Rica
ECI	Economic Complexity Index
EURAMET	European Association of National Metrology Institutes
FSC	Forest Stewardship Council
GCI	Global Competitiveness Index
GDP	Gross Domestic Product
GS	Global South
GQII	Global Quality Infrastructure Index
GULFMET	Gulf Association for Metrology
IAAC	Inter-American Accreditation Cooperation
IAF	International Accreditation Forum
IEC	International Electrotechnical Commission
ILAC	International Laboratory Accreditation Cooperation
INMETRO	Brazilian National Institute of Metrology, Standardization and Industrial Quality
ISA	International Federation of the National Standardizing Associations
ISO	International Organization for Standardization
INetQI	International Network on Quality Infrastructure
INTI	National Institute for Industrial Technology (Argentina)
ITC	International Trade Centre
ITU	International Telecommunication Union
JRC	Joint Research Centre of the European Commission
K&SC	Key and Supplementary Comparisons
KCDB	Key Comparison DataBase
KRISS	Korea Research Institute of Standards and Science
MIT	Massachusetts Institute of Technology
MLA	Multi-Lateral Recognition Arrangement (the term used by the IAF)
MRA	Mutual Recognition Arrangement (the term used by BIPM and ILAC)
MSTQ	Metrology, Standards, Testing and Quality
NAB	National Accreditation Body
NATA	Australian National Association of Testing Authorities
NIST	National Institute of Standards and Technology
NMI	National Metrology Institute
NMISA	National Metrology Institute of South Africa
NQI	National Quality Infrastructure
NQS	National Quality System
NSB	National Standards Body
ODA	Official Development Aid
OECD	Organization for Economic Co-operation and Development
OIML	International Organization of Legal Metrology
OUA	National Accreditation Body of Uruguay
PAQI	Pan-African Quality Infrastructure
PTB	German Federal Metrology Institute
RAC	Regional Accreditation Cooperation
SGG	Sustainable Development Goals
SIM	Interamerican Metrology System
QI	Quality Infrastructure
SADCA	Southern African Development Cooperation in Accreditation
SADCAS	Southern African Development Community Accreditation Service
SMCC	Smart Manufacturing Coordinating Committee
SQAM	Standards, Quality Assurance, Accreditation and Metrology
TC	Technical Committee
TIC	Testing, Inspection and Certification
TÜV	Technical Inspection Association (Germany)
UKAS	United Kingdom Accreditation Service
UNECE	United Nations Economic Commission for Europe
UNIDO	United Nations Industrial Development Organization
USA	United States of America
WBG	World Bank Group
WTO	World Trade Organization

ACKNOWLEDGEMENTS

Interest in Quality Infrastructure (QI) has grown enormously during the past decade, especially in international development cooperation circles. At the same time, there has been an increasing need for reliable data that informs about the development of QI in developing and emerging countries.

The Global Quality Infrastructure Index (GQII) programme is an initiative aimed at compiling and analyzing reliable QI information and making it freely available to an interested public. The 2020 edition is the product of research stimuli and discussions over the past ten years. The authors of this report, Dr Ulrich Harmes-Liedtke and Juan José Oteiza Di Matteo, benefited from the exchange with numerous experts within QI organizations and international development cooperation.

Without claiming completeness, the authors would like to thank Anett Matbadal, Annelien Cunningham, Christian Schoen and Manfred Kindler for their continuous support, especially for their assistance in collecting data from the accreditation bodies. Our thanks also go to the many experts and researchers who commented on the draft publications: Andreas Stamm, Andy Henson, Cesar Parga, Claudio Maggi, Daniel Masso Aguado, Elsie Meintjies, Emanuel Rivera, Fahim Khanzada, Francisco García, Gabriela de la Guardia, Georgeta Auktor, Hanspeter Ischi, Hao Zhang, Ileana Martinez, Javier Arias, Jörn Stenger, Juan Pablo Davila, Knut Blind, Kory Eguino, Martha Lucia Castro, Martin Kaiser, Ramón Madriñán, Ron Josias, Sebastian Bustos, Shawn Cunningham, Tilman Altenburg, Victor Gandi and Yolanda Vinni-combe.

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The authors would like to thank the participants of the metrology focus group for their valuable comments, namely Anett Matbadal (Germany), Byounghoon Jeon (KRISS, Korea), Claudio Santo (Uruguay, SIM), David Tomlinson (Barbados, CROSQ), Héctor Laiz (INTI, Argentina), Ndwakhulu Mukhufhi (NMISA, South Africa), Peter Ulbig (PTB, Germany), Tobias Diergardt (PTB, Germany), Valnei Cunha (INMETRO, Brazil) and the members of the accreditation focus group Alessandro Nisi (Accredia, Italy), Beatriz Paniagua (Costa Rica), Cora Roos (PTB), Graham Talbot (UK, Taiwan), Hanspeter Ischi (Switzerland), Liane Somma (Uruguay, OUA, IAAC), Manfred Kindler (Germany), Ron Josias (South Africa, AFRAC), Seidy Alfaro Gutiérrez (ECA, Costa Rica), Verónica García Malo (México) and Xavier Mugari (SADCAS).

Suggestions and critiques have enabled us to improve the informative power of the GQII. At the same time, the authors are aware that they could not entirely refute all the points of criticism. The ranking of economies remains a sensitive issue and needs to be communicated. The GQII aims to contribute to a reliable information base for the development of QI worldwide. The authors hope that the information provided by the GQII will be a helpful reference for many actors inside and outside QI.

1

INTRODUCTION

Quality Infrastructure provides a foundation for economic development

Quality Infrastructure (QI) provides the necessary foundation for the economic development of any country. This applies to countries that have been industrialized early as well as emerging, transitional and developing countries. For this reason, international development cooperation is increasingly involved in promoting QI in the Global South.

The Global Quality Infrastructure Index (GQII) gives those responsible for QI and internation-al development cooperation an overview of the development of QI worldwide. The index and the underlying database also offer valuable information to researchers in trade and development. The index allows the QI data of an economy to be seen in context and also to compare it with that of other economies. At the same time, the GQII makes it possible to compare QI data with other global rankings such as the Economic Complexity Index (ECI).

QI is mostly known only to experts

Regardless of its importance for developing countries, the concept of QI is still a very technical niche topic that is often not well understood outside QI expert circles. Leading international organizations from the fields of metrology, standards and accreditation have only recently agreed on a definition of QI and, with the support of development organizations such as the World Bank Group and the United Nations Industrial Development Organization (UNIDO), they are promoting the establishment and expansion of National Quality Infrastructure (NQI) worldwide.

Additionally, there are various international development organizations support programmes and projects to promote QI (see Section 2.4). One such organization is the Physikalisch-Technische Bundesanstalt (PTB), the German Federal Metrology Institute. On behalf of the Federal Ministry for Economic Cooperation and Development (BMZ), the PTB promotes QI projects in partner countries of German development cooperation. Within this framework, the PTB has supported the preparation of the 2020 edition of the GQII.

The GQII is a collaborative and open-data platform for evidence-based quality infrastructure development.[1] The consulting firms Mesopartner (Germany) and Analyticar (Argentina) initiat-ed and hosted the GQII programme. It is a non-profit initiative that is open to anyone interested in the further development of QI – especially in developing and emerging countries. Experts from national, regional and international QI institutions worldwide, and consultants and repre-sentatives of development cooperation organisations with a focus on QI promotion are invited to participate.

Our idea is to promote QI data demo-cratisation access but also to boost data-driven decisions that empower QI worldwide. The GQII aims to unite people into actionable collective actors to achieve huge improvements in living conditions and to change entrenched power structures.

The GQII is becoming a platform of open and independent dialogue to critically accompany and support QI's continuous change. One focus will be on the quality and transparency of data and information on the quality infrastructure. At the same time, the authors wish to address questions about the future and strategic development of the quality infrastructure. In analogy to business intelligence (BI) (Chugh and Grandhi, 2013), the authors are looking to develop a concept of QI Intelligence.

[1] For more information see https://gqii.org

The authors have intimate knowledge of QI in many countries on five continents gained through more than a decade of consultancy work. Moreover, the authors are in constant contact with the representatives of QI institutions, their international and regional associations, and the specialized funding agencies of international development cooperation. At he same time, as ex-ternal experts, the authors have the necessary distance and global perspective to describe the development of QI neutrally.

The GQII underpins the concept of QI with reliable data. The unique feature of the GQII is that the index exclusively uses publicly accessible data from the institutions of the national quality infrastructure and their regional and international associations. The research team of Mesopartner and Analyticar has compiled the different institutions' data, curated them and made them comparable. Special thanks are due to accreditation, metrology and standards experts and those who participated in collecting and interpreting the data.

QI development correlates strongly with economic performance

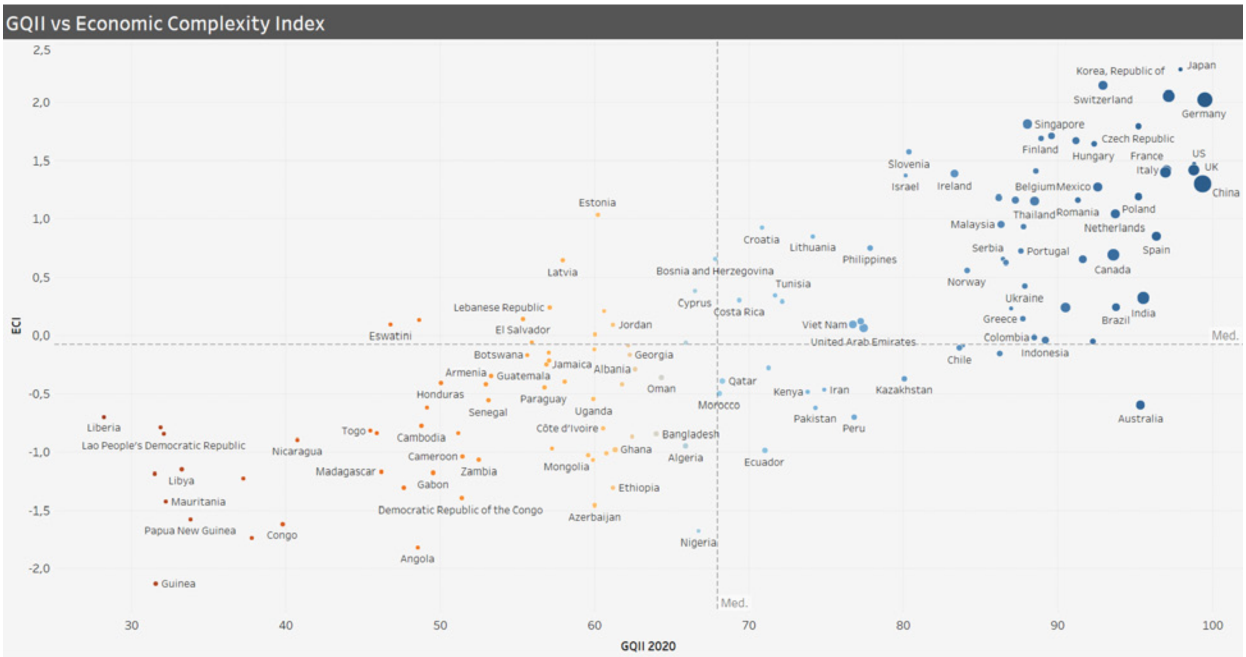
Following the common understanding, the GQII formula includes the central component of a QI system, i.e. metrology, standards and accreditation. Representing the user, the conformity assessment services are included in each component. For each component, the authors have identified key indicators to assess the state of the country's QI development. Consequently, the GQII provides metrics on QI and its components for 184 economies around the world. This allows us to assess and rank the development of the different QI elements of a country.

The authors' research on an index of international QI goes back to 2011. In that year, Ulrich Harmes-Liedtke and Juan José Oteiza Di Matteo published the first working paper on the measurement of QI. A key finding of the report was that a country's QI development status correlates strongly with its economic performance (GDP per capita), export performance and competitiveness. In a further publication (Harmes-Liedtke and Oteiza Di Mateo, 2019), the authors confirmed this correlation for the indicator of economic complexity. Again, this edition of the GQII 2020 clearly shows the strong correlation between economic development and QI.

Figure 1 shows the correlation between the development of quality infrastructure and the eco-nomic complexity of a country. The Economic Complexity Index (ECI) relies on trade data and measures the intensity of an economy in terms of the knowledge it incorporates in the products it exports. This indicator predicts economic growth (Hausmann et al, 2013) and explains inter-national variations in income inequality (Hartmann and Hidalgo, 2017). The linear correlation between GQII and ECI is significantly positive ($r = 0.79$; $p = 0.0001$). This finding supports the well-known relationship between a country's export activity and its QI.

Not only is QI more developed in economies that aggregate more knowledge in their exports, but these economies account for most of the world's export trade, which can be seen in

Figure 1 in the increasing size of the bubbles representing each economy when one looks at the cloud of dots ascending from left to right. In short, the higher the development of QI, the higher the export capacity and the higher the value-added of these products and services in terms of knowledge.



Source: https://gqii.org/. Creative Commons licence apply.
Notes: ECI from Harvard Growth Lab. Own calculations for GQII 2020. Significant Pearson linear correlation of 0,78. Size means Exports 2019 in current USD.

Figure 1: Correlation of the GQII and ECI

QI actors need to cooperate

GQII data and information is helpful for QI actors themselves as well as for international de-velopment cooperation. The strong correlation between technical QI interventions and trade promotion calls for cross-functional collaboration between actors, while so far QI interventions have been considered predominantly technical and are often implemented in isolation from each other. The report findings point to the reinforcing mechanisms between economic development interventions. A systematic embedding of QI in comprehensive development programmes is needed.

This report is divided into six chapters. The introduction (Chapter 1) is followed by introducing the concept of quality infrastructure, its evolution and its importance for economic development (Chapter 2). Next in Chapter 3, the authors explain the methodological foundations of the GQII, including its data base. They present the empirical results of the GQII in the form of rankings and maps (Chapter 4). They analyse the performance of QI in the economies in comparison to other well-known measures and rankings such as Gross Domestic Product (GDP), exports of goods and services and the Economic Complexity Index (ECI) (Chapter 5). Finally, the authors review the essential findings and provide an outlook for the further development of QI measurement worldwide.

A new feature of the GQII 2020 is the visual presentation of eight QI country profiles (Brazil, Colombia, India, Indonesia, Kenya, Morocco, Sri Lanka and Ukraine) (see Annexure). The publication of other country profiles is in progress. More information on the databases and the country profiles can be found in the GQII Programme.[2]

[2] See www.gqii.org.

2

QUALITY INFRASTRUCTURE

DEFINITION

The term Quality Infrastructure (QI) is relatively new and has so far been familiar mostly to experts working in this sector. Therefore it is crucial to explain that the term does not mean the quality of infrastructures such as roads, ports or power grids. There is no doubt that QI services are used for the quality assurance of pieces of physical infrastructure, but the meaning of the term goes much further. The term refers to the hardware and software required to assure the quality of products and services.

Quality Infrastructure describes a system that guarantees quality

QI describes a system of institutions that guarantees the definition and control of quality criteria. The main technical components of an NQI system are:

- *Standardisation* is the activity of establishing, regarding actual or potential problems, provisions for common and repeated use aimed at the achievement of the optimum degree in each context. The activity consists of the processes needed to formulate, issue and implement standards to improve the suitability of products, processes and services for the intended purpose: prevention of barriers to trade and facilitation of technological cooperation (Kellermann, 2019).
  In general, each country or economy has a single recognized national standards body (NSB) which represents the economy in ISO.
- *Metrology* is the science of measurement and its application, embracing both experimental and theoretical determination of any level of uncertainty in any field of science and technology. Metrology consists of the definition of internationally accepted units of measurement, the realization of measurement standards and the guarantee of international traceability of measurements.

A national metrology institute's (NMI) role in a country's measurement system is to conduct scientific metrology, realise base units, and maintain primary national standards. Not all countries and economies have a centralised metrology institute; some have a lead NMI and several decentralised institutes specialising in specific national standards.

- *Accreditation* is the formal attestation or statement by an independent third party (accreditation body) that a conformity assessment body is competent to carry out specific services.
  A national accreditation body (NAB) is an institution which attests to the competence and impartiality of conformity assessment bodies, according to international standards such as ISO/IEC. Some countries do have more than one accreditation body.
- *Conformity* assessment demonstrates that specified requirements of products, processes, systems, persons, or bodies are fulfilled the standards and requirements covered in the ISO/IEC 17000 conformity assessment activities. The requirements are typically stated in standards and technical regulations. The elements of conformity assessment include inspection, testing, certification, validation and verification.[3] (Kellermann, 2019).
  Different types of conformity assessment bodies (CABs) can undertake conformity assessment activities. They can come in different organisational form and ownership and can be commercial or not-for-profit entities. CABs can be government agencies, national standards bodies, trade associations, consumer organisations, or private or publicly owned companies.[4]

Figure 2 shows in the centre the main components of a NQI system (accreditation, standardization and metrology, certification, testing and inspection)[5]. The individual components exchange services and form an overall system. On the right-hand side, international recognition is represented by membership in international professional organizations. On the left-hand side, the users of the system emerge in the form of a value chain. QI thus creates trust between trading partners and promotes cooperation between enterprises and support organisations.

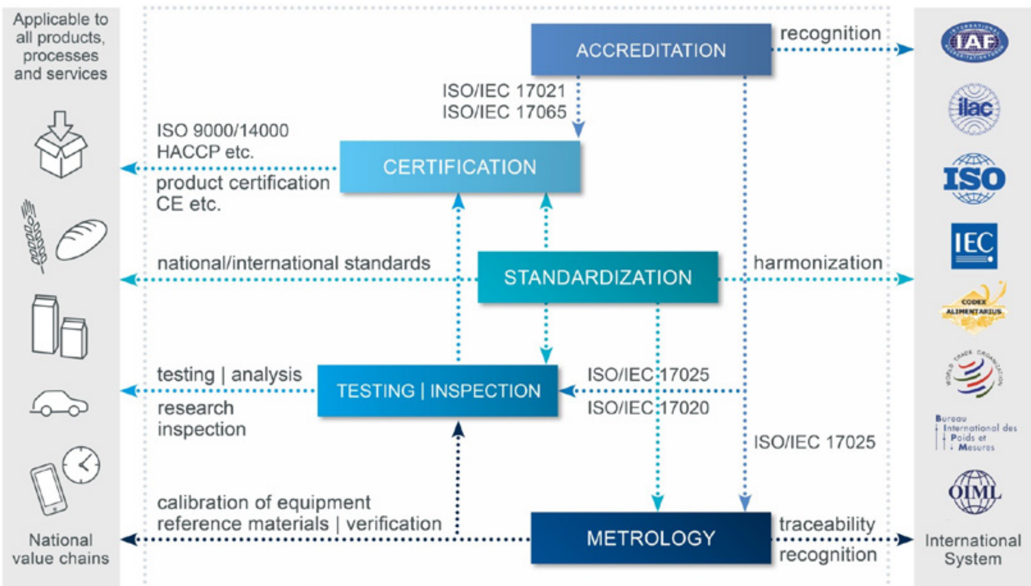


Figure 2: National Quality Infrastructure System[6]

[3] Sometimes calibration is considered a conformity assessment, but it is not. Calibration belongs within the metrology environment.
[4] https://casco.iso.org/bodies.html.
[5] In contrast to the broad definition of QI by the INetQI,
[6] Reference: Physikalisch-Technische Bundesanstalt (PTB).
[7] https://www.bipm.org/utils/common/pdf/QI-definition.pdf (Retrieved 13/03/2021)
Figure 2, as well as the GQII, does not include market surveillance. Nevertheless, the GQII includes the legally regulated area through the counting of conformity assessment bodies.

QI institutions can be seen as the underlying foundation of international trade. Developed quality infrastructure is a prerequisite for developing countries to access international markets according to modern principles. Even though many products and services produced in developing countries may be of high quality, it is still difficult for developing countries to market their products and services internationally if the national quality infrastructure does not function satisfactorily and according to international best practice. Similar to the physical infrastructure, the provision of QI is considered a public task. In many countries, however, various QI services are provided by private and non-profit organizations.

QI is a critical element for sustainable development and wellbeing

The leading international institutions and promoters of QI have recently developed a formal definition of this concept. In 2017, this definition was endorsed by the international organizations for metrology (the BIPM and the OIML), standards (ISO, IEC and ITU) and accreditation (IAF and ILAC), and by the International Trade Centre (ITC), the United Nations Industrial Development Organization (UNIDO), the United Nations Economic Commission for Europe (UNECE) and the World Bank within the framework of the International Network on Quality Infrastructure (INetQI) cooperation network. Here QI is defined as:

"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 Quality Infrastructure is required for the effective operation of domestic markets, and its international recognition is essential to enable access to foreign markets. It is a critical element in promoting and sustaining economic development and environmental and social wellbeing. It relies on metrology, standardization, accreditation, conformity assessment, and market surveillance (in regulated areas)[7]".

QI replaces the previously used acronym MSTQ (Metrology, Standards, Testing and Quality) with SQAM (Standards, Quality Assurance, Accreditation and Metrology).

The new definition from 2017 represents an extension of the scope of QI. In the past, QI was mainly seen as an instrument of trade facilitation. Today's understanding of QI relates strongly to health, environmental and consumer protection. QI aims to contribute to a comprehensive culture of quality and general wellbeing.

QI IN EVOLUTION

Prehistory of measurements and standards

The origins of metrology and standardisation go back to the beginnings of global historiog-raphy. Standard weights and measures were developed as early as the Bronze Age by the Indus civilisation in the north-west of the Indian subcontinent. The centralised system of weights and measures served the commercial interests of Indus Valley traders, as smaller weight measures were used to measure luxury goods, whereas larger weights were used to purchase bulkier items, such as food grains. Technical standardisation enabled the effective use of measuring instruments for measuring angles and taking measurements in construction.[8]

Independently, other advanced civilisations in different parts of the world developed their sys-tems of measurement and standardisation. The ancient Egyptians based their measurements on the royal cubit Meh, for which the pharaoh provided a prototype made of granite.[9] In ancient China, the Shi was considered the basic unit of weight. Shi Huang Di, China's first emperor, standardised the rules for determining the basic units in 221 BC and created the shi.[10] In what is now Mexico, the Maya used a measurement system, the Zapal, to build their cultural cities of Uxmal, Kabah and Chichén Itzáetwa.[11] Other civilised peoples also developed comparable methods of measurement to facilitate trade.

Beginning of modern metrology and standardisation

Today's QI origins go back to the Industrial Revolution in the second half of the 18th century. During this time, economic and social conditions, and working and living conditions changed profoundly and permanently, starting in England, expanding to Western Europe and the United States (US). Since the 19th century, also in Japan and other parts of Europe and Asia, the Industrial Revolution led to the transition from agricultural to industrial societies.

The new, more complex production methods brought with them specific risks. Exploding steam boilers, for example, led industrialists in Germany to set up technical inspection associations (TÜV),[12] which have established themselves as internationally active conformity assessment providers to this day. Here the reader can see the origins of today's use called QI services to guarantee safety and occupational health.

At the beginning of the 20th century, the lack of harmonisation of standards hindered emerging international trade. In response, engineers started to form national standardization bodies. The first national standardization body was the British Standards Institution (BSI) in England (1901),[13] followed by the American National Standards Institute (NIST) in 1901, the German Institute for Standardization (today DIN) in 1917, and the French Commission Permanente de Standardization (today AFNOR) in 1926.

Already at the beginning of the 20th century, the need for international harmonization of standards became apparent. In 1906, the International Electrotechnical Commission (IEC) was founded as the first international standards organization. This was followed in 1926 by the International Federation of the National Standardizing Associations (ISA) to promote international cooperation for all technical standards and specifications, the predecessor of today's International Organization for Standardization (ISO).

8 https://www.khanacademy.org/humanities/world-history/world-history-beginnings/ancient-india/a/the-indus-river-valley-civilizations (Retrieved 13/03/2021)
9 https://teqegypt.com/history-of-metrology/ (Retrieved 13/03/2021)
10 http://www.chinadaily.com.cn/a/201802/10/WS5a7e1a59a3106e7dcc13be7c.html (Retrieved 13/03/2021)
11 https://www.cambridge.org/core/journals/american-antiquity/article/abs/an-ancient-maya-measurement-system/70084796C4CD27D02961F033BB87E8EA#article (Retrieved 13/03/2021)
12 https://www.tuvsud.com/en/about-us/history/our-foundation-years-1866-1900 (Retrieved 13/03/2021)
13 https://www.bsigroup.com/en-GB/about-bsi/our-history/ (Retrieved 13/03/2021)

An international quality system requires comparable measurements. Consequently, on 20 May 1875, seventeen countries agreed on a metric system of measurement and set up their own insti-tution, the International Bureau of Weights and Measures (Bureau International des Poids et Mesures, or BIPM).[14] This was the first international scientific institution ever, and it has been coordinated since than by the International System (IS). In the following years, signatory states of the Metre Convention established national metrology institutes. Today's PTB (founded as the PTR in 1887)[15] in Germany and the NIST (1901)[16] in the United States were among the pio-neers. Other countries followed. Today, the BIPM has sixty-three Member States and forty Associate States and Economies.[17]

Accreditation connects the quality infrastructure system

Accreditation is the youngest type of institution of the QI system. The origins of accreditation go back to the period after World War II. In 1947, the Australian National Association of Testing Authorities (NATA) was founded to ensure that ammunition in Australia met high standards.[18] Therefore NATA is often referred to as the oldest national accreditation body, although this role was not formalized until 1988 through a Memorandum of Understanding (MoU) with the Australian Government. In the 1960s and 1970s, other countries also established accreditation bodies. These countries convened in 1977 at a conference in Copenhagen, and founded the International Laboratory Accreditation Cooperation (ILAC). Since then, the international accreditation community has followed the slogan "Accredited once, accepted everywhere".

With accreditation, test and other conformity assessment results are comparable, and multiple assessments are avoided. Thus the costs of conformity assessment are reduced. Today, the accreditation bodies of more than a hundred countries are internationally recognized. Two international organizations are responsible for multilateral recognition of the accreditation of conformity assessment bodies:

(1) The International Laboratory Accreditation Cooperation (ILAC) is the international organization for accreditation bodies responsible for the accreditation of calibration and testing laboratories, medical laboratories, inspection bodies, proficiency testing providers and reference material producers.

(2) The International Accreditation Forum, Inc. (IAF) is the world association for accredita-tion bodies in management systems, products, services, personnel, and other similar certification programmes as well as verification and validation programmes.

Both organizations cooperate closely, and at the Joint General Assembly in Frankfurt/Main in October 2019 they decided to merge.[19] The result will be a worldwide uniform and more efficient system for managing the accreditation global recognition arrangement.

Part of the international cooperations are the regional accreditation cooperations (APLAC, ARAC, AFRAC, IAAC, EA and SADCA), which bring together all ABs are MLA signatories in differents accreditations schemes. These regional groups offer discussion space, harmonize concepts, give guidelines to the correct operation of the AB, and ensures they accomplished all the requirements established in ISO/IEC 17001 for the accreditation process development. The recognition by these regional groups is the first step to achieve the MLA with IAF or ILAC.

The authors see accreditation as a catalyst for the QI system.

14 https://www.bipm.org/en/worldwide-metrology/metre-convention/ (Retrieved 13/03/2021)
15 https://www.ptb.de/cms/fileadmin/internet/presse_aktuelles/broschueren/geschichte_ptb/PTR_and_PTB_History_of_an_Institution.pdf (Retrieved 13/03/2021)
16 https://www.nist.gov/history (Retrieved 13/03/2021)
17 See https://www.bipm.org/en/about-us/member-states/ (Retrieved 13/03/2021)
18 NATA (2017). Celebrating 70 years, Sydney.
19 https://ilac.org/about-ilac/partnerships/international-partners/iaf/ (Retrieved 13/03/2021)

Integration of a system

Regarding the components of QI as a system is more recent. In the 1990s, experts began to use combinations of letters such as MSTQ (metrology, standards, testing, quality assurance) or SQAM (standards, quality assurance, accreditation and measurement) to describe the system (BMZ, 2004; NEDLAC, 2001). Others favoured the term National Quality System (Guasch et al., 2007; Frota et al., 2010). Only later, as described above, did the current term Quality Infra-structure emerge and gain international acceptance.

The development of the QI concept is closely related to the institutionalization of global trade within the framework of the World Trade Organization (WTO). For barrier-free trade, it is nec-essary that trading partners mutually recognize the procedures and results of conformity assessment. In 1995, during the Uruguay Round, WTO members agreed on the elimination of technical trade barriers. The Agreement on Technical Barriers to Trade (TBT) calls on countries to actively recognize the results of other countries' conformity assessments such as testing, examination, inspection, calibration, verification and certification. Crucial here is accred-itation bodies' role in establishing trust between trading partners and thus offering a passport to global trade. The international associations for accreditation provide the appropriate framework with the Mutual Recognition Arrangements (ILAC-MRA) and the Multilateral Recognition Arrangements (IAF-MLA) (de Brito et al., 2016).

Accompanying four industrial revolutions

The technological development of the last hundred-and-fifty years has significantly shaped QI. Its beginnings lie, as described, in the first Industrial Revolution from today's perspective. Its focus was on the mastery of steam engines and mechanics.

The second industrial revolution with is mass production demanded metrics, standards and con-formity assessment for electrification and chemistry. Biological and chemical test laboratories were needed, and a whole new metrology field emerged with chemical metrology (Sargent et al., 2019).

Computer technology triggered the automation of production processes and with it the third industrial revolution. During this time management demands increased, to which the standardization institutes responded with the development of quality management systems.

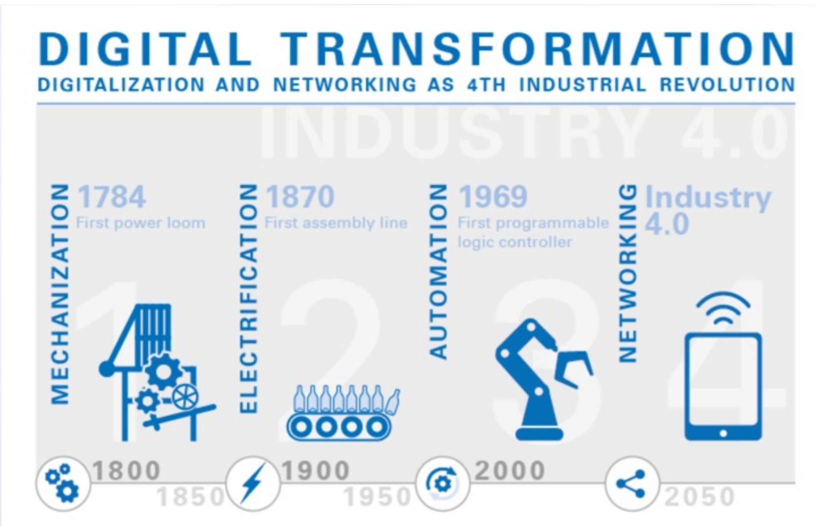


Figure 3: Four industrial revolutions[20]

[20] TÜV Rheinland/ Techvision, https://www.tuv.com/landingpage/de/countdown-to-the-future/

Quality Infrastructure 4.0

Today we are in the midst of a fundamental transformation that will radically change how we live, work and interact with each other. This transformation began before COVID-19 but has accelerated through the pandemic. Klaus Schwab, the founder and Executive Chairman of the World Economic Forum, speaks in this context of a "Fourth Industrial Revolution" (Schwab, 2017), which will be in its scale, scope and complexity a transformation unlike anything humanity has ever experienced. Although we do not know yet precisely how it will unfold, the expected changes must be integrated comprehensively and inclusively.

The Fourth Industrial Revolution differs from its predecessors in speed, scope and impact on systems. Moreover, this revolution will affect almost every industry in every country. The breadth and depth of these changes mark the transformation of the entire production, management and leadership systems.

The Fourth Industrial Revolution in turn requires Quality Infrastructure (QI) to adapt in all its areas:

- Metrology 4.0: Researchers and technicians are working on various projects for the digitalization of metrology. Industrial metrology is developing a machine-readable calibration certificate and the corresponding infrastructure, which will enable calibration labor-atories and companies to exchange related certificates digitally (Hackel et al., 2017). In legal metrology, metrology supports industry and market surveillance authorities in smart metering and the measurement of e-mobility. At the same time, European Metrology Institutes are working to create a metrology cloud that supports traceability and verification of measurements.[21]
- Standardization 4.0: Equally, standardization focuses on digitization. The networking of devices, machines and people via the Internet is causing dynamically growing data traffic. Therefore an internationally agreed standard that allows intelligent integration of systems across all domains and hierarchies is needed. Industry 4.0 can only become a reality if digitalization and standardization go hand in hand. The International Standards Organization (ISO) and the International Electro-technical Commission (IEC) have established the Smart Manufacturing Coordinating Committee (SMCC). The Committee promotes the international exchange of information and works on the mapping of smart manufacturing standards. Other standards committees deal with automation systems and integration (ISO/TC 184), artificial intelligence (ISO/IEC JTC 1 SC 42) and robotics (ISO/TC 299). Together the various standard initiatives provide the framework for global digital value chains. Strategic fields of action are the autonomy, interoperability and sustainability of the industrial ecosystem of the future.[22]
- Accreditation 4.0: The opportunities for Industry 4.0 employment matter also for conformity assessment and accreditation.[23] For example, the accreditation body in the UK (UKAS) sees opportunities to strengthen their role and that of the testing, inspection and certification (TIC) industry as a "trusted partner" in the networking of value chains and at the same time to be a driving force for new technologies. Accreditation underpins confidence in systems and software for automation, mobile payments or driverless cars and contributes to the responsible handling of

[21] Thiel, 2018. Opens external link in new window - Digital transformation of legal metrology - The European Metrology Cloud, OIML Bulletin, vol. LIX, 2018(1), pp. 10-21, https://www.oiml.org/en/publications/bulletin/pdf/oiml_bulletin_jan_2018.pdf (Retrieved 13/03/2021).

[22] ISO 2018. The new Industrial Revolution, ISO focus, November-December 2018, Number 131, https://www.iso.org/files/live/sites/isoorg/files/news/magazine/ISOfocus%20(2013-NOW)/en/2018/ISOfocus_131/ISOfocus_131_en.pdf. (Retrieved 13/03/2021)

confidential information and data protection. Conformity assessment bodies are already active in information and cybersecurity, eGaming, digital forensics and software testing. Some accredited certification and inspection bodies have already developed cloud-based systems to provide better insight into customers and their supply chains.[24]

The examples from metrology, standardization and accreditation show that all areas of QI are intensively integrating the concept of Industry 4.0 and are participating in the digital transfor-mation.

Digitalization requires that the QI institutions restructure themselves internally and change their services and how they are fundamentally delivered. As a result, QI will gain flexibility, interop-erability and speed. The next challenge is to relate and integrate the activities in the different components more closely. QI 4.0 would have to focus precisely on the system's integration, integrity and interoperability.

Technology impacts, environmental movements and rebooting of QI

Unintended effects are part of technological development. During the first Industrial Revolution, industrial accidents were rapidly increasing, as illustrated by exploding steam boilers. In the course of the second Industrial Revolution, catastrophes such as the dioxin accident in Seveso (1976) or the fatal toxic gas cloud in Bhopal (1984) or the nuclear disaster in Chernobyl (1986) remain in sad memory. As a reaction to these catastrophes, an environmental movement first emerged in the industrialized countries, which sought to persuade the chemical industry and society to act sustainably without polluting the environment.

As a result of this social pressure, governments of industrialized countries began to tighten environmental and occupational health and safety regulations. Consequently, QI facilities were challenged to use their services more for clean and environmentally friendly production. Moreover, companies were becoming more aware of their social and environmental responsibilities through self-regulation. Standards for Corporate Social Responsibility (CSR) such as ISO 26000 and the emergence of private sustainability standards (Potts et al., 2014) express this trend.

In today's time of the Covid-19 pandemic and climate change, many are questioning our current economic model, including global trade. In the face of planetary boundaries, global social issues and the current COVID crisis, it is not enough for companies to strive for quality and competitiveness alone. The challenge is to establish a socially, ecologically and economically sustainable model. Paradigms of CO2 neutrality or the Circular Economy are the new guiding principles.

This means that the QI institutions must realign their understanding and service offerings. Institutions such as the United Nations Industrial Development Organization (UNIDO) are therefore calling for a rebooting of QI: "QI is a marvellous tool for improving economic develop-ment. QI needs to evolve - and swiftly - to be relevant in the face of ever more rapid techno-logical innovations and the threats posed by climate change pollution, diminution of resources and destruction of the biosphere." (UNIDO, 2020). Today, QI needs to and can contribute to the three pillars - people, prosperity and planet - of the United Nations' Sustainable Development Goals (SDGs) by reorientating its knowledge and tools to the broader development ap-proach.

[23] Bohun, 2019. Accreditation 4.0: Adapting to a new revolution, Blog post https://www.quality.org/knowledge/accreditation-40-adapting-new-revolution.
[24] Deshpande, Stewart, Lepetit, Gunashekar, 2017. Distributed Ledger Technologies/Blockchain: Challenges, opportunities and the prospects for standards, May 2017.
Prepared for the British Standards Institution (BSI), London, https://www.bsigroup.com/LocalFiles/zh-tw/InfoSec-newsletter/No201706/download/BSI_Blockchain_DLT_Web.pdf (Retrieved 13/03/2021)
[25] https://www.tuev-nord.de/explore/en/explains/from-duev-to-tuev/

QI AND DEVELOPMENT

Modern QI originated in the Northern Hemisphere

The development of QI is closely linked to the development of trade relations between different countries. Economies of the Northern Hemisphere started to develop metrology, standards and conformity assessment even during the early phase of industrialization. Due to the dynamically growing trade links, these countries were required to harmonize their respective systems.

In the Southern Hemisphere, QI started to develop much later, mainly from the second half of the 20th century. The main reason for their lagging behind was due to colonial trade structures. The countries of the Northern Hemisphere dominated the trade flows using their domestic standards and measurement procedures. The colonial powers only built up, if it did so at all, rudimentary institutions for food and drug control in their colonies.

However, it is striking that some Global South (GS) countries, specifically in South America (Argentina, Brazil, Peru and Venezuela), were among the first signatories to the 1875 Metre Convention.[26] However, the early industrialization of these countries failed, which was reflected in a discontinuity in establishing a national QI. It was only in the second half of the 20th century that Southern Hemisphere countries started to establish their own National Metrology Institutes (NMIs), National Standards Bodies (NSB) and much later National Accreditation Bodies (NAB). This was in response to the increasing political independence and diversification of trade relations of the Southern Hemisphere countries. The Northern Hemisphere countries supported this institution building, as they were interested in establishing an equivalent quality system with their emerging trading partners.

Today the existence of a national QI is a necessary condition for participation in international trade. More and more countries of the Global South are now becoming members of the World Trade Organization (WTO). Their QI institutions are members of international professional organizations and signatories of mutual recognition agreements (de Brito et al., 2016). At the same time, many countries of the Global South faced with the decision as to whether to align their trading systems with the high standards of the North or whether to benefit from cheap imports from China and Southeast Asia. The question arises as to whether the high standards for exports should also apply to the local market.

The asymmetry between countries of the Global North and South

Today although there is still considerable asymmetry between countries in the Northern and Southern hemispheres, both have equal technical competence. In the National Metrology Institutes (NMI) field, the Global South has reached world-class competence in metrology. It is represented on the Consultative Committees of the International Committee for Weights and Measures (CIPM). These committees bring together the world's experts in their specified fields as advisers on scientific and technical matters. Among the tasks of these committees is the detailed consideration of advances in physics that directly influence metrology, the preparation of recommendations for discussion at the International Committee for Weights and Measures (CIPM), the identification, planning and execution of key comparisons of national measurement standards, and the provision of advice to the CIPM on the scientific work in the laboratories of the BIPM.[27] An outstanding example is the Korea Research Institute of Standards and Science (KRISS) in South Korea,[28] which today stands for international excellence at a similar level as its tutors from the US and Germany (Choi, 2013, Choi et al., 2014). NMIs from other larger economies such as Argentina, Brazil, China, India, Mexico, and South Africa are also represented on the CIPM's Consultative Committees.

Concerning the current debates on post-colonialism (Young, 2020), we can ask to what extent the development of QI in the countries of the Global South differs or should differ from that of the North. Is the development of QI in the countries of the Global South solely a matter of catching up, or does it require unique strategies geared to the specific characteristics of the Global South countries?

[26] BIPM, The first 17, Sèvres/ France, https://www.bipm.org/en/about-us/member-states/original_seventeen.html. (Retrieved 13/03/2021)

Unique challenges for QI in the Global South

Quality Infrastructure in the countries of the Global South often faces unique challenges:

- Funds for research and development are scarce, so that QI bodies must finance them-selves or depend on international development cooperation support.
- QI is geared primarily to the export of the industry's needs, so there is a duality between high standards for exports and low standards for domestic consumers.
- The private sector is weakly organized so that the state is more prone to intervene in the market. In this respect, there is often a preference for technical regulations, whereas in-dustry self-regulation is weaker.
- The dominant micro and small enterprise sectors and the usually large informal sector hardly benefit from the services provided by the country's quality infrastructure.
- International service providers dominate the field of conformity assessment.

These structural characteristics limit the possibility of merely transferring best practices from the industrialized countries of the North to those of the South. Besides, QI in countries of the Global North has developed considerably over the past decades, and the development gap between the North and South has grown significantly. This often creates additional difficulties for the transfer of experience. For example, in the 1970s and 1980s, it was easy for researchers and technical experts of National Metrology Institutes (NMIs) from developing countries to acquire their skills in laboratories of the National Institute of Standards and Technology (NIST) or the Physikalisch-Technische Bundesanstalt (PTB) and to implement them in their countries' laboratories after returning home.[29] Today, however, the laboratories of the North have achieved a technical sophistication that makes it nearly impossible for newcomer countries to catch up quickly.

There is a saying that "one should not measure with the maximum accuracy, but with the necessary accuracy". This means that NMIs must have the capacity to meet the level of accuracy required by their industry and trade. For example, to measure time with today's possible highest accuracy of 10^{15}, or 1 second in about 30 million years,[30] is not necessary for countries that lack a defence or space industry.

[27] BIPM, The role of the Consultative Committees, Webpage [Retrieved 07/12/2020], https://www.bipm.org/en/committees/cc/cipm-consultative-committees.html. (Retrieved 13/03/2021)

[28] Like other East Asian countries, South Korea has shifted its development from a country of the global South to the North, see https://www.encyclopedia.com/social-sciences/applied-and-social-sciences-magazines/north-and-south-global (Retrieved 13/03/2021)

[29] Kellermann, M. (2019). QI Toolkit Case Studies. Case Brazil, Washington D.C.

South-South and Triangular Cooperation

South-South cooperation is taking on a new function in technology transfer. The developing countries of the Southern Hemisphere are now able to pass on their experience to their neigh-bours and even to countries on other continents (see, for example, the cooperation of the Brazilian National Institute of Metrology, Standardization and Industrial Quality (INMETRO) with Portuguese-speaking countries in Africa).[31] Many countries of the South now operate their own international cooperation departments and programmes. At the same time, the countries of the North support South-South cooperation in the field of QI in the context of so-called Triangular cooperation.

Finally, there are also areas which are new to all countries. The application of the knowledge and tools of QI to combat climate change, preserve biodiversity and digitize the economy and society are all relatively new topics for the actors in QI. Here countries of the Global South could be among the pioneers and leapfrog development. At the same time, new developments affect the South differently and require solution strategies adapted to their respective conditions.

Development cooperation for QI in developing economies

QI is an emerging theme for international development cooperation. A study by the World Bank Group (WBG) shows the growing interest in international development cooperation in QI.[32]

The WBG surveyed fourteen international bilateral and multilateral development partners be-tween December 2019 and March 2020, seven of which responded. The total annual funding of all respondents is US$253 million.

The respondents have supported QI programmes in 143 countries. Regions benefiting from QI programmes are South Asia (86%), Africa (79%), East Asia-Pacific (71%), Latin America and the Caribbean (57%), Middle East-North Africa (50%) and East Central Asia (50%).

Standards reform is the dominant QI area for development work (79%), followed by metrology (64%), accreditation (64%), technical regulations (64%), TBT agreement implementation (64%), inspection (57%), certification (57%), testing (50%) and market surveillance (43%).

Capacity-building and training programmes account for most support (93%), while technical assistance and advisory services receive 86% support. Other types of support include financial aid (loans or grants, 57%), knowledge, analysis and diagnostic studies (57%) and hard infra-structure (29%).

There are increasing opportunities to support QI development in middle and low-income countries. In implementing the WBG's QI programmes, it was noted that governments had recognized the importance of developing practical, efficient and internationally recognized QI services: for governments, a QI system strengthens relevant trade and industrial policies and ensures compliance with mandatory technical regulations and sanitary and phytosanitary (SPS) measures; for businesses, a modern, efficient QI system helps contain production costs, increases productivity and technology transfer, and enables firms to be more competitive in domestic and foreign markets; for consumers, a QI system ensures public health and safety and environmental and consumer protection.

During the Covid-19 pandemic, the authors observed a particular focus on QI promotion in products and services in the medical sector. Advanced QI services and mutual recognition ar-rangements between trading partners are fundamental to governments' efforts to provide needed medical products and ensure food safety in the most efficient, effective and sustainable way.

[30] Bauch, A. (2012). Time – the SI Base Unit "Second", In: Special Issue/PTB-Mitteilungen 122 (2012), No. 1 (Retrieved 13/03/2021)

[31] Pace Alves, L. (2013). Triangular Technical Cooperation and the role of INMETRO; In: Austral: Brazilian Journal of Strategy & International Relations, v.2, n.4, Jul-Dec. 2013, p.117-139

[32] https://iaf.news/2020/06/30/quality-infrastructure-qi-a-rising-topic-for-development/ (Retrieved 13/03/2021)

QI AND DATA

Statistical data on the development status of QI is still lacking

The GQII provides curated data on the development of quality infrastructure in 184 economies. The index thus includes all industrialized and developing countries. This information platform is intended to serve quality infrastructure managers, policymakers and users of QI services. At the same time, the authors see the GQII as a source of information for donors and international development cooperation programmes that want to monitor the impact of their support and the development progress of QI in partner countries.

Today QI facilities are part of the necessary institutional landscape of sovereign states. In recent decades, developing and emerging countries have established metrology and standardization institutes and often accreditation bodies or focal points. There is anecdotal evidence but not suf-ficient statistical data to prove this development. The GQII programme aims to close this infor-mation gap, but the accreditation community needs to improve the transparency and comparabil-ity of their statistical data.

Despite this progress in the institutional field, a reliable database and indicators to illustrate or compare a country's QI development status are still lacking. Although international, regional and national QI institutions provide data, these only refer to the individual components and never to QI as a whole. Moreover, as will be seen in the following chapters of this report, data quality varies widely as does its availability, and is not always user-friendly.

The authors systematically validated the information during data collection and analysis by comparing the data with their previous publications. If there were significant discrepancies in the data in one area, the authors first checked their count or consulted the institution in question. Studying publications or consulting QI experts helped them to interpret the data in the best pos-sible way.

The reservoir for QI intelligence remains untapped

At the dawn of the digital age with artificial intelligence (AI), Big Data, Blockchain-based de-velopments and the Internet of Things (IoT), QI institutions are challenged in many ways. Covid-19 has already been a catalyst for remote auditing and virtual meetings of the standards committees. However, the challenges are certainly greater and require a systematic approach to collecting and strategically using data.

So far, accreditation bodies have mainly used their data to prove that conformity assessment bodies are competent in their scope of the accreditation they award. At the same time, this in-formation remains unused mainly for prospective purposes. There is even less exchange of data and information between QI institutions, so it remains neglected for the purpose of joint strate-gizing. Like business intelligence (Chugh and Grandhi, 2013), the authors see an untapped res-ervoir of QI intelligence, i.e. a technology-driven process for analysing data and presenting actionable information to QI leaders and users.

3

MEASURING QUALITY INFRASTRUCTURE

THE METHODOLOGY OF THE GQII

The GQII is a composite indicator

The Joint Research Centre of the European Commission (JRG) and the Organisation for Economic Co-operation and Development (OECD) see composite indicators (CIs) that compare the performance of countries as increasingly useful tools in policy analysis and public communication (Joint Research Centre-European Commission and OECD, 2008). Composite indicators are now attracting considerable interest in comparing and ranking countries' performance in areas such as industrial competitiveness, sustainable development, globalisation and innovation.

It often seems easier for the public to interpret composite indicators than to identify common trends across many separate indicators. They have also proven useful for benchmarking country performance. Allergens Composite indicators can also send misleading policy messages if they are poorly constructed or misinterpreted. In particular, their "big picture" results can mislead policymakers into drawing simplistic analytical or policy conclusions. In this respect, composite indicators should be seen as a means to stimulate discussion and arouse public interest. Their relevance should be assessed in terms of the groups and organisations affected by the composite index.

The GQII provides a composite indicator for the QI domain. In constructing the GQII, the authors were inspired by the Handbook on Constructing Composite Indicators (Joint Research Centre-European Commission and OECD, 2008).

The GQII measures the relative level of QI development in an economy

The GQII follows a systemic approach illustrated above in Figure 2, and measures the level of QI development in developed and developing economies. For this purpose, the authors collect and analyse data from national and international organizations for metrology, standardization, accreditation and conformity assessment.

The authors have identified indicators for each component and for the connections between the components of the NQP. Some indicators refer to the international recognition of the QI bodies. Others refer to the service supplier's scope or the demand for accredited conformity assessment bodies of the numbers of enterprises with a certified management system. Together the indicators provide a measure of the level of QI development in a given economy.

The GQII uses only published data from QI institutions

According to the Handbook on Constructing Composite Indicators, "… overall quality of composite indicators depends on two aspects: the quality of basic data, and the quality of procedures used to build and disseminate the composite indicator" (Joint Research Centre-European Commission and OECD, 2008).

The GQII builds on data published on international and national QI organizations' websites. Therefore the validity of the GQII is limited to the availability and quality of the data provided by the QI organizations. The cured raw data is freely available and downloadable on the GQII website.[33]

[33] See https://gqii.org.
[34] https://www.intra-afrac.com/News%20Attachments/PAQI_TBT_Stocktaking_2020_En_WEB.pdf. (Retrieved 13/03/2021)

The attractiveness of the GQII undoubtedly lies in its global reach. In this context, the authors would like to mention a parallel project to measure the development of quality infrastructure in Africa.[34] The regional organization of Pan-African Quality Infrastructure (PAQI) produced a so-called stocktaking instrument for the development of QI in 55 African countries in 2014, 2017 and 2020. Using the traffic light colours (green, yellow and red), the document illustrates the development status of QI in the countries in general and in the different QI components. The strengths of this approach are the validation of the information by representatives of the regional organizations for metrology, standardization and accreditation, and the presentation of the development over time. In contrast to the GQII, however, the PAQI method is only indi-rectly based on published data. Both ways are complementary, and the results are highly comparable.

The GQII is based on earlier versions from 2011 and 2019 when the authors began to evaluate and compare the data on QI development (Harmes-Liedtke and Oteiza Di Matteo, 2011; Harmes-Liedtke and Oteiza Di Mateo, 2019). Our approach was widely received in the following years, discussed and cited by QI experts and researchers.[35] Overall, feedback from the preliminary studies was encouraging, and the critique helped the authors to substantially improve the validity and scope of the GQII. Their aim in this report is also to explain the context and the method in detail and in a generally understandable way.

Critique and limitations of GQII

The authors would like to mention that some experts have expressed some fundamental criticisms and concerns about the GQII: One criticism relates to the ranking of economies per se. Table 1 gives an overview of the gen-eral debate on the pros and cons of composite indicators. Basically, there are two views of whether it makes sense to combine indicators in some way to produce aggregate statistics. One view is that such summary statistics can indeed capture reality and are meaningful, and that em-phasising the bottom line is extremely useful in attracting media interest and policymakers' attention. Critics see the combination of weighting variables as arbitrary and prefer the use of individual data sources. Ultimately, however, the appeal of composite indicators and rankings summarises complex and sometimes elusive processes into a single number to assess a country's performance for policy use.

Table 1: Pros and cons of composite indicators

PROS	CONS
• Can summarise complex, multi-dimensional realities to support decision-makers. • Are easier to interpret than a battery of many separate indicators. • Can assess the progress of countries over time. • Reduce the visible size of a set of indicators without dropping the underlying information base. • Thus make it possible to include more information within the existing size limit. • Place issues of country performance and progress at the centre of the policy arena. • Facilitate communication with the general public (i.e. citizens, media, etc.) and promote accountability. • Help to construct/underpin narratives for lay and literate audiences. • Enable users to compare complex dimen-sions effectively.	• May send misleading policy messages if poorly constructed or misinterpreted. • May invite simplistic policy conclusions. • May be misused, e.g. to support the desired policy, if the construction process is not transparent and lacks sound statistical or conceptual principles. • The selection of indicators and weights could be the subject of political dispute. • May disguise severe failings in some di-mensions and increase the difficulty of iden-tifying proper remedial action if the con-struction process is not transparent. • May lead to inappropriate policies if dimensions of performance that are difficult to measure are ignored.

Source: JRC and OECD, 2008, p 13f.

[35] See Acknowledgements.

In the case of the GQII, the ranking could be misunderstood to mean that all countries should aim for the highest possible level of QI. At the same time, there could be incentives to influence certain indicators in order to achieve a better ranking (gaming). This criticism is undoubtedly justified, but in principle it can be applied to any ranking. Due to the selection of different data sources, the authors see the possibilities of gaming as very difficult. Even if an economy strengthens only one component of its QI, this is reflected in the strengthening of the entire QI system.

Other points of criticism relate to the significance of the data itself. For example, the number of calibration and measurement capabilities (CMC) alone is only a limited reflection of a country's metrology performance. Experts also doubted that the number of accredited conformity assess-ment bodies is an essential indicator of a national accreditation body's performance. When read-ing the GQII, readers should not interpret higher values as fundamentally "better" but instead see the ranking in the context of the respective economy's development.

Another point relates to the significance of the index. The index shows the relative development status of the QI in a specific economy. This says nothing about whether the provision of QI services is appropriate to the level of development of the economy or the demand of local busi-nesses. However, the strong correlations with exports and economic complexity (see Chapter 5) show that the QI development of a country usually corresponds to its economic capabilities.

Although all these points of criticism are justified, the authors would like to point out that inter-national and national QI organisations do use some of the GQII data, e.g. to prove the increas-ing importance of certain QI services. The advantage of the present study is that the different data are placed in an international context and are made comparable with each other. The alloca-tion of QI data to the unit of a (national) economy is also significant because this level contin-ues to be the central reference for all studies on trade and development.

At the same time, the numbers of the GQII must be interpreted in each specific context and need to be combined with qualitative information. The GQII does not claim to map QI world-wide precisely, but serves as the best proxy to map the development of the National Quality Infrastructure system.

Beyond the debate on ranking, all experts consulted agreed that more systematic use of data is of great importance for further developing QI. The GQII database offers the possibility for spe-cific analyses, e.g. looking at the global distribution of new accreditation schemes. Here the authors see substantial input for what they call QI Intelligence in the future. Here the authors are referring to the concept of business intelligence used in a corporate context, which supports the systematic collection and processing of acquired information. Thus QI Intelligence means that QI institutions share their data for the purpose of prospecting and for the evidence-based underpinning of their joint strategic planning. Concrete tools could be QI development dash-boards or market research studies. Basically it is about QI bodies being able to identify future trends and needs at an early stage and to proactively support economic and social development.

GEOGRAPHICAL COVERAGE

The GQII covers almost all economies in the world

In line with the practice of the accreditation community, the authors use the term economies because the GQII counts data not only from sovereign states but also from territorial entities without recognized statehood (such as Kosovo, Palestine or Hong Kong, Macao and Taiwan, the last three being counted as part of "One China").

In naming the economies, the authors use the country code ISO 3166 and use the standardized abbreviations. Since the BIPM, among others, calls the economies by different names in some cases, the authors have harmonized the names based on the ISO standard.

Table 2: Membership of international organizations and coverage of the GQII
Sources: Website of organizations

Organization	UN	GQII	ISO	WTO	ILAC-MRA	IAF-MLA	BIPM
Members/Economies	193	184	165	164	102	85	63

The number of economies included goes far beyond the members of the international QI organizations (see Table 2). In previous studies, the authors essentially limited themselves to the signatories of the IAF's MRA (currently 85 economies). This delimitation had the advantage that the countries analyzed all had an internationally recognized system. The disadvantage of this selection, on the other hand, was that a large part of the developing countries could not be included. To account for the differences between the IAF's MRA signatories and the other economies, the authors weighted the accreditations accordingly (see 3.4 Formula).

The GQII considers cross-border accreditation

The expansion of the number of countries poses particular challenges for data comparison. In order to distinguish the level of QI development in smaller countries, the authors looked for indicators other than internationally recognized accreditation. Therefore in countries without their own accreditation body, the authors measured the number of conformity assessment bod-ies accredited abroad. For this purpose, the authors systematically collected and considered data on cross-border accreditation for the first time. A detailed study on the topic of cross-border accreditation will be published shortly (Harmes-Liedtke/ Matta, 2021).

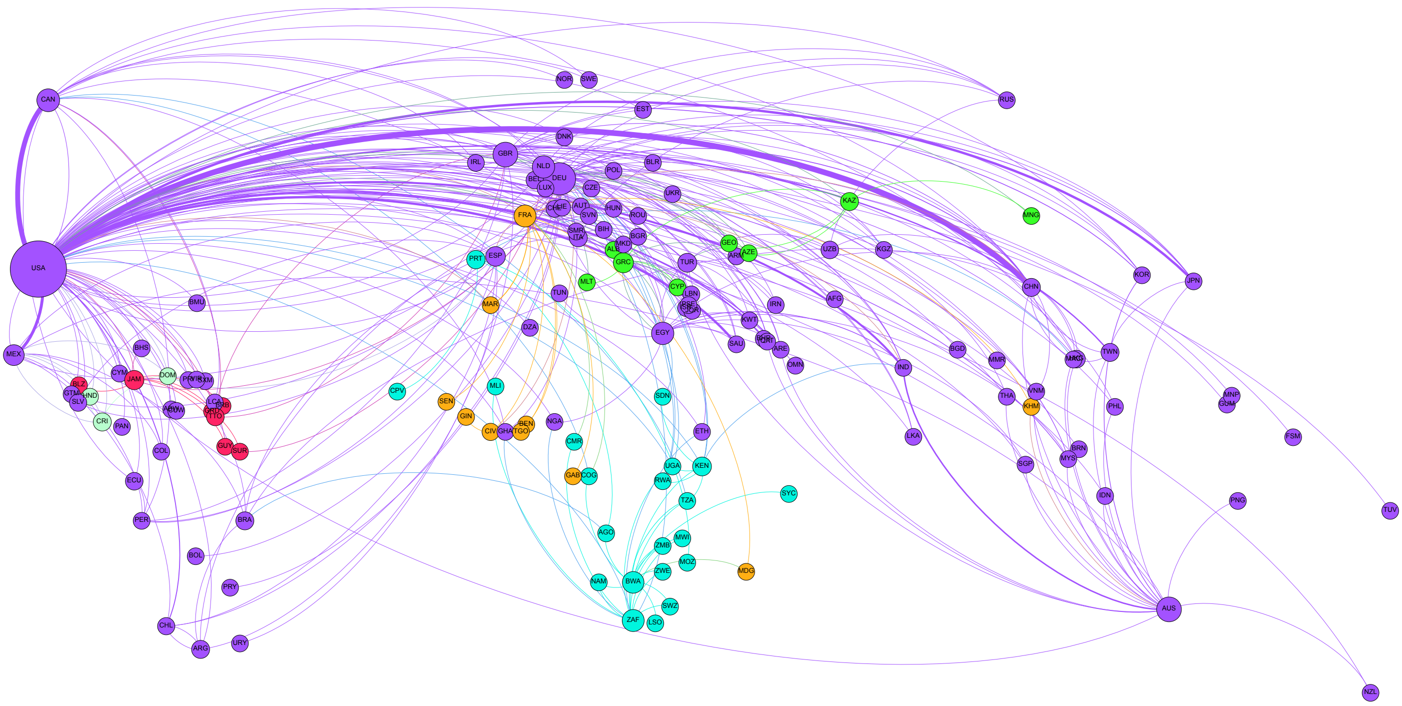


Figure 4: Cross-border accreditation[37]

Figure 4 visualizes the phenomenon of cross-border accreditation.

The circles represent the economies whose accreditation bodies accredit conformity assessment bodies abroad or economies whose conformity assessment bodies have been accredited by a foreign accreditation body. The size of the circles indicates the number of exported or imported accreditations. The circles are arranged according to the world map. The large circle in the northwest represents the US, the circles in the centre above represent Europe and southeast Australia. In terms of colour, the map shows different clusters representing one global and several regional cross-border accreditations.

From a development perspective, one strength of the GQII is that it covers all members of the OECD Development Aid Committee (DAC) and almost all ODA recipients. The only exceptions are small states such as Kiribati, Niue, Palau, São Tomé and Principe, Tuvalu, Tokelau and the Democratic People's Republic of Korea. These countries do not yet have any relevant QI or are beneficiaries of development cooperation.

[37] Authors' elaboration in separate study by Harmes-Liedtke/Matta (2021) in progress.

DAC MEMBERS	ODA RECIPIENT			OTHER
	LEAST DEVELOPED AND LOW INCOME	LOWER MIDDLE INCOME	UPPER MIDDLE INCOME	
Australia	Afghanistan	Angola	Albania	Antigua y Barbuda
Austria	Bangladesh	Armenia	Algeria (LM)	Bahamas
Belgium	Benin	Bolivia	Antigua and Barbuda[2]	Bahrain
Canada	Bhutan1	Cabo Verde	Argentina	Barbados
Czech Republic	Burkina Faso	Cameroon	Azerbaijan	Brunei
Denmark	Burundi	Congo	Belarus	Bulgaria
European Union	Cambodia	Côte d'Ivoire	Belize	Chile
Finland	Central African Republic	Egypt	Bosnia and Herzegovina	Croatia
France	Chad	El Salvador	Botswana	Chypre
Germany	Comoros	Eswatini	Brazil	Estonia
Greece	Democratic People's Republic of Korea	Georgia	China (People's Republic of)	Hong-Kong
Hungary	Democratic Republic of the Congo	Ghana	Colombia	Israel
Iceland	Djibouti	Guatemala	Costa Rica	Kuwait
Ireland	Eritrea	Honduras	Cuba	Latvia
Italy	Ethiopia	India	Dominica	Liechtenstein
Japan	Gambia	Indonesia	Dominican Republic	Lithuania
Korea	Guinea	Jordan	Ecuador	Macao
Luxembourg	Guinea-Bissau	Kenya	Equatorial Guinea	Malta
The Nether-lands	Haiti	Kosovo	Fiji	Oman
New Zealand	Kiribati	Kyrgyzstan	Gabon	Qatar
Norway	Lao People's Democratic Republic	Micronesia	Grenada	Romania
Poland	Lesotho	Moldova	Guyana	Russian Federation
Portugal	Liberia	Mongolia	Iran	Saint Kitts and Nevis
Slovak Republic	Madagascar	Morocco	Iraq	Samoa
Slovenia	Malawi	Nicaragua	Jamaica	Saudi Arabia
Spain	Mali	Nigeria	Kazakhstan	Seychelles
Sweden	Mauritania	Pakistan	Lebanon	Singapore
Switzerland	Mozambique	Papua New Guinea	Libya	Taiwan
United Kingdom	Myanmar	Philippines	Malaysia	Trinidad y Tobago
United States	Nepal	Sri Lanka	Maldives	UAE
	Niger	Syrian Arab Republic	Marshall Islands	Uruguay
	Rwanda	Tajikistan	Mauritius[3] (H)	
	São Tomé and Principe[1]	Tokelau*	Mexico	
	Senegal	Tunisia	Montenegro	
	Sierra Leone	Ukraine	Montserrat*	
	Solomon Islands[1]	Uzbekistan	Namibia	
	Somalia	Vanuatu	Nauru[3] (H)	
	South Sudan	Viet Nam	Niue*	
	Sudan	West Bank and Gaza Strip (Palestine)	North Macedonia	
	Tanzania		Palau[2]	
	Timor-Leste		Panama[2]	
	Togo		Paraguay	
	Tuvalu		Peru	
	Uganda		Saint Helena*	
	Yemen		Saint Lucia	
	Zambia		Saint Vincent and the Grenadines Samoa	
	Zimbabwe		Serbia	
			South Africa	
			Suriname	
			Thailand	
			Tonga	
			Turkey	
			Turkmenistan	
			Venezuela	
			Wallis and Futuna*	

Table 3: Donors and receivers of official development assistance (ODA)

Reference OECD[38,39]; * Countries and territories not classified in World Bank income groups. Economies given in Italics are not part of the GQII.

DATA SOURCES

GQII uses only publicly available data

The central data sources are:

- The Key Comparison Data Base and the BIPM website
- The ISO Survey (2020) and the ISO and IEC websites
- The IAF and ILAC websites, as well as the databases on accredited conformity assessment bodies of the websites of one hundred and sixty-four (164) accreditation bodies worldwide[40]

Table 4: Overview of the data used for the GQII

QI System	Inputs	Outputs
Accreditation	Membership/ signatories of IAF, ILAC or Regional Accreditation Cooperation (RAC) Coverage of all accreditation scopes	Accredited CABs for Products Certification (ISO 17065) Accredited CABs for Management Systems (ISO 17021) Accredited CABs for Testing Labs (ISO/ IEC 17025)
Metrology	Membership/ signatory of BIPM/CIPM and OMIL and/or Regional Metrology Organiza-tions (RMOs)	Key and Supplementary Comparisons (K&SC) Calibration and Measurement Capabilities (CMC) coverage Accredited Calibration Laboratories (ISO/ IEC 17025)
Standardisation	Membership in International Standard Organizations ISO and IEC	Participation in Technical Committees Companies with Certified Management System (ISO Survey)

References: Authors' elaboration

In recent years, the BIPM in particular has been active in renewing the Key Comparison Data Base (KCDB). The new KCDB 2.0 makes data export easy and provides statistical comparisons by metrology areas and economy. However, the KCDB only provides current data and no time series. Since the counting of Calibration Measurement Capabilities (CMCs) has also been modified and is to be reduced overall in the future, the authors have refrained from using the number of CMCs as an indicator of an economy's metrological competence. Instead, the authors have developed an indicator of CMC coverage, which expresses how many metrological disciplines a national metrology institute (possibly together with the designated institutes) covers through CMCs. In the opinion of the metrology experts interviewed, this indicator better expresses the metrological competence of an NMI.

The ISO website provides up-to-date information on members and participation in technical committees. The ISO Survey also provides information on the use of ISO management stand-ards. The data is based on an annual survey in which IAF-MLA-accredited certification bodies participate. The validity of the survey depends on the participation of the certification bodies and is therefore limited. Nevertheless, the ISO Survey remains the best source of data available worldwide on formal standards.

[38] https://www.oecd.org/dac/development-assistance-committee/ (Retrieved 15/02/21)

[39] http://www.oecd.org/dac/financing-sustainable-development/development-finance-standards/DAC-List-ODA-Recipients-for-reporting-2021-flows.pdf (Retrieved 13/03/2021)

[40] The data collection period was from May to July 2020.

The biggest challenge was the collection of the accreditation data

The biggest challenge in the data collection of the GQII was in the area of accreditation. Accreditations can be counted by a body or by a site. Following the counting practice of the IAF, the authors chose to count the bodies. They recorded the number of bodies for each accreditation scheme at level 3 (see Table 5). In the management systems under ISO/IEC 17021, the authors always recorded the highest value of the systems counted at level 4 and noted it as the value for level 3. This procedure made it possible to harmonize all data at level 3.

The institutional framework for accreditation is set by the international organizations IAF and ILAC as well as the RACs. The signatories to the MLA and MRA are regarded as international competence certificates for national accreditation bodies.

Not all accreditation bodies have international recognition. From a developmental point of view, it was vital for the authors to consider the accreditation bodies that are still on the way to international recognition. To express the different degrees of recognition, the authors weighted the number of accredited conformity assessment bodies: an accreditation by a signatory of an MRA/MLA of IAF/ILAC or an RAC is given the maximum value of one. If the accreditation body has any other kind of membership in IAF/ILAC or an RAC, the authors evaluate the number of accredited conformity assessment bodies by a factor of 0.5. For all other accreditation bodies, the authors multiply the number of accredited conformity assessment bodies by a factor of 0.1. If a national accreditation body achieved international recognition, it would rise significantly in the ranking.

The accreditation bodies that are members of IAF/ILAC and the RACs regularly record the number of accredited conformity assessment bodies. This data also serves as the basis for calculating the membership fees of IAF/ILAC and the RACs. The IAF and the ILAC regularly publish this data in an aggregated form to show the development of accreditation worldwide and in the world regions respectively.

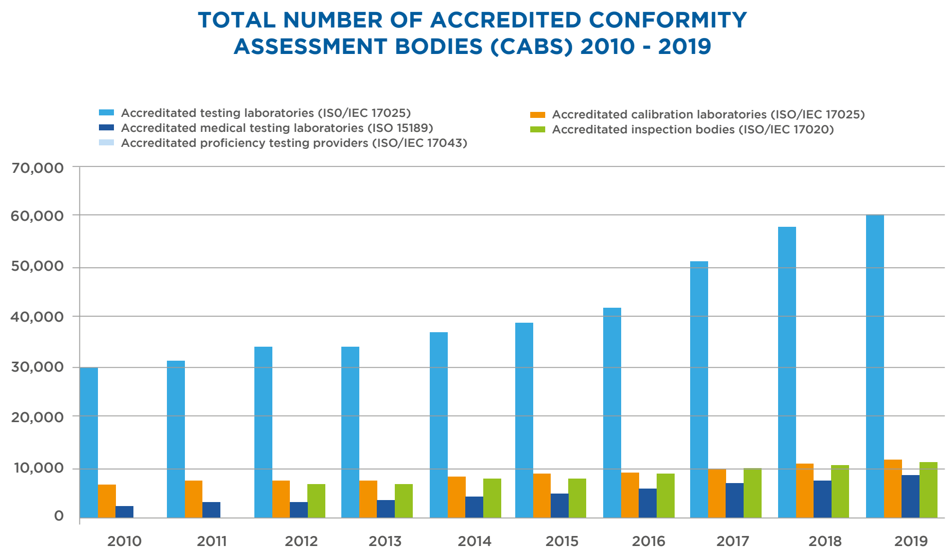


Figure 5: Total Number of CABs accredited by ILAC [43]

[41] There are a total of nine metrological disciplines: Acoustics, Ultrasound, Vibration (AUV), Electricity and Magnetism (EM), Length (L), Mass and related quantities (M), Photometry and Radiometry (PR), Chemistry and Biology (QM), Ionizing and Radiation (RI), Thermometry (T), Time and Frequency (TF).

[42] The ISO Survey includes data on twelve management standards: ISO 9001:2015 - Quality Management Sys-tem (QMS), ISO 14001:2015 - Environmental Management System (EMS), ISO/IEC 27001:2013 - Infor-mation Technology - Security Techniques - Information Security Management Systems (ITMS), ISO 22000:2018 - Food Safety Management Systems (FMS), ISO 45001:2018 - Occupational Health and Safety (OHSMS), ISO 13485:2016 - Medical Devices Quality Management Systems (MDMS), ISO 50001:2018 - Energy Management Systems (EnMS), ISO 22301:2019 - Security and Resilience - Business Continuity Man-agement Systems (BCMS), ISO 20000-1:2011 - Information Technology - Service Management (ITSM), ISO 28000: 2007 - Specifications for Security Management Systems for the Supply Chain (SMSC). ISO 37001:2016 - Anti-bribery Management Systems (ABMS), ISO 39001:2012 - Road Traffic Safety Management Systems (RTSMS).

[43] ILAC 2020: ILAC MRA 2019 ANNUAL REPORT, https://ilac.org/?ddownload=891. This figure does not include medical laboratories, PT providers, and reference material producers.

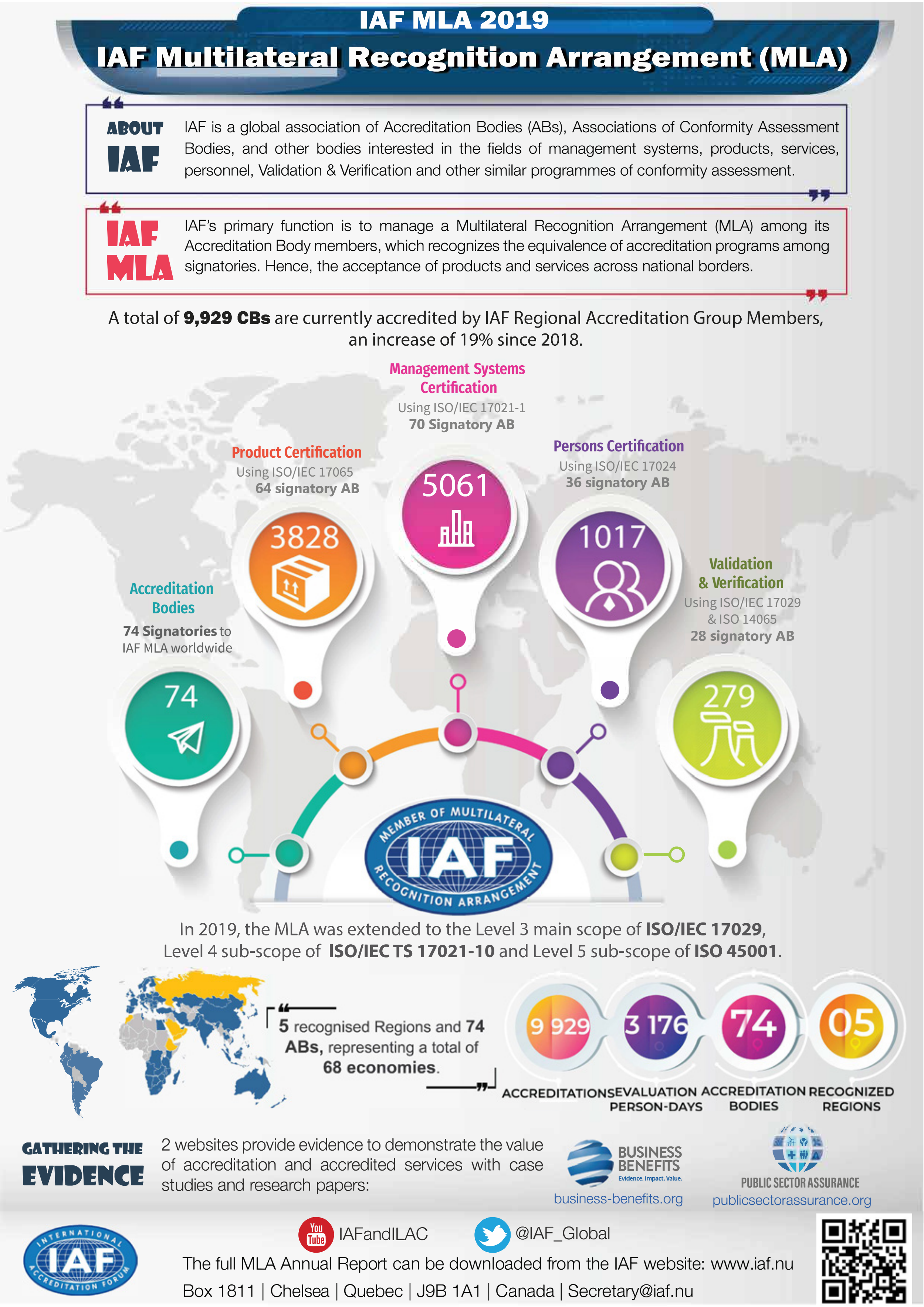


Figure 6: IAF infographic on accreditation data. Reference

Unfortunately, IAF/ILAC do not publish this data disaggregated at the level of the economy. Therefore the GQII team had no choice but to read the data on the websites of 164 accreditation bodies themselves. Not every country has its own national accreditation body, while other countries have several accreditation bodies. The authors used the obligation of accreditation bodies according to ISO/IEC 17011:2017 that they "...should provide detailed information on criteria and procedures for the assessment and accreditation of conformity assessment bodies." In principle, lists of accredited conformity assessment bodies, including their scope, can be found on accreditation bodies' websites. However, the information is not structured uniformly and is not designed for statistical evaluation.

To validate the correctness of their data collection, the authors wrote to the accreditation bodies after the census and asked them to validate their numbers. Accreditation bodies of seventy-four (74) economies validated the numbers the authors collected. In the GQII database, you will find corresponding information if the national accreditation body has validated the numbers. The authors were also able to cross-check their data with two of the RACs, AFRAC and IAAC. For the GQII, they collected data for a total of seventeen (17) accreditation scopes (see Table 5).

	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
IAF MLA	Product Certification	ISO/IEC 17065:2012	GLOBALG.A.P IFA General Regulations V4	GLOBALG.A.P IFA Control Points and Compliance Criteria V4
	Management System Certification	ISO/IEC 17021-1:2015	ISO/TS 22003:2013	ISO 22000:2018, 2005 (FSMS)
			ISO/TS 22003:2013 FAMI-QS Rules for Certification Bodies Version 8	FAMI-QS Certification Scheme Code Version 6
			ISO/IEC 17021-3:2017	ISO 9001:2015 (QMS)
			ISO/IEC 17021-2:2016	ISO 14001:2015 (EMS)
			ISO/IEC 27006:2015	ISO/IEC 27001:2013 (ISMS)
			ISO 5003:2014	ISO 50001:2018, 2011 (EnMS)
				ISO 13485:2016 (MDMS)
			ISO/IEC TS 17021-10:2018	ISO 45001:2018 (previous OHSAS 18001)
			ISO/TS 2003:2013 FSSC Scheme Part 3 – Requirements for the Certification Process FSSC Scheme Part 4 – Requirements for Certification Bodies	FSSC Scheme Part 2 – Requirements for organizations to be audited
	Person Certification	ISO/IEC 17024:2012		IPC PL-11-006
	Validation and Verification	ISO 14065:2013	ICAO CORSIA ETM – Volume IV V1, ISP 14064-3:2006; ISO 14066:2011	ICAO CORSIA SARPs – Annex 16 Volume IV VI
		ISO/IEC 17029:2019		
ILAC MRA	Testing	ISO/IEC 17025	WADA ISL	Scope of accreditation
		ISO 15189	ISO 22870	
	Calibration	ISO/IEC 17025	ISO 15195	
	Inspection	ISO/IEC 17020		
	Proficiency Testing	ISO/IEC 17043		
	Reference Material Production	ISO 17034		

Table 5: Accreditation arrangements and levels

Reference: Authors' elaboration based on IAF MLA Status 23/02/2011 and ILA-R6:05/2019

For the index itself, the authors selected four metrics, namely the total number of accredited conformity assessment bodies for products (ISO/IEC 17065), management systems (ISO/IEC 17021), calibration laboratories (ISO/IEC 17025) and testing laboratories (ISO 17025). For a detailed analysis of an accreditation body's technical competence, the remaining data can be found in the GQII database.

From a developmental perspective, the authors wanted to record the use of accreditation in countries that do not have their own accreditation body or whose accreditation body is only in the process of being established. In this regard, the authors also always recorded the location when assigning the data on the accredited conformity assessment bodies and attributing the value to the target country. A detailed study of cross-border accreditation (Harmes-Liedtke, Matta 2020) complements these procedures and facilitates the interpretation of the information from the GQII.

A specific challenge is to attribute the data from bi-national and regional accreditation bodies to individual economies. In the case of the Joint Accreditation System of Australia and New Zea-land (JAS-ANZ), the authors weighted the number according to the conformity assessment bodies accredited from each country. They attributed 90% of JAS-ANZ accreditations to Aus-tralia and 10% to New Zealand.

Another case is the Southern African Development Community Accreditation Services (SAD-CAS) which is a not-for-profit company registered in 2005 in Gaborone, Botswana. This mul-ti-economy accreditation body provides accreditation services for fourteen countries, namely Angola, Botswana; Comoros, Democratic Republic of the Congo (DRC), Lesotho, Madagas-car, Malawi, Mozambique, Namibia, Seychelles, Eswatini (Swaziland), Tanzania, Zambia and Zimbabwe. In this case, where possible the authors attributed the accreditations to the country where the CABs are headquartered. The accreditations of SADCAS outside the region they have attributed to Botswana, the headquarters of the accrediting body.

FORMULA

The formula includes indicators on metrology, standardization and accreditation

A core part of the GQII is the formula that calculates the relative level of development of an economy's QI. The formula is based on the simplifying assumption that three components, namely metrology, standardization and accreditation, contribute equally to the QI system. The authors calculated a sub-index that expresses the relative level of development of metrology, standardization and an economy's accreditation for each element.

$$GQII_i =$$

$$[Membership_i + CMC\ Coverage_i + CIPM\ Cons.Comm._i + K\&SC_i + CABs\ (Calbr.\ Labs.)^*{}_i] \times \frac{1}{5} +$$

$$[Membership_i + ISO\ Tech.\ Comm._i + ISO\ Survey_i] \times \frac{1}{3} +$$

$$[Membership_i + CAB\ Coverage_i + (CABs\ (ISO\ 17065)_i + CABs\ (ISO\ 17021)_i + CABs\ (Tst.\ Labs.)^*{}_i/3)] \times \frac{1}{3}$$

Notes: All values in the formula are expressed in Percentile Ranks. *ISO/IEC 17025

Figure 7: The GQII formula[45]

The metrology component consists of five indicators, which the author's weight equally:

(1) Membership in the international and regional metrology organizations (BIPM, OIML or AFRIMETS, APMP, COOMET, EURAMET, GULFMET, SIM).
(2) Membership in the CIPM Consultative Committees
(3) Coverage of the areas of Calibration and Measurement Capabilities (CMC)
(4) Number of Key & Supplementary Comparisons
(5) Number of accredited calibration laboratories in the country

The standardization component is made up of three equally weighted indicators:

(1) Membership in international standards organizations (ISO, IEC).
(2) Participation in ISO Technical Committees
(3) Number of companies certified for management standards

The accreditation component is made up of five equally weighted indicators:

(1) Membership in or signatories to international or regional accreditation organizations (ILAC and IAF or AFRAC, APAC, ARAC, EA, IAAC, SADCA (MRA/MLA).
(2) Coverage of internationally recognized accreditation schemes
(3) Number of accredited conformity assessment bodies for product certification (ISO 17065)
(4) Number of accredited conformity assessment bodies for management systems (ISO 17021)
(5) Number of accredited conformity assessment bodies for testing laboratories (ISO 17025)

Indicators 3, 4 and 5 refer to the number of accredited conformity assessment bodies and are calculated together as one sub-indicator.

The current formula essentially follows the proven measurement concept of the authors' two previous publications. However, the current formula takes into account the critique on its pre-decessors and has the following special features:

- The information on membership is now directly assigned to the technical components.
- The weight of the absolute numbers is reduced, for example by taking only the coverage into account instead of the number of CMCs. In the area of accreditation, coverage has also been added as a new parameter.
- Weighting with the population is dispensed with because the correlation of the individu-al measures with the population is generally weak. Medium-sized and smaller countries can cover all components.

The formula refers exclusively to QI metrics

The attractiveness of the formula lies in the fact that it refers solely to QI measures. To ensure the relevance of the index, the authors followed the guidelines of the JRC-OECD handbook and selected the baseline data to cover an appropriate range of areas in a balanced manner (Joint Research Centre-European Commission and OECD, 2008, 49).

The authors presented and validated the formula of the GQII to international experts and representatives of accreditation bodies and metrology institutes in two workshops. In the process, they addressed various points of criticism and modified the original formula. Ultimately, the decision in favour of a particular formula is always subjective, and especially the ranking of countries should always be viewed with a certain degree of caution. Nevertheless, the authors consider this formula to be the best expression of the relationship between the level of development of different countries and components of national quality infrastructures. The consolidation of the formula will then make it possible in the coming years to compare the GQII data over time.

The final score produced by the GQII formula is an average of the various positions that each economy obtains in the different sub-areas of the QI captured by the indicator. The authors transform the counts and percentages that emerge from the data collection and convert them into percentile ranks, that is, into a position within an ordered row with a minimum of 0 and a maximum of 1. Thus if a country excels in metrology, standards and accreditation, it will have a score that will leave it very high in the overall GQII table. To achieve this, the economy must lead in each of the subcomponents that comprises each term of the formula.

This methodology solves two problems in the construction of the indicator: first, it allows us to normalize, i.e. to bring together in a single calculation metrics that are different (e.g., number of laboratories and number of ISO certificates); and second, it allows us to attenuate to a large extent the size effect that exists in the QI phenomenon. For example, a country like China has 1 390 calibration laboratories (including cross-border), which, compared to Uruguay with 11 laboratories, means 126 times more. However, when applying the percentile ranks to both values, the discrepancy drops to less than double, i.e. while China occupies the 99th position in a row that goes up to 100, Uruguay reaches the 64th position in the global list. Ultimately, if the authors look at each country's placing on the list, the discrepancy is only 55%. They prefer this methodological approach over other options such as weighting by population size or GDP.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EMPIRICAL RESULTS, RANKINGS AND MAPS

Economies can be ranked according to their QI development

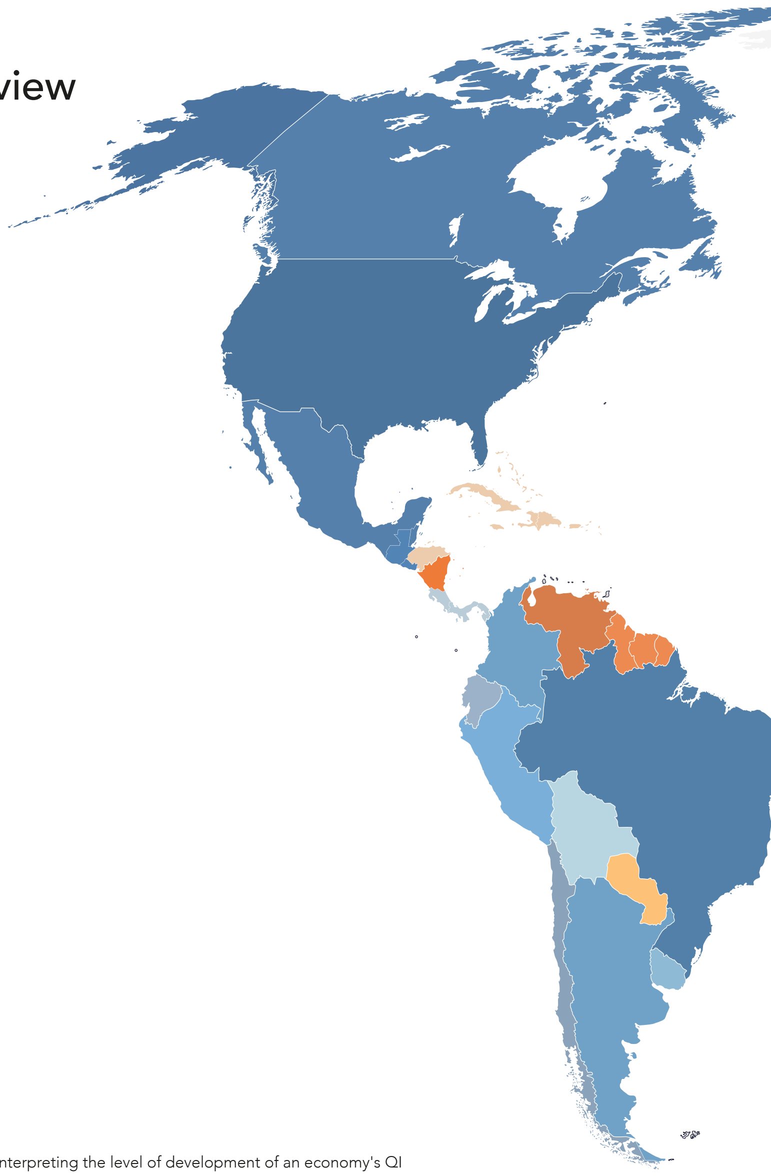
The GQII ranks the 184 economies according to the relative development of their QI. Based on the formula, a score is calculated for each economy based on its position in the three sub-rankings for metrology, standards and accreditation.

An economy that ranks first in all areas would achieve a score of 100. In the GQII 2020, the top-ranked economy (Germany) achieves a score of 99.5, while the bottom-ranked economies (Solomon Islands, South Sudan and Timor-Leste) have a combined score of 24.

Quality Infrastructure World Overview

GQII 2020 over 184 economies

Figure 8: GQII map[46]

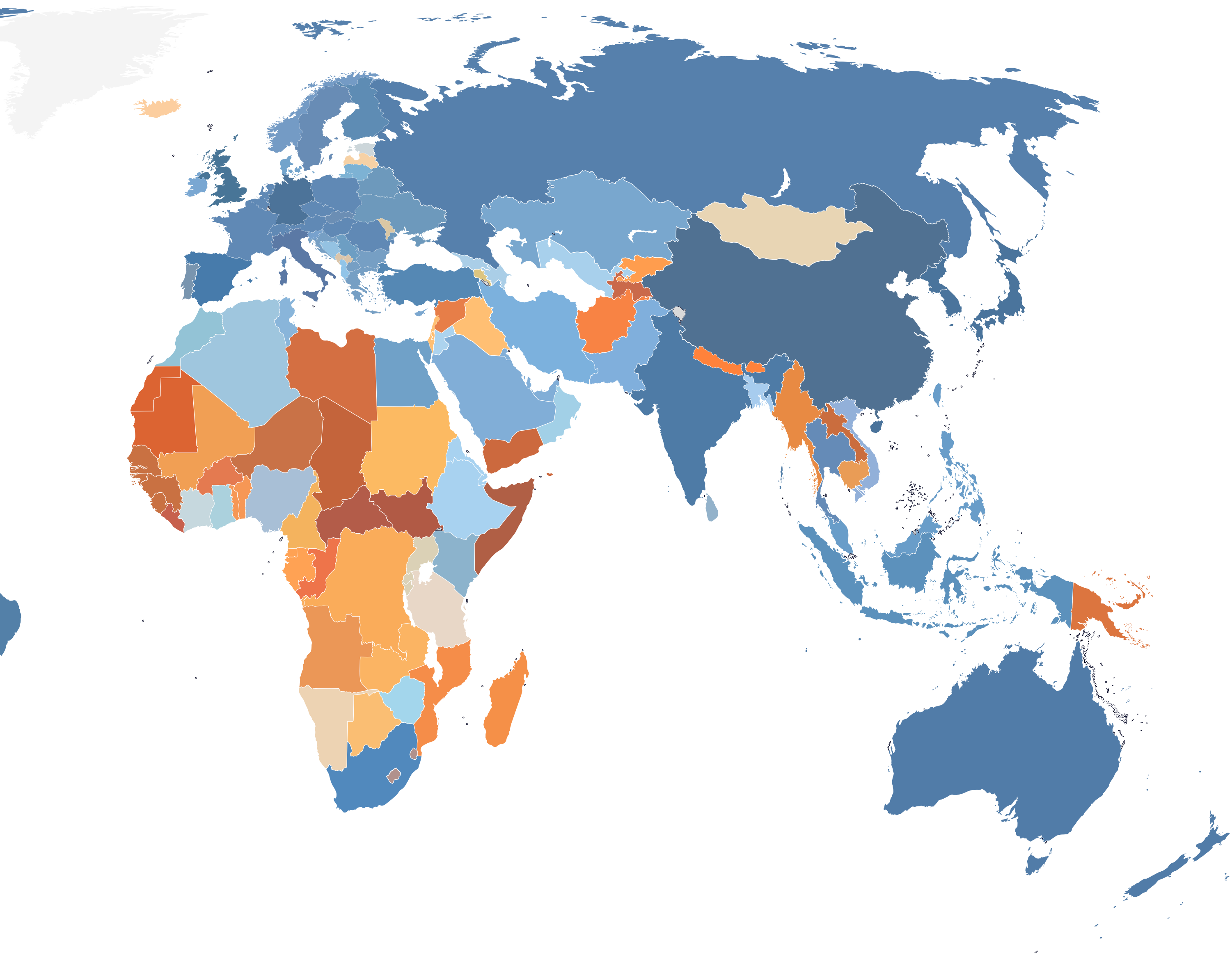


[46] Authors elaboration

[47] The authors chose blue and orange rather than the usual traffic light colors to avoid misinterpreting the level of development of an economy's QI as better or worse. The GQII is a value-free indicator of the relative devel-opment of QI. Another question is whether this level of development is appropriate to the needs of the local industry.

The map in Figure 9 shows the relative level of development of the economies' quality infra-structure according to a colour scale from dark blue (highly developed) to dark orange (less developed).[47] The world overview shows a north-south divide. North America and Western Europe have a highly developed quality infrastructure. In contrast, large parts of Africa and parts of Latin America and Asia have several economies with less or barely developed QI. The QI development level is high in Australia, Japan and in the BRICS countries (Brazil, Russia, India, China and South Africa). At the same time, the authors see some economies that deviate from the general pattern on their continent. These are often relatively small economies that source QI services heavily from their larger neighbours. Examples are Belize, Iceland, Lichtenstein and Tajikistan. In these cases, a lower rank does not mean that local businesses will not get the services they need. Other outliers such as Venezuela show the consequences of ongoing local political and institutional crises.

The complete ranking can be reviewed on the following pages:



GQII 2020 I Global Ranking and Sub Rankings

Economy	GQII 2020	Rank GQII 2020	Rank GQII Metrology	Rank GQII Standard	Rank GQII Accreditation
Germany	99,5	1	2	2	2
China	99,4	2	3	1	3
US	98,9	3	1	10	1
UK	98,8	4	6	3	5
Japan	98,0	5	4	4	13
Korea, Republic of	97,2	6	7	8	14
Italy	97,0	7	16	4	4
France	97,0	8	4	6	20
Spain	96,4	9	12	8	10
India	95,6	10	19	7	9
Australia	95,4	11	8	19	6
Poland	95,3	12	15	12	7
Czech Republic	95,2	13	14	11	12
Brazil	93,8	14	9	16	26
Netherlands	93,7	15	21	12	15
Canada	93,6	16	10	27	16
Switzerland	93,0	17	13	14	33
Mexico	92,6	18	16	40	8
Hungary	92,4	19	18	19	18
South Africa	92,3	20	11	30	22
Turkey	91,6	21	25	21	17
Romania	91,3	22	25	14	30
Sweden	91,2	23	19	17	35
Russian Federation	90,5	24	31	18	23
Austria	89,6	25	22	25	37
Indonesia	89,2	26	35	36	18
Finland	88,9	27	22	28	38
Slovak Republic	88,6	28	34	29	32
Thailand	88,5	29	24	24	44
Colombia	88,5	30	42	31	21
Singapore	88,0	31	25	44	31
Ukraine	87,9	32	28	48	28
Belarus	87,8	33	30	45	26
Greece	87,7	34	42	35	23
Portugal	87,6	35	32	23	46
Belgium	87,3	36	46	25	34
New Zealand	87,0	37	38	52	11
Bulgaria	86,7	38	39	33	39
Serbia	86,4	39	33	39	45
Malaysia	86,3	40	37	21	50
Argentina	86,2	41	29	31	49
Denmark	86,2	42	35	41	42
Norway	84,1	43	48	38	47
Egypt	83,9	44	41	43	48

Economy	GQII 2020	Rank GQII 2020	Rank GQII Metrology	Rank GQII Standard	Rank GQII Accreditation
Chile	83,6	45	47	49	40
Ireland	83,3	46	49	42	43
Slovenia	80,4	47	44	54	54
Israel	80,1	48	55	33	65
Kazakhstan	80,1	49	44	65	25
Philippines	77,9	50	63	45	57
United Arab Emirates	77,4	51	62	53	51
Saudi Arabia, Kingdom of	77,2	52	58	45	72
Peru	76,8	53	56	55	61
Viet Nam	76,8	54	60	64	36
Iran	74,9	55	85	36	68
Pakistan	74,3	56	82	50	60
Lithuania	74,2	57	52	70	53
Kenya	73,8	58	53	62	64
Taiwan (Province of China)	72,6	59	40	114	29
Uruguay	72,2	60	50	73	63
Tunisia	71,7	61	59	63	71
Sri Lanka	71,3	62	74	60	59
Ecuador	71,0	63	57	76	56
Croatia	70,9	64	51	50	135
Luxembourg	70,3	65	88	57	66
Costa Rica	69,4	66	61	88	52
Hong Kong, China	68,6	67	54	115	41
Qatar	68,3	68	79	59	84
Morocco	68,1	69	65	67	86
Bosnia and Herzegovina	67,8	70	67	67	83
Nigeria	66,7	71	116	56	75
Cyprus	66,5	72	114	69	55
Algeria	65,9	73	122	58	73
North Macedonia	65,9	73	69	86	67
Oman	64,3	75	91	61	102
Bangladesh	64,0	76	82	82	70
Malta	63,9	77	98	81	69
Albania	62,6	78	75	105	58
Zimbabwe	62,4	79	80	94	76
Georgia	62,3	80	68	101	74
Mauritius	62,2	81	88	89	79
Uzbekistan	61,8	82	81	108	62
Ghana	61,3	83	97	89	80
Jordan	61,2	84	135	72	81
Ethiopia	61,2	85	94	86	87
Bolivia, Plurinational State of	60,8	86	87	95	90
Panama	60,6	87	78	82	109
Côte d'Ivoire	60,6	88	123	76	78
Estonia	60,3	89	76	66	137
Bahrain, Kingdom of	60,1	90	103	80	96
Azerbaijan	60,0	91	70	111	82

Economy	GQII 2020	Rank GQII 2020	Rank GQII Metrology	Rank GQII Standard	Rank GQII Accreditation
Kuwait, the State of	60,0	92	84	93	101
Uganda	59,9	93	127	75	89
Tanzania	59,9	94	96	84	97
Mongolia	59,6	95	101	84	95
Namibia	58,1	96	85	108	92
Latvia	58,0	97	76	79	136
Iceland	57,9	98	132	78	99
Cuba	57,3	99	63	74	139
Lebanese Republic	57,1	100	155	91	92
Dominican Republic	57,1	101	119	102	77
Trinidad and Tobago	57,1	102	99	96	105
Jamaica	56,9	103	91	105	97
Paraguay	56,8	104	72	124	91
Moldova, Republic of	55,9	105	73	97	134
Iraq	55,9	106	71	71	143
Botswana	55,7	107	88	112	104
El Salvador	55,4	108	125	100	94
Montenegro	54,8	109	66	92	138
Sudan	54,5	110	102	99	122
Guatemala	53,3	111	114	124	88
Senegal	53,1	112	127	104	110
Armenia	53,0	113	137	98	115
Zambia	52,5	114	93	130	108
Rwanda	52,2	115	127	117	103
Cameroon	51,5	116	137	102	125
Democratic Republic of the Congo	51,4	117	137	105	117
Malawi	51,2	118	120	120	107
Suriname	51,2	119	104	124	111
Honduras	50,1	120	127	131	100
Seychelles	50,0	121	94	143	114
Gabon	49,6	122	127	119	125
Mali	49,2	123	137	112	129
Benin	49,0	124	123	122	123
Cambodia	48,8	125	132	128	113
Kyrgyz Republic	48,7	126	125	154	84
Macao, China	48,6	127	135	133	111
Angola	48,6	128	120	136	118
Bahamas	47,7	129	137	131	120
Mozambique	47,7	130	137	137	116
Eswatini	46,8	131	118	156	106
Guyana	46,3	132	104	150	123
Madagascar	46,2	133	137	141	120
Myanmar	45,9	134	157	120	132
Togo	45,5	135	137	143	125
Afghanistan	44,2	136	157	138	128
Liechtenstein	43,5	137	157	148	119
Barbados	42,2	138	104	115	151

Economy	GQII 2020	Rank GQII 2020	Rank GQII Metrology	Rank GQII Standard	Rank GQII Accreditation
Syrian Arab Republic	40,9	139	100	118	160
Nicaragua	40,8	140	117	145	140
Saint Lucia	40,5	141	104	124	149
Cabo Verde	40,2	142	157	162	132
Nepal	40,0	143	157	110	146
Congo	39,8	144	157	164	130
Lesotho	39,8	145	137	171	131
Palestinian Territories	38,9	146	157	135	142
Burkina Faso	37,8	147	137	122	153
Venezuela, Bolivarian Republic of	37,3	148	156	150	141
Fiji	34,4	149	157	129	160
Burundi	34,3	150	137	140	160
Bhutan	34,0	151	157	134	160
Papua New Guinea	33,8	152	157	153	145
Brunei Darussalam	33,7	153	157	138	155
Dominica	33,6	154	104	157	160
Belize	33,5	155	104	173	148
Saint Kitts and Nevis	33,3	156	104	160	160
Libya	33,3	157	132	163	150
Niger	33,0	158	137	152	155
Grenada	32,6	159	104	173	152
Vanuatu	32,6	159	157	142	160
Mauritania	32,2	161	157	147	155
Lao People's Democratic Republic	32,1	162	157	146	160
Haiti	32,0	163	137	155	160
Tajikistan	31,9	164	137	159	155
Kosovo	31,7	165	157	181	144
Guinea	31,6	166	157	165	147
Yemen	31,5	167	137	166	154
Sierra Leone	31,3	168	157	149	160
Antigua and Barbuda	30,7	169	104	176	160
Saint Vincent and the Grenadines	30,5	170	104	178	160
Gambia	30,2	171	157	158	160
Chad	30,0	172	137	167	160
Maldives	29,9	173	157	161	160
Equatorial Guinea	29,2	174	137	171	160
Central African Republic	29,1	175	137	173	160
Liberia	28,2	176	157	168	160
Djibouti	28,1	177	157	169	160
Somalia	28,0	178	157	170	160
Guinea-Bissau	27,8	179	157	176	155
Samoa	27,3	180	157	178	160
Tonga	27,3	180	157	178	160
Solomon Islands	27,0	182	157	181	160
South Sudan	27,0	182	157	181	160
Timor-Leste	27,0	182	157	181	160

Metrology, standardisation and accreditation are usually equally developed

Looking at the sub-rankings, there is a remarkable coherence in the positions. If a country has well-developed metrology, standardization and accreditation are usually also well developed. The same applies to medium and low development. There are some exceptions here: in some African countries (Algeria, Jordan, Côte d'Ivoire, Lebanon and Uganda), metrology is relatively weak compared to standardization and accreditation. Conversely, the small states in the Carib-bean benefit from the fact that the CARICOM Regional Organization for Standards and Quality (CROSQ) is a member of the BIMP and thus shows a higher value in metrology than the other components. Other outliers we see are comparatively low values in the area of accreditation in Israel and the Kyrgyz Republic, or low values in standardization for Hong Kong and Taiwan. The latter can be explained by the fact that these economies, as part of China, do not have mem-bership in ISO. We attribute the relatively low value of the standard component in the US to the fact that this economy has adopted fewer ISO/IEC standards (Choi and Puskar, 2014). [48]

Due to modifications of the formula and the expansion of the economies included, the GQII does not yet allow any statements to be made about the evolution of the ranking positions. However, in future editions of the GQII, this will be done explicitly, so that information can also be provided on ascenders and descenders in the ranking. The authors emphasize that the rank of an economy in the GQII only offers limited information about QI development. The general ranking position and the characteristics of the ranks of the components give the first impression. The GQII database contains additional information that can be used for a more differentiated analysis. Finally, the assessment of the QI of an economy should always be supplemented by qualitative expert analyses.

[48] „The ... alignment ratio (15.5%) of the US is low compared to that of its major trade partners. Canada adopt-ed 1 376 ISO standards, representing 36.4% of its 3 776 national standards, with 43 at the end of December 2008. Today it is estimated that around 35% of Canada's national standards are harmonized with ISO and IEC44. Other trading partners have similarly high rates of harmonization. In 2009, the rate of ISO/IEC harmo-nization was 28% by China, 63% by Japan and 55% by Korea."

Medians are the 50th percentiles, i.e. the values in the middle of a row, ordered from the lowest to the high-est.

PERFORMANCE OF THE GQII

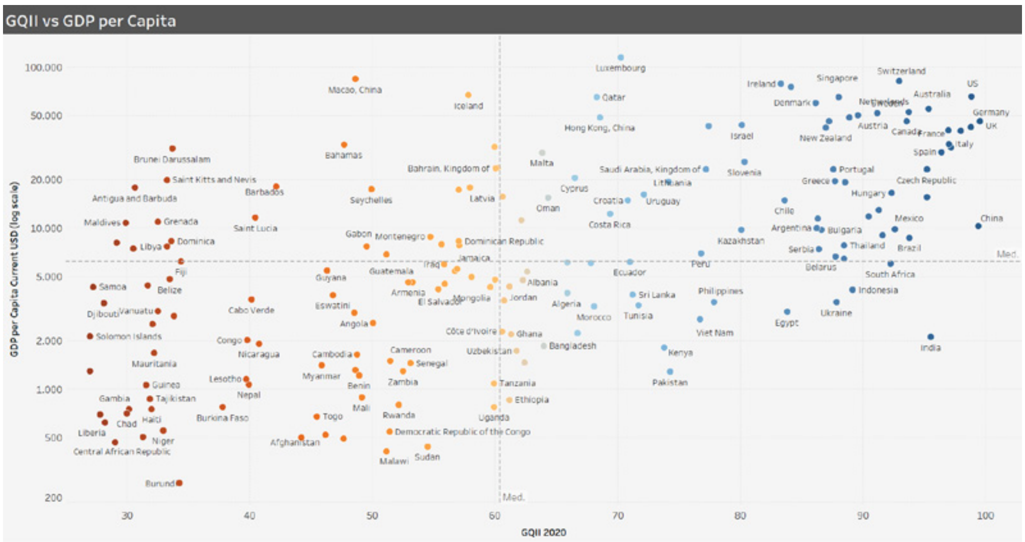
QI data can be compared with other global rankings

A particular interest for the readers of the GQII is to capture the relationship between QI and economic development. The GQII offers the possibility to compare QI data with other globally available statistics and rankings. For this report, the authors examined the correlation of the GQII with the gross domestic product (GDP) per capita, exports of goods and services and the Economic Complexity Index (ECI). For a better understanding, the correlation graphs have been divided into quadrants in each case. The dashed lines show the medians (and not the means, as the data distribution is asymmetrical for exports and GDP per capita. Conversely, GQII scores are very well behaved since their distribution looks flat, very symmetrical and therefore homogenous.

Correlation between GQII and GDP per capita

People may think that the development of QI in a country depends on the wealth of the country. However, the correlation between GQII and GDP per person is 0.58. According to a socio-scientific study, a value of more than 0.5 indeed suggests a correlation of effects. Nevertheless, there is only a diffuse correlation between GDP per capita and QI. In the following, it will be shown that QI has so far only been of particular importance for certain areas of an economy.

There are several wealthy economies with poorly developed QI. Macao, Brunei Darussalam and the Bahamas are smaller economies with a less diversified economy. These countries also often use QI services provided by their neighbours. Conversely, there are several poorer countries with comparatively well-developed QI. These include larger economies such as India, Indonesia, Kenya and Ukraine. In these countries, QI is often targeted at the economy's strong and dynamic sectors but does not necessarily reach the informal sector and peripheral areas. In the end, the prosperity of an economy says little about the development of its QI.



Source: https://gqii.org/. **Creative Commons licence apply.**
Notes: GDP per Capita 2019 in current USD (World Bank). Own calculations for GQII 2020. Log scale for GDP per Capita axis. Significant correlation of 0,58.

Figure 9: GQII and GDP per capita

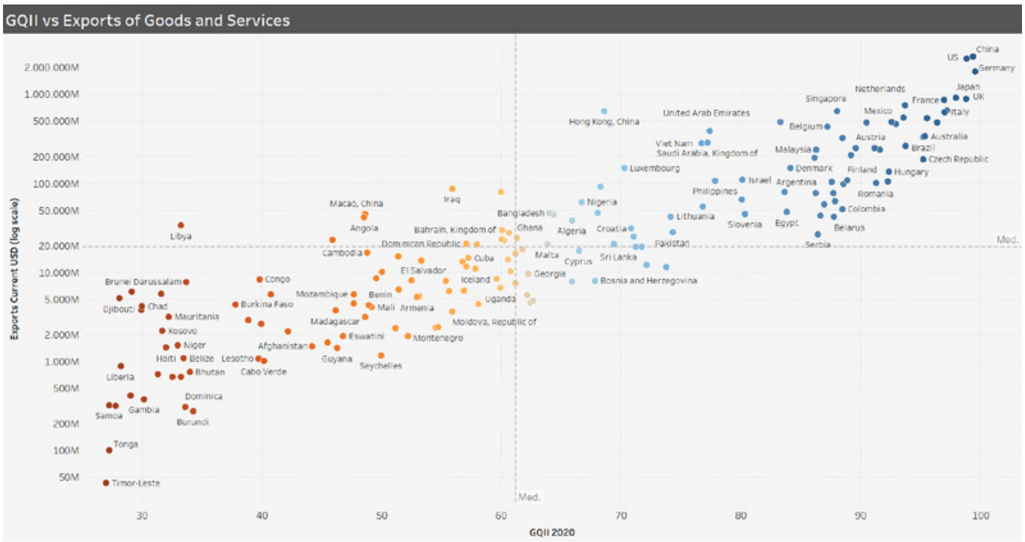
Correlation between GQII and exports

In contrast to the previous graph, in Figure 10 the correlation between the relative level of QI development and exports is significant and particularly pronounced, with a correlation of 0.89.

Only a few outliers can be found in the graph. Examples are Libya, which has been politically unstable since the military intervention in 2011, and the metropolis and Chinese special admin-istrative region of Hong Kong.

The strong relationship between QI and exports is plausible since a functioning QI is one of the World Trade Organization's requirements. The World Trade Organization and bilateral and multilateral trade agreements explicitly refer to the use of mutual recognition of accredited con-formity assessment services.

Although no conclusions can be drawn from a correlation, the graph gives the impression that the economies develop their QI according to their export activity.



Source: https://gqii.org/. Creative Commons licence apply.
Notes: Exports of goods and services 2019 in current USD (World Bank). Own calculations for GQII 2020. Log scale for Export axis. Significant correlation of 0,89.

Figure 10: GQII and exports

Correlation between Global Quality Infrastructure and Economic Complexity

The Economic Complexity Index (ECI) measures the intensity of an economy in terms of the knowledge it incorporates in the products it exports. This indicator predicts economic growth (Hausmann et al., 2013) and explains variations in international income inequality (Hartmann and Hidalgo, 2017). With a value of 0.79, the correlation between GQII and ECI is also signifi-cantly positive, although slightly weaker than for exports.

In several economies (China, Poland, Mauritania), the development of QI corresponds to that of economic complexity. In economies that are heavily based on natural resources (e.g. Austral-ia, Azerbaijan, Nigeria and Peru), we observe that QI is comparatively well developed com-pared to the level of complexity of the economy.

In high-tech countries (Japan, Switzerland, the Czech Republic, Germany and the US), QI is more agile when it comes to the economies' degree of complexity. This may well be the case, since for technological excellence, in addition to QI services, other institutions of the Science Technology and Innovation (STI) system are also well developed and take on corresponding tasks. In the case of developing and transition countries (Bosnia and Herzegovina, El Salvador, Eswatini and Liberia), which have a more developed QI compared to the degree of complexity, the question is whether

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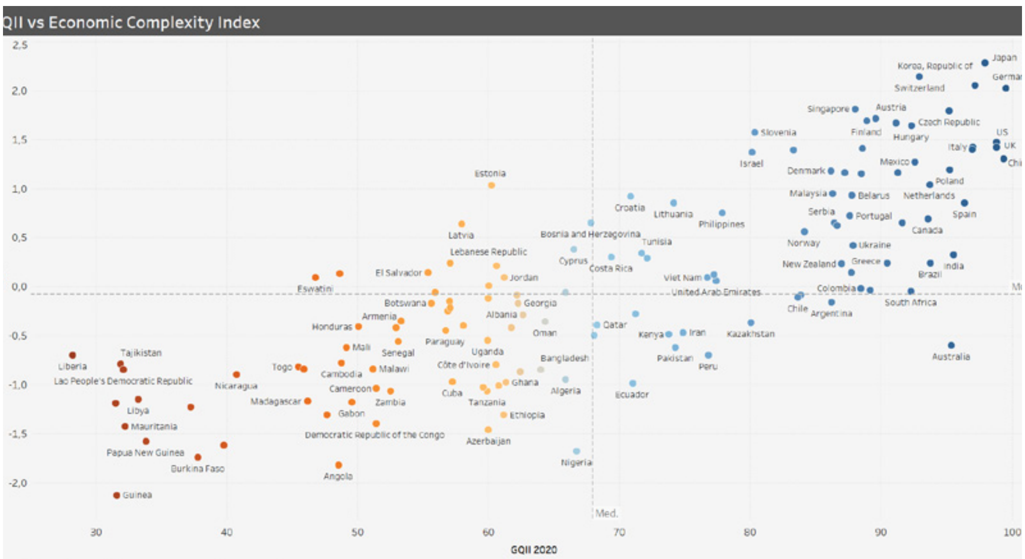
QI is a future investment, and could become the enabler of greater di-versification of the economy.

Overall, the comparison of the GQII data with the other rankings confirms the strong correla-tion between a country's economic performance and the relative level of development of its quality infrastructure. For further editions of the GQII, it will be interesting to observe this cor-relation and the individual performance of economies over time.



urce: https://gqii.org/. Creative Commons licence apply.
es: ECI from Harvard Growth Lab. Own calculations for GQII 2020. Significant linear correlation of 0,78.

Figure 11: GQII and Economic Complexity Index

6

CONCLUSIONS AND OUTLOOK

A milestone of global QI measurement

The GQII-Index 2020, covering 184 countries, is a milestone in measuring the relative devel-opment status of QI worldwide, building on earlier versions and research over the past ten years. International development cooperation organizations active in this field will obtain an evidence-based overview for their programs and projects. The data from the GQII can be used, for example, in the project design for a baseline study. In the context of regional projects, the GQII data allow benchmarking and mutual learning. Simultaneously, the data and ranking serve the QI organizations themselves to assess their current relative development status.

This study confirms the strong correlation between QI development and a country's export ca-pacity. Leading export economies such as the US, China and Germany are at the top of the global QI ranking, as expected. While this relationship does not suggest a correlation, it does clearly indicate that an increase in exports requires correlation with a more robust national QI system.

Given the correlation, it should be convincing for policymakers to invest resources in QI. At the same time, additional analysis is always needed to better understand the correlation between QI investments and economic development. Policymakers in economies with high QI invest-ments and relatively low dynamism may ask whether the investments have been used effective-ly and efficiently. This is where the GQII data can provide valuable input.

The position of an economy in the GQII provides a rough guide to the development status of QI in a country. For a detailed analysis, it is advisable to evaluate all the data of the GQII and its sources in detail. Qualitative information and expert assessments should always be consulted when analysing the QI of an economy. It is also interesting to see to what extent the different components of QI are developing similarly and how differences in the state of development of metrology, standardization and accreditation can be explained.

Data collection has given insights into data transparency and quality

The collection of data has provided us with valuable insights regarding data transparency and quality. For metrology, the KCDB in its new version is a reliable and easily accessible source. We have learned that measuring the number of CMCs is not necessarily a good indicator of an economy's metrological competence. The CMC coverage indicator which the authors have de-veloped, on the other hand, is meaningful as metrology experts have confirmed.

In standardization, the ISO Survey data are informative as they document the use of manage-ment standards by companies. Since these data are based on a survey, and it is not clear which certification bodies provided information, misinterpretations can occur. However, these can be mitigated if the current ISO Survey data for an economy is compared with the comparative data from previous years.

This study required the collection of a number of accredited conformity assessment bodies by consulting the website of 165 accreditation bodies worldwide. Today there is no standardized and transparent presentation of the data. To enable possible data transparency, the authors recommend that the national accreditation bodies develop a guideline for data collection and presentation and that the statistics of the international and regional accreditation organizations be published at the level of individual organizations and economies. Publication of this data would lead to more transparency and confidence in accreditation. In fact, the impression is that the publication of accreditation data has induced some accreditation bodies to take greater care in the publication of their data and to make their websites more user friendly.

Ranking economies according to the relative level of development of their QI, is somewhat con-troversial. Some experts whom the authors consulted fear that the ranking could be criticized by representatives of less highly ranked economies. Again, this ranking does not allow any direct qualitative conclusion as "the higher, the better"; for small economies with limited trade such as Bhutan, for instance, rank 151 may be perfectly acceptable.

The choice of indicators could also be questioned. It is certain that the assessment of the relative level of development of the QI of an economy is always associated with a certain degree of measurement uncertainty. On the other hand, the use of various sub-indicators ensures that the overall assessment of a country's QI is accurate. Thus the experts in focus groups on accredita-tion and metrology have basically confirmed the plausibility of the ranking of the economies.

QI development and export correlation justify development cooperation efforts

A ranking of the relative level of development of QIs is needed to compare them with other rankings. The significant correlation of QI development with export performance and the com-plexity of the economies is ultimately a justification for development cooperation to continue investing in the expansion of QIs. It will be interesting to observe this correlation as well as the individual performance of economies over time.

The GQII database and ranking is a vital step towards basing the promotion of QI on evidence. The database provides valuable data that can be used for different types of analysis. Analogous to business intelligence, we see great potential for a technology-driven process for analysing data and presenting actionable information that helps QI body representatives, policymakers and leaders make informed business decisions. The GQII offers an open platform to promote data-driven QI development.

See Acknowledgements.

ANNEXURE: COUNTRY PROFILES

Each county profile contains basic information on the respective economy, such as the official name, the flag, a profile of the territory and data on population, GDP per capita and exports. The focus is on information on the relative state of development of the national quality infra-structure and its components (metrology, standards and accreditation). For each of these com-ponents, the respective rank among the 184 countries is expressed. The graphs also show the score value and the distribution of all the economies. Each chart also gives the names and icons of the central institutions of the national QIs and the indicators used in the GQII formula.

In the field of metrology, the country profile shows whether and since when the NMI has been a member of the CIPM and in what percentage of the total of ten Consultative Committees of the CIPM the NMI is represented. The coverage of the Calibration and Measurement Capabilities (CMCs) indicates the percentage of the nine metrological areas that have registered their own CMCs. Added to this are the absolute numbers of key and supplementary comparisons regis-tered with the BIPM and the number of accredited calibration laboratories in the country.

In the field of standardisation, the country profile records the membership in ISO as well as the number of ISO technical committees in which representatives of the economy participate as full members or observers. The number of certified ISO management systems in the country are also included.

In the area of accreditation, the profile records whether the country is a signatory to an MRA or MLA. The coverage of the Conformity Assessment bodies is the percentage that a country co-vers of the sixteen accreditation scopes covered. Added to this are the absolute numbers of con-formity assessment bodies accredited in the country for product certification, management sys-tems and test laboratories.

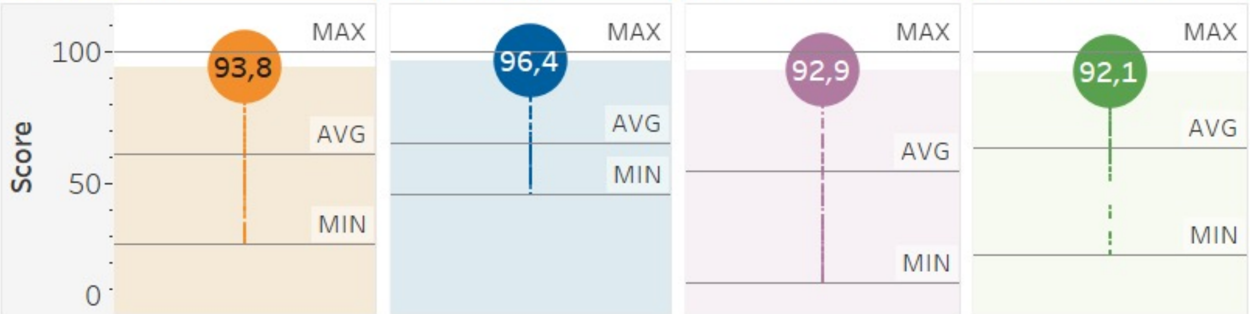
Global Quality Infraestructure Index ©
Country Profile 2020

Brazil

14th /184

Population	211,0M
GDP per Capita (Current USD)	$ 8.717
Exports (Current USD)	$ 263.498M

GQII | 2020 — Metrology — Standards — Accreditation



Rank.	14th	9th	16th	26th

Metrology | Instituto Nacional de Metrologia, Qualidade e Tecnologia (INMETRO)

INMETRO

CIPM-MRA Status: Member State	Participation in Consultative Committees	Coverage of Calibration and Measurement Capabilities	Key and Supplementary Comparisons	Calibration Labs 17025
1999-10-14	75%	100%	276	426

Standardization | Associação Brasileira de Normas Técnicas (ABNT)

ISO Membership:	Technical Committees (Participating Member)	Technical Committees (Observing Member)	ISO Management System Certificates
Member body	234	54	21.549

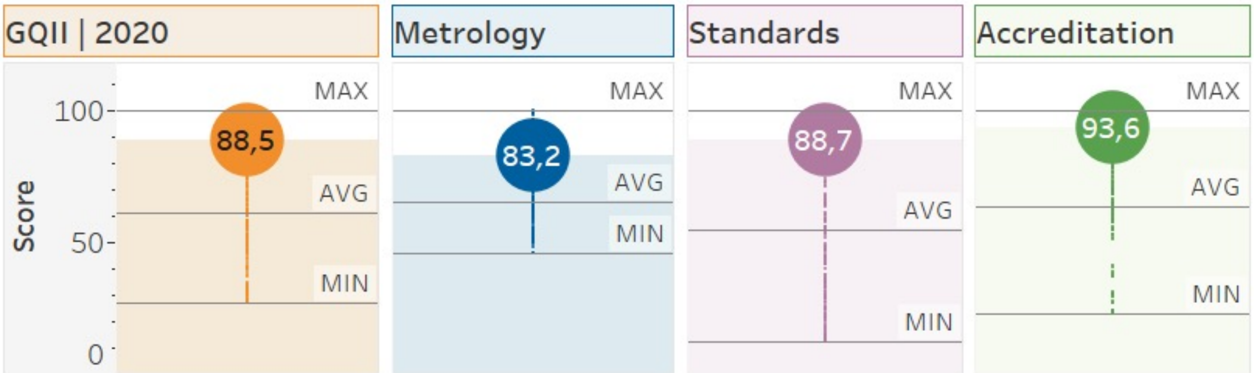
Accreditation | General Coordination for Accreditation (CGCRE)

ILAC-IAF Membership:	Conformity Assessment Bodies Coverage	Product Certification ISO-17065	Management Systems ISO-17021	Testing Labs ISO-17025
Signatory - Signatory	88%	117	40	1.166

Source: https://gqii.org/

Global Quality Infraestructure Index ©
Country Profile 2020

Colombia			
30th /184	Population	50,3M	
	GDP per Capita (Current USD)	$ 6.432	
	Exports (Current USD)	$ 51.465M	



Rank.	30th	42th	31th	21th

Metrology | Instituto Nacional de Metrología de Colombia (INM(CO))

CIPM-MRA Status: Member State	Participation in Consultative Committees	Coverage of Calibration and Measurement Capabilities	Key and Supplementary Comparisons	Calibration Labs 17025
2013-05-15	0%	56%	52	189

Standardization | Instituto Colombiano de Normas Técnicas y Certificación (ICONTEC)

ISO Membership:	Technical Committees (Participating Member)	Technical Committees (Observing Member)	ISO Management System Certificates
Member body	69	107	14.181

Accreditation | Organismo Nacional de Acreditación de Colombia (ONAC)

ILAC/IAF Membership:	Conformity Assessment Bodies Coverage	Product Certification ISO-17065	Management Systems ISO-17021	Testing Labs ISO-17025
Signatory/ Signatory	100%	38	15	236

Source: https://gqii.org/

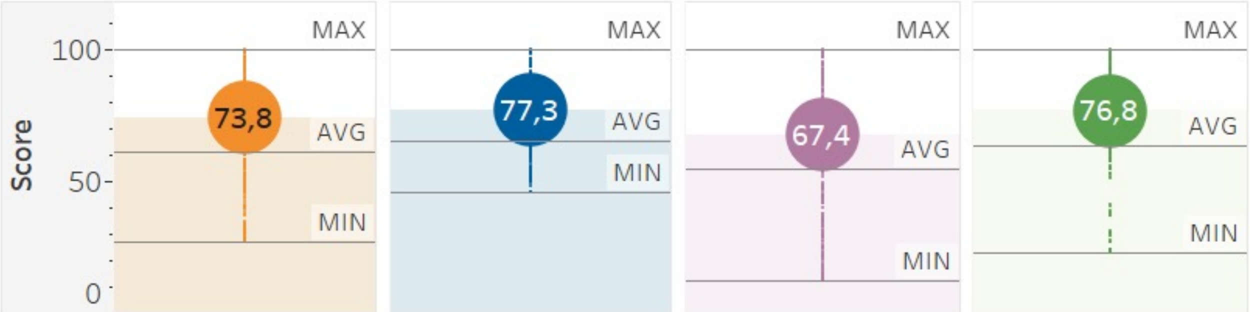
Global Quality Infraestructure Index ©
Country Profile 2020

Kenya

58th /184

Population	52,6M
GDP per Capita (Current USD)	$ 1.817
Exports (Current USD)	$ 11.491M

GQII | 2020	Metrology	Standards	Accreditation



Rank.	58th	53th	62th	64th

Metrology | Kenya Bureau of Standards (KEBS)

CIPM-MRA Status: Member State	Participation in Consultative Committees	Coverage of Calibration and Measurement Capabilities	Key and Supplementary Comparisons	Calibration Labs 17025
2002-11-21	10%	22%	32	22

Standardization | Kenya Bureau of Standards (KEBS)

ISO Membership:	Technical Committees (Participating Member)	Technical Committees (Observing Member)	ISO Management System Certificates
Member body	76	153	698

Accreditation | Kenya Accreditation Service

ILAC-IAF Membership:	Conformity Assessment Bodies Coverage	Product Certification ISO-17065	Management Systems ISO-17021	Testing Labs ISO-17025
Signatory - Signatory	56%	3	4	43

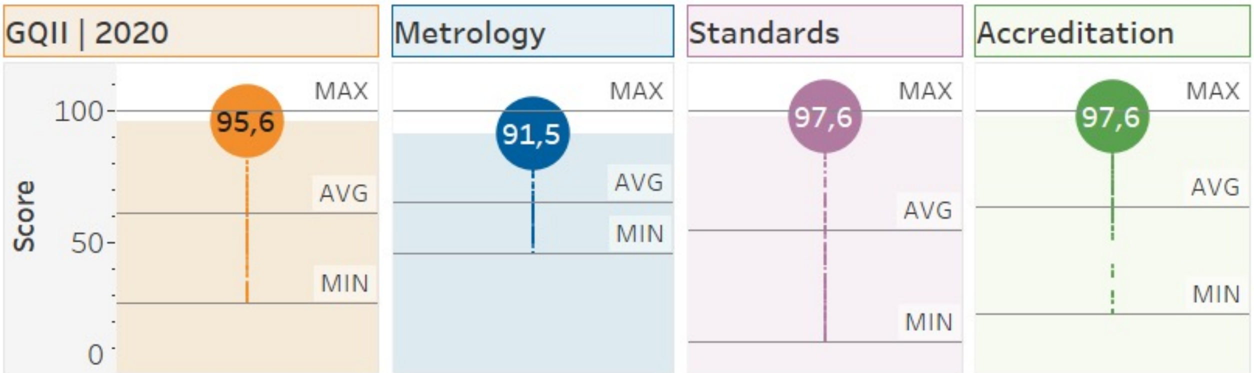
Source: https://gqii.org/

Global Quality Infraestructure Index ©
Country Profile 2020

India

10th /184

Population	1.366,4M
GDP per Capita (Current USD)	$ 2.104
Exports (Current USD)	$ 536.558M



Rank.	GQII 2020	Metrology	Standards	Accreditation
	10th	19th	7th	9th

Metrology | CSIR National Physical Laboratory of India

CIPM-MRA Status: Member State	Participation in Consultative Committees	Coverage of Calibration and Measurement Capabilities	Key and Supplementary Comparisons	Calibration Labs 17025
1999-10-14	40%	89%	181	1.034

Standardization | Bureau of Indian Standards

ISO Membership:	Technical Committees (Participating Member)	Technical Committees (Observing Member)	ISO Management System Certificates
Member body	473	194	51.294

Accreditation
| Accreditation Commission for Conformity Assessment Bodies
| National Accreditation Board for Certification Bodies (NABCB)
| National Accreditation Board for Testing & Calibration Laboratories NABL
| Quality and Accreditation Institute Private Limited (QAI)

ILAC-IAF Membership:	Conformity Assessment Bodies Coverage	Product Certification ISO-17065	Management Systems ISO-17021	Testing Labs ISO-17025
Signatory - Signatory	100%	24	101	3.661

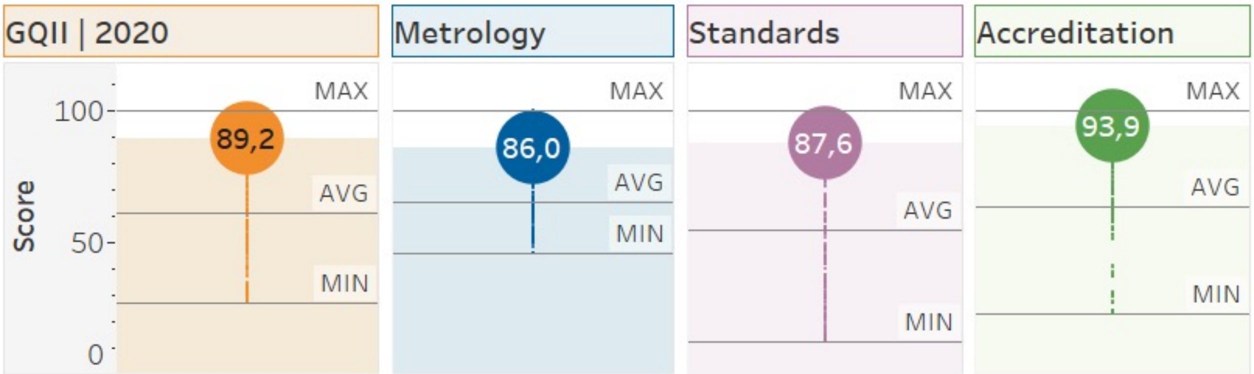
Source: https://gqii.org/

Global Quality Infraestructure Index ©
Country Profile 2020

Indonesia

***26th** /184*

Population	270,6M
GDP per Capita (Current USD)	$ 4.136
Exports (Current USD)	$ 206.015M



Rank.	26th	35th	36th	18th

Metrology | National Standardization Agency of Indonesia (SNSU-BSN)

CIPM-MRA Status: Member State	Participation in Consultative Committees	Coverage of Calibration and Measurement Capabilities	Key and Supplementary Comparisons	Calibration Labs 17025
2004-06-02	0%	78%	84	223

Standardization | National Standardization Agency of Indonesia (BSN)

ISO Membership:	Technical Committees (Participating Member)	Technical Committees (Observing Member)	ISO Management System Certificates
Member body	100	170	9.752

Accreditation | Komite Akreditasi Nasional (KAN)

ILAC/IAF Membership:	Conformity Assessment Bodies Coverage	Product Certification ISO-17065	Management Systems ISO-17021	Testing Labs ISO-17025
Signatory/ Signatory	94%	76	52	1.183

Source: https://gqii.org/

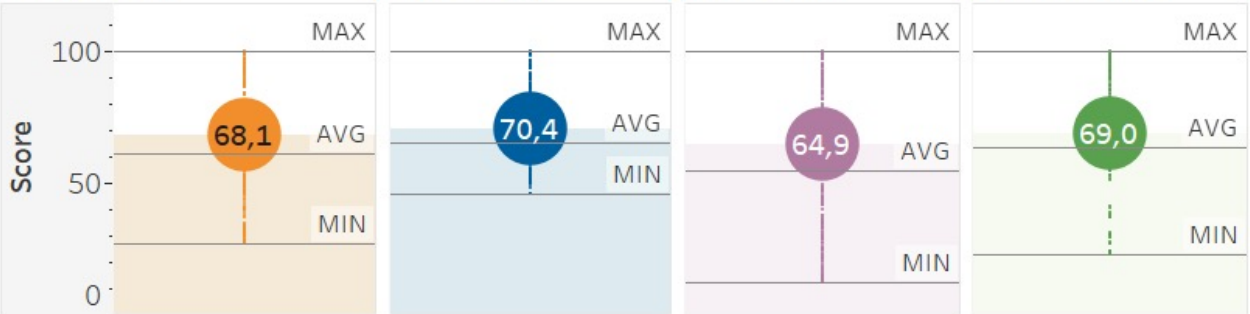
Global Quality Infraestructure Index ©
Country Profile 2020

Morocco

69th /184

Population	36,5M
GDP per Capita (Current USD)	$ 3.255
Exports (Current USD)	$ 46.468M

GQII | 2020	Metrology	Standards	Accreditation



Rank.	69th	65th	67th	86th

Metrology | Laboratoire National de Métrologie du Laboratoire Public d'Essais et d'Études

CIPM-MRA Status: Member State	Participation in Consultative Committees	Coverage of Calibration and Measurement Capabilities	Key and Supplementary Comparisons	Calibration Labs 17025
2019-07-15	0%	0%	1	23

Standardization | Institut Marocain de Normalisation (IMANOR)

ISO Membership:	Technical Committees (Participating Member)	Technical Committees (Observing Member)	ISO Management System Certificates
Member body	28	72	1.455

Accreditation | Moroccan Accreditation Service (SEMAC)

ILAC Membership:	Conformity Assessment Bodies Coverage	Product Certification ISO-17065	Management Systems ISO-17021	Testing Labs ISO-17025
Associate	31%	0	0,1	96

Source: https://gqii.org/

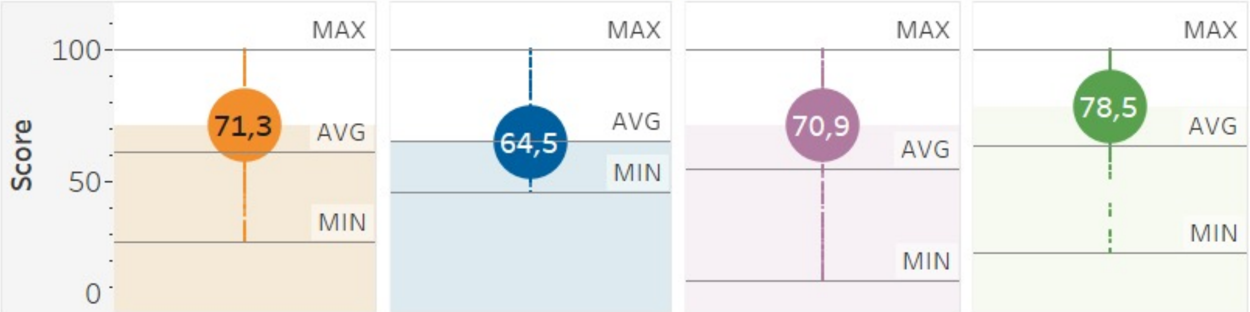
Global Quality Infraestructure Index ©
Country Profile 2020

Sri Lanka

62th /184

Population	21,8M
GDP per Capita (Current USD)	$ 3.853
Exports (Current USD)	$ 19.426M

GQII | 2020	Metrology	Standards	Accreditation



Rank.	*62th*	*74th*	*60th*	*59th*

Metrology | Measurement Units, Standards & Services Department

CIPM-MRA Status: Associate of CGPM	Participation in Consultative Committees	Coverage of Calibration and Measurement Capabilities	Key and Supplementary Comparisons	Calibration Labs 17025
2016-08-17	0%	0%	9	12

Standardization | Sri Lanka Standards Institution

ISO Membership:	ISO Technical Committees (Participating Member)	ISO Technical Committees (Observing Member)	ISO Management System Certificates
Member body	82	121	2.346

Accreditation | Sri Lanka Accreditation Board for Conformity Assessment

ILAC/IAF Membership:	Conformity Assessment Bodies Coverage	Product Certification ISO-17065	Management Systems ISO-17021	Testing Labs ISO-17025
Signatory/ Signatory	69%	3	2	70

Source: https://gqii.org/

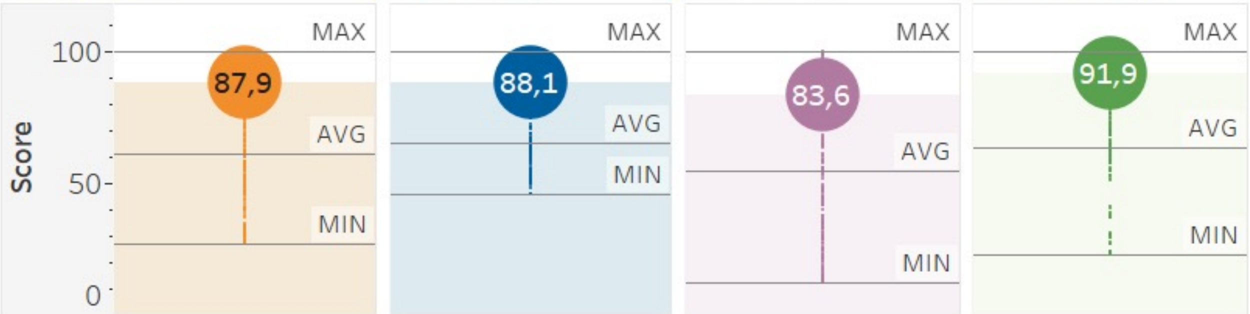
Global Quality Infraestructure Index ©
Country Profile 2020

Ukraine

32th /184

Population	44,4M
GDP per Capita (Current USD)	$ 3.465
Exports (Current USD)	$ 63.315M

GQII | 2020 — Metrology — Standards — Accreditation



Rank.	32th	28th	48th	28th

Metrology | Ministry of Economic Development and Trade of Ukraine (ME)

MINISTRY OF ECONOMIC DEVELOPMENT AND TRADE OF UKRAINE

CIPM-MRA Status: Member State	Participation in Consultative Committees	Coverage of Calibration and Measurement Capabilities	Key and Supplementary Comparisons	Calibration Labs 17025
2003-10-14	10%	100%	126	31

Standardization | Ukrainian Scientific Research and Training Center for Standardization, Certification and Quality Problems (UkrNDNC)

UAS

ISO Membership:	Technical Committees (Participating Member)	Technical Committees (Observing Member)	ISO Management System Certificates
Member body	136	233	2.305

Accreditation | National Accreditation Agency of Ukraine (NAAU)

Національне агентство з акредитації України
National Accreditation Agency of Ukraine

ILAC/IAF Membership:	Conformity Assessment Bodies Coverage	Product Certification ISO-17065	Management Systems ISO-17021	Testing Labs ISO-17025
Signatory/ Signatory	88%	123	62	532

Source: https://gqii.org/

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