UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

INETQI
INTERNATIONAL NETWORK ON QUALITY INFRASTRUCTURE

SUSTAINABLE DEVELOPMENT GOALS

QI4SD

QUALITY INFRASTRUCTURE FOR SUSTAINABLE DEVELOPMENT INDEX

Methodological Annex

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

QUALITY INFRASTRUCTURE FOR SUSTAINABLE DEVELOPMENT INDEX

Methodological Annex

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ACRONYMS

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

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

1. Overview

Quality Infrastructure (QI) and sustainable development are both multidimensional concepts that cannot be directly measured. They can however be broken down into smaller concepts—QI into its respective dimensions, and sustainable development into the 17 Sustainable Development Goals (SDGs) or the 3 or 5Ps. Even these sub-concepts are complex, however.

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

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

Building a composite indicator or a scoreboard requires following a number of steps, which are roughly summarised here:

1. Establish what you are trying to measure, who will use the end product, and what kind of questions you expect the framework to be able to answer.
2. Carefully map the main dimensions and sub-dimensions of the concept via a literature review and interviewing experts.
3. Collect indicators to populate your conceptual framework. This may involve collecting your own raw data through surveys or data mining.
4. Select the most relevant indicators through a series of indicator criteria.
5. Build the index/scoreboard, and perform statistical analysis; adjust accordingly.
6. Check that the results make sense with experts and stakeholders, and that the product agrees with expectations; adjust accordingly.
7. Check robustness through uncertainty and sensitivity analysis.
8. Visualise the data – this can involve static or interactive data visualisations, and is ideally hosted online for maximum visibility. Make data and methodology clearly available.
9. Extract conclusions and narratives from the data by comparing with other quantities, highlighting higher/lower performers, regional/time trends.
10. Communicate the results through reports, infographics, articles, social media and so on, as appropriate to the context.

These steps are not exhaustive and are also not usually followed strictly one after another – often the framework will be iteratively adjusted after expert consultation and based on data availability and so on. In general, these steps are an adaption of the steps found in the JRC and OECD Handbook on Constructing Composite Indicators,[1] which is the main reference for composite indicator construction.

A composite indicator approach was used to measure QI and its intersections with sustainable development, at the national level. This methodological annex describes the main steps that were taken in building the QI4SD Index.

We note from the outset that the choice of whether the indicator framework should be aggregated into a composite index, or simply left as a scoreboard, is delicate and dependent on the context and the concept to be measured. Our decision was to use a composite indicator approach, for at least the following reasons:

1. It results in a digestible summary measure that is easy to communicate to stakeholders.
2. The final number of indicators (36) would be very difficult to present in a concise manner if it were a scoreboard.
3. It provides an accessible entry point to the underlying indicator data.
4. Composite indicators allow analysis at a concept level, i.e. it is possible to see how QI relates to other variables such as GDP, wealth, sustainable development, and trade.
5. An index is complementary to a scoreboard – effectively it is a summary of a scoreboard. That means that it is not an either/or choice because underlying indicator data can be presented next to the index scores (see the Country Profiles). One can have it both ways.

The rest of this document is organised as follows. We begin in Section 2 by describing the conceptual framework; that is, how the concept of QI and sustainable development was mapped, and how indicators were selected. Then in Section 3 we describe the methodology applied to build each indicator, including the general methodology for "P-indicators" (those that are broken down into the three pillars of sustainable development). In Section 4 we describe the UNIDO/ISO survey that was launched to collect missing indicators. In Sections 5 and 6 we describe the methodology for aggregating the data into an index, with the former giving a description and explanation for methodological choices, and the latter giving some technical details of the R code that was used to build the index. Finally, the last section contains the Appendix with the UNIDO/ISO survey.

[1] JRC, OECD, 2008. JRC/OECD Handbook on constructing composite indicators: methodology and user guide. OECD publishing. Handbook on Constructing Composite Indicators: Methodology and User Guide (oecd.org)

2. Conceptual framework

2.1

CONCEPT MAPPING

One of the first steps in building any composite indicator is to better understand the target concept. In this case, the concept is "Quality Infrastructure" (QI), in particular with an emphasis on sustainable development. Both QI and sustainable development are multidimensional concepts, so must be decomposed into simpler dimensions that can be more readily captured with indicators. This decomposition is called a "conceptual framework" because it maps the main dimensions (and possibly sub-dimensions) of the concept.

The conceptual framework of the QI4SD Index, and its indicators, were assembled based on a literature review and several rounds of consultation with experts from INetQI organisations. The main dimensions of QI are defined as follows[2]:

1. Standards (also include technical regulations)
2. Accreditation
3. Metrology (Scientific, Industrial and Legal)
4. Conformity Assessment (Management System, Product and Personnel Certification Bodies, Testing and Calibration Laboratories, and Inspection Bodies)
5. Market Surveillance (for technical regulations only)

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

6. Policy measures

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

Sustainable development, on the other hand, is detailed in the 17 Sustainable Development Goals (SDGs). To simplify this division, this work uses the so-called "3Ps", which are People, Planet and Prosperity. Aggregating to the PPP level allows a potentially clearer analysis according to the canonical "pillars[3]" of sustainable development: social (people), environmental (planet) and economic (prosperity).

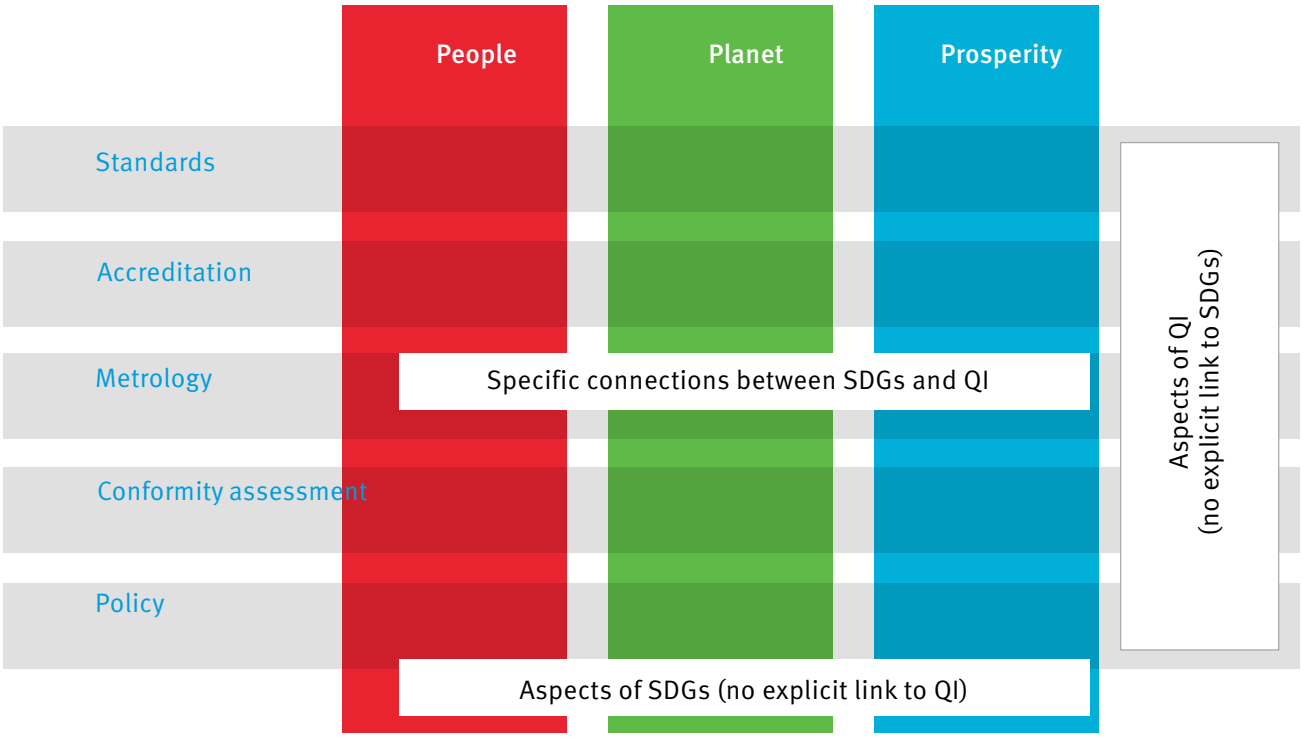
The division of SDGs used in this work is shown in Figure 1.

FIGURE 1: Grouping of SDGs into "P" dimensions

[2] See: https://tii.unido.org/sites/default/files/publications/QI_SDG_PUBLICATION_Dec2019.pdf

[3] For clarity, we refer to People, Planet and Prosperity as "pillars" of sustainable development, and Accreditation, Standards, Metrology, etc., as "dimensions" of QI.

FIGURE 2: Merging the conceptual frameworks of Quality Infrastructure and sustainable development



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

Merging the two multidimensional frameworks (the five dimensions of QI, and the three pillars of sustainable development), results in a conceptual matrix shown in figure 2

There are at least three conceivable types of indicators here, which are shown in the grey boxes.

1. Indicators that measure specific intersections between QI dimensions and the SDGs. An example would be adopted environmental standards: this maps a QI dimension (standardisation) to an SDG dimension (Planet). These are the most desirable indicators but are hard to obtain. They require two main components:

    a. A detailed data set, e.g. in the example given, we would need to know which specific standards have been adopted by each country.

    b. A mapping that tells us to which dimension of the SDGs the QI indicator is contributing. In the example given, we would need to know to which P each standard is contributing.

Clearly, this kind of data is not always possible to obtain, although it is available in some cases.

2. Indicators that measure aspects of QI but have no explicit link to SDGs. This could be the number of accredited labs in a country, or the membership of international QI organisations. Such indicators are very relevant to QI, and these activities no doubt contribute to SDGs, but there is no way to decompose or link them to specific dimensions of sustainable development.

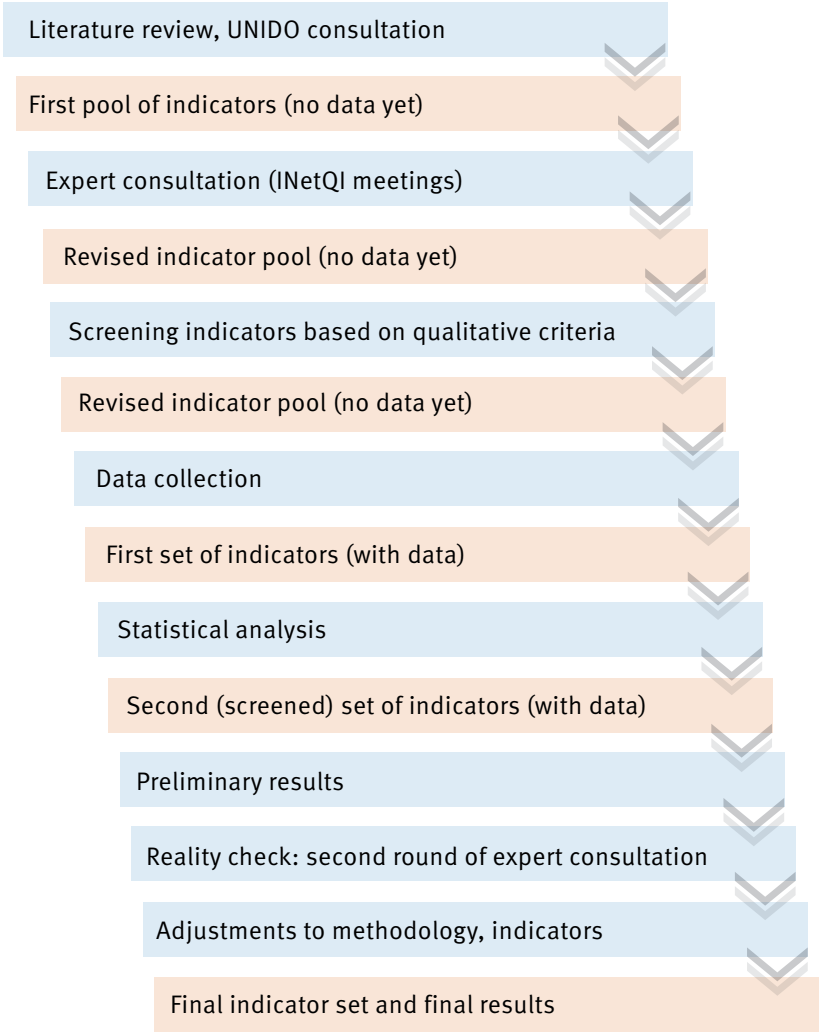
3. Indicators that measure sustainable development but have no particular link to QI. These are generic indicators linked to SDGs, which can be found in any of the many indexes and scoreboards that measure sustainable development. They are likely to be the least relevant indicators, in that we are interested in measuring QI that can contribute to SDGs, not the SDG outcomes themselves.

The "matrix" framework here is somewhat unconventional in composite indicators, in that it attempts to merge two multidimensional concepts (QI and sustainable development). This has presented challenges in indicator selection, processing, analysis and presentation of results, in particular because it effectively results in four indexes. Figure 2 simply shows the union of the two concepts of QI and sustainable development. The final conceptual framework of the QI4SD Index is presented in Section 2.3.

2.2 INDICATORS

Given the framework proposed in the previous section, indicators were selected, and data collected/analysed, according to the process shown in Figure 3.

FIGURE 3: The indicator selection process



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

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

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

Finally, the preliminary results were presented to QI experts as a reality check. Following feedback, the methodology and indicators were refined as necessary. The idea of this process was to involve experts at each step of the index construction, to provide the best outcome and to keep the index on track. Further details on each step are given in the following sections.

2.2.1

Expert input

Based on UNIDO expertise and the literature review, a list of around 80 candidate indicators was prepared. For most indicators in this list, data was not readily available. The first task, therefore, was to approach each INetQI organisation in bilateral meetings to elicit their opinions and to see whether they could help with data acquisition.

INetQI organisations are typically (mainly) associated with one dimension of QI, so each organisation can provide

expert guidance on their respective dimension, but in many cases, they can also offer valuable input on other dimensions, and on the overall concept of the QI4SD Index.

Experts from each QI organisation were asked questions on the following issues, among others:

1. Whether the proposed indicators are relevant in measuring/monitoring the relevant dimension, in particular with relation to SDGs
2. Whether they have any data relevant to these indicators that could be used in the QI4SD Index, or whether they could suggest data sources
3. Whether they would propose any additional indicators
4. Whether any indicators in our list are not suitable
5. Whether they have any general thoughts, suggestions, and criticisms about our approach to measuring QI

These questions, and further discussions, resulted in a refinement of the indicator list and helped to identify a number of data sources. In some cases, INetQI organisations were prepared to share non-public data, and this has helped to enrich the QI4SD data set.

2.2.2

Selection criteria

The literature review and the expert consultation resulted in a set of candidate indicators, which were then subjected to a set of indicator criteria, beginning with qualitative considerations. After data was collected for the remaining indicators, it was possible to also apply quantitative criteria, such as checking data availability—this is discussed in the next section.

Indicator selection criteria were as follows.

- Relevance to the framework, and in particular to the intersection of the P and QI component in question (note that, although ideally indicators should address a particular intersection of a P and QI, indicators that generally address a QI contribution to sustainable development, or specific dimensions of QI can also be considered).
- Availability of data, in terms of:
- Cross-country coverage
- Time coverage (i.e. time series data is an advantage, and suggests that the indicator would be regularly updated)
- Cost/ease of data acquisition (if not already available). Since some indicator data might be acquired through a survey.
- Reliability of data: is the data from a trusted source and representative of the reality?
- Value added: indicators should each bring unique information to the framework, and overlaps should be minimised.
- Interpretability: it should be clear what the indicator is measuring, so that it is useful to end-users on its own, as well as part of a framework.
- Differentiation: indicators should show a range of values between countries. If the indicator has the same or very similar values for all or most countries, it is not very useful in making comparisons.

It is worth noting that although repetitions and overlaps should be avoided in the context of a composite indicator and a coherent scoreboard, some indicators can have a standalone value. Indicators that repeat similar information still could be included in a separate pool of auxiliary indicators which still could be useful to stakeholders interested in particular quantities, rather than the overall index/scoreboard.

In general, these criteria were used as guidance for selection, but compromises sometimes have to be made between, e.g. relevance, data availability, and sometimes data reliability.

2.2.3

Data collection

Data quality and availability can be inconsistent between different countries. As a result, some previous efforts to quantify QI focus only on countries that are embedded in the international QI and trade system, aiming to improve comparability.[4] In practice, this means belonging to international institutions on accreditation, certification, standardisation or metrology (e.g. ISO, ITU, and BIPM).

The present QI4SD Index is more ambitious and leverages UNIDO's connections in the INetQI community to obtain data that may not otherwise be available or immediately obvious.

Overwhelmingly, the data collected has been through INetQI organisations, since no centralised statistics exist on Quality Infrastructure (e.g. through the World Bank, OECD, or other typical sources of national-level indicators). The data from the INetQI organizations was collected from February to June 2021. However, the data year might differ from the year of collection as these organizations have different timeframes to update their own information. Full details on each indicator are given in Section 3, but data is generally collected from the following sources:

[4] Harmes-Liedtke, U., Oteiza Di Matteo, J.J., 2021. Global Quality Infrastructure Index Report 2020. GQII Report 2020 – Global Quality Infrastructure Index (GQII) Program

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

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

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

The final category was used only for key indicators for which no other source is available. UNIDO was able to launch a dedicated survey in collaboration with ISO, using the ISO member network. This survey is described in more detail in Section 4.

2.3

FINAL FRAMEWORK

The conceptual framework and indicator/data collection resulted in the final framework shown in Figure 4:

The conceptual framework can be better explained by considering that in measuring the intersection of QI4SD and SDGs, two types of indicators arise (see also Section 2.1).

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

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

The result is that there are in fact **four indexes**:

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

Importantly, this means that the 3P-Indexes (items 2–4 above) do not include the general indicators. The reason for this is to isolate the "P-contribution" of these indicators. An alternative would be to also include general indicators in the P-indexes, but this was found to "dilute" the effect of the P-indicators and the results were too similar to the general index.

Overall, the P-indexes should be viewed as a somewhat separate measure to the general index, in that the set of indicators is not the same. Nevertheless, the P-indexes include many important indicators, such as adopted standards, participation in technical committees (TCs), and others.

FIGURE 4: Conceptual framework/matrix of the QI4SD index

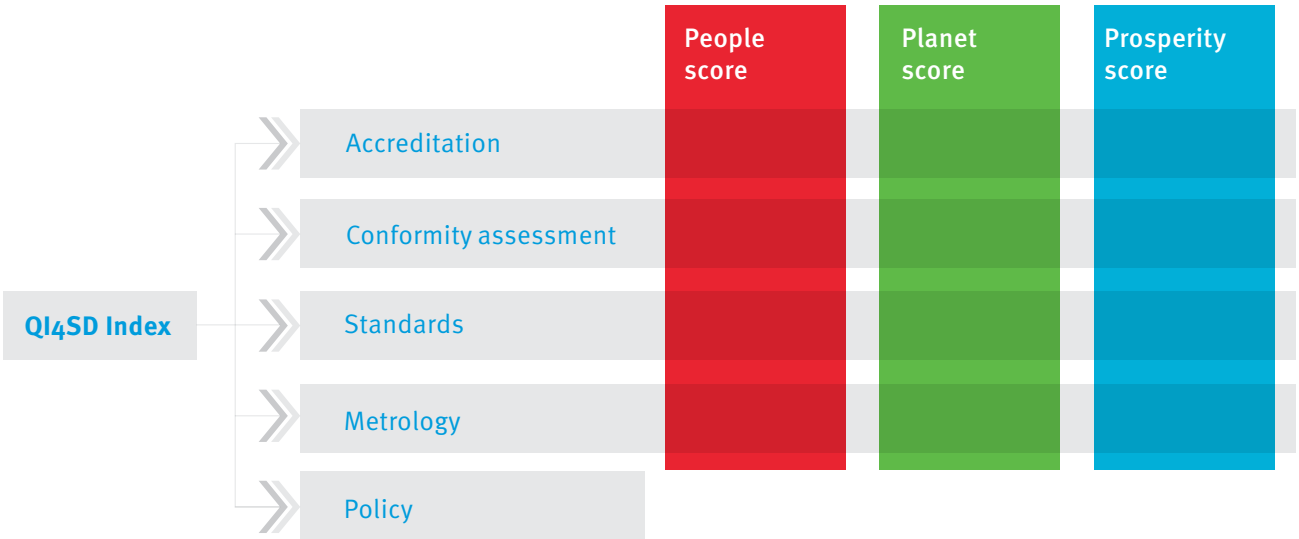


Table 1 shows the indicators in the "full" index, and Table 2 shows the indicators included in each of the P-indexes for completion.

Table 1: Indicators in the full QI4SD Index. Type "P" refers to "P-indicators" as defined previously; "G" refers to "general indicators"

Dimension	Name	Unit	Organisation	Type	Weight
ACCREDITATION	Scopes of IAF accreditation bodies	Number	IAF	P	1
	Signatory to the IAF MLA	Yes/no	IAF	G	1
	Scopes of ILAC accreditation bodies	Number	ILAC	P	1
	Signatory to the ILAC MRA	Yes/no	ILAC	G	1
CONFORMITY	Membership of IEC conformity assessment systems	Number	IEC	G	1
	Number of IECEE certificates recognised	Number	IEC	G	1
	Number of recognised certificates (IQNet)	Number	IQNet	P	0,5
	Membership of IQNet	Composite score	IQNet	G	1
	Number of recognised certificates (ISO)	Number	ISO	P	0,5
METROLOGY	Participation in CIPM Consultative Committees	Number	BIPM	G	1
	Participation in key and supplementary comparisons	Number	BIPM	G	1
	Number of CMCs	Number	BIPM	P	0,5
	Breadth of CMCs	Number of types	BIPM	P	0,5
	Membership of BIPM	Categorical	BIPM	G	1
	Membership of OIML	Categorical	OIML	G	1
	OIML-CS - number of services offered	Number	OIML	G	0,5
	OIML-CS - number of services recognised	Number	OIML	G	0,5
	Involvement in OIML project groups	Composite score	OIML	G	1
POLICY	Participation in capacity building progammes	Number of types	UNIDO/ISO	G	1
	Quality policy in place	Yes/no	UNIDO/ISO	G	1
	Dimensions of QI addressed by quality policy	Number	UNIDO/ISO	G	1
	Support and funding for quality policy	Yes/no	UNIDO/ISO	G	1
	Government/political endorsement for quality policy	Yes/no	UNIDO/ISO	G	1
	Government approval of quality policy	Yes/no	UNIDO/ISO	G	1
	Stakeholder involvement of quality policy	Yes/no	UNIDO/ISO	G	1
	Consideration of diversity in quality policy	Yes/no	UNIDO/ISO	G	1
	Implementation plan for quality policy	Yes/no	UNIDO/ISO	G	1
	Monitoring and evalution for quality policy	Yes/no	UNIDO/ISO	G	1
	Reviewing and updating for quality policy	Yes/no	UNIDO/ISO	G	1

STANDARDS	Adopted ISO standards	Number	ISO	P	1
	Adopted IEC standards	Number	IEC	P	1
	Membership of IEC	Categorical	IEC	G	1
	Participation in IEC technical committees	Number	IEC	P	1
	Membership of ISO	Categorical	ISO	G	1
	Participation in ISO technical committees	Number	ISO	G	1
	Membership of ITU	Composite score	ITU	G	1

Table 2: Indicators in the P-indexes. Type "P" refers to "P-indicators" as defined previously

DIMENSION	NAME	DESCRIPTION	UNIT	ORGANISATION	TYPE	WEIGHT
ACCREDITATION	Scopes of IAF accreditation bodies	Number of scopes for the IAF Multilateral Recognition Arrangement mapped into the 3Ps.	Number	IAF	P	1
	Scopes of ILAC accreditation bodies	Number of scopes for the ILAC Mutual Recognition Agreement mapped into the 3Ps.	Number	ILAC	P	1
CONFORMITY	Number of recognised certificates (IQNet)	Number of recognised certificates from IQNet database mapped into 3Ps.	Number	IQNet	P	0,5
	Number of recognised certificates (ISO)	Number of recognised certificates from ISO databse mapped into 3Ps.	Number	ISO	P	0,5
METROLOGY	Number of CMCs	Total number of Calibration and Measurement Capacities (CMCs) in any area mapped into 3Ps	Number	BIPM	P	0,5
	Breadth of CMCs	Total breadth of Calibration and Measurement Capacitiy (CMC) types with at least one capacity mapped into 3Ps	Number of types	BIPM	P	0,5
STANDARDS	Adopted ISO standards	ISO standards that had been adopted into national legislation and mapped into the 3Ps	Number	ISO	P	1
	Adopted IEC standards	IEC standards that have been adopted and mapped into the 3Ps	Number	IEC	P	1
	Participation in IEC technical committees	IEC technical committees (TCs) participation mapped into the 3Ps	Number	IEC	P	1

3. Indicator construction

Here the methodology for each indicator is explained in detail. There are two types of indicators in the QI4SD framework:

1. General indicators that measure various aspects of QI
2. P-indicators that can be used to map QI to specific aspects of SDGs: the 3Ps

It is important to point out that the fact that an indicator is "general" does not mean that it represents something that does not contribute to SDGs. It is simply that we cannot map its contribution to specific dimensions of sustainable development, either because the data is not available, or because it gives a very general contribution (e.g. membership of INetQI organisations) which is conceptually difficult to map.

With many indicators, it is required to convert qualitative/categorical data into numerical data, in order to be aggregated into an index. This inevitably involves assigning subjective scores to these categories, such as yes = 1 and no = 0, or numbers representing different membership categories. Although assigning scores in this way is subjective, all methodology was circulated to INetQI experts, and in some cases adjusted. Moreover, these scores are indicators rather than precise measurements.

3.1

ON P-INDICATORS

P-indicators follow a general methodology which is explained here to avoid repetition. The underlying requirement is to have detailed data at the country level, and a mapping of aspects of that data to the SDGs (or simply the 3Ps).

Taking the example of Recognized Certificates (ISO), the ISO survey provides data on how many valid Recognized Certificates (ISO) of different types are present in a country, as shown in the following table.

ISO also has a mapping of its standards to SDGs. In this case, it is done at the SDG level, and the standard either contributes (1) to each SDG or not (0). An example is given in the following table, with columns omitted for space reasons.

Table 4: Example of mapping an ISO standard to SDGs – further columns omitted for brevity

Standard	SDG 1	SDG 2	SDG 3	SDG 4	SDG 5	SDG 6
ISO 22000:2018	0	1	1	0	0	0

Using this mapping information, we calculate the overall contribution of the standard to each P by taking the sum of the number of SDGs to which the standard contributes in each P group, divided by the total number of SDGs to which it contributes. To continue with the ISO 22000 example above, the ISO mapping indicates that it contributes to:

» Two SDGs in the "**People**" group (SDGs 2 and 3)

» One SDG in the "**Planet**" group (SDG 12)

» No SDGs in the "**Prosperity**" group

We then calculate the "value" of the standard to each P as:

People value = 2/3

Planet value = 1/3

Prosperity value = 0

We divided by three since it is the total number of SDGs to which this standard contributes.

TABLE 3: CA sample of ISO survey data showing the number of selected valid Recognized Certificates (ISO) for selected countries

Country	ISO 9001:2015	ISO 14001:2015	ISO/IEC 27001	ISO 22000:2018	ISO 45001:2018
Afghanistan	5	1	33	12	
Albania	363	151	1	11	43
Algeria	499	124	1		34
Andorra	27	11	2	5	1
Angola	78	11			3
Antigua and Barbuda	2	0	38	132	
Argentina	6611	1581	19	29	115

Next, we multiply the P-values by the number of certificates. In this case, for example, Argentina has 29 valid ISO 22000 certificates, so its P-scores for this standard would be:

People score = 2/3 x 29 = 19.33

Planet score= 1/3 x 29 = 9.67

Prosperity score= 0 x 29 = 0

Then, the total P-scores for each country are calculated by taking the sum of the P-scores for each standard. This means that the P-scores do not represent exactly the number of standards with respect to each P, but are more a score of the overall contribution of that country's standards to each P. However, the sum of the P-scores (over the 3Ps) will still add up to the total number of ISO standards.

The underlying assumptions of this approach are:

a. The mapping is correct.

b. Each standard is in total "worth" the same. The sum of the People, Planet and Prosperity values is always one. This means that a standard that contributes to all SDGs is still worth the same as one that only contributes to one SDG, albeit in the latter case the value is all placed in one P.

c. Countries with more standards score higher than countries with fewer standards. This means that larger countries will generally score higher, but later on we analyse the index results with respect to GDP. An alternative approach could be to already divide P-scores by GDP or population, but this choice is delicate and would have to be applied to all indicators.

In the following sections we describe the methodology behind each indicator in detail.

3.2 ACCREDITATION

This dimension consists of four indicators, based around IAF and ILAC. Conceptually, they group into two pairs – scopes and signatories of agreements; and are described as such below.

3.2.1 Scopes of IAF and ILAC accreditation bodies

Both **IAF** and **ILAC** have, in addition to the membership status of accreditation bodies (ABs), data on the "scope" of the signatory ABs.* There are five main "scopes"[5] for the IAF MLA:

- Management Systems Certification (ISO/IEC 17021-1)
- Product Certification (ISO/IEC 17065)
- Certification of Persons (ISO/IEC 17024)
- Greenhouse Gas Validation and Verification (ISO 14065)
- Validation and Verification (ISO/IEC 17029)
- For completeness, the number of scopes of IAF MLA also include the so-called "sub-scopes", which are "*certificates that are 'equivalent' because the management systems, products, services or persons conform to the same standard*"[6].
- For ILAC, each AB is listed as having one or more of the following "scopes"[7]:
- Calibration (ISO/IEC 17025)
- Testing (ISO/IEC 17025)
- Medical testing (ISO 15189)
- Inspection (ISO/IEC 17020)
- Proficiency testing providers (ISO/IEC 17043)
- Reference material producers (ISO 17034)

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

FIGURE 5: Accreditation indicators

Dimension	Name	Unit	Organisation	Type	Weight
ACCREDITATION	Scopes of IAF accreditation bodies	Number	IAF	P	1
	Signatory to the IAF MLA	Yes/no	IAF	G	1
	Scopes of ILAC accreditation bodies	Number	ILAC	P	1
	Signatory to the ILAC MRA	Yes/no	ILAC	G	1

[5] Scopes - IAF
[6] Scopes - IAF
[7] https://ilac.org/signatory-search/

These scopes can be mapped to SDGs, although this mapping is slightly crude. Although ISO has a mapping of many standards to SDGs, none of the above standards are included, so this was done manually. The scores of these indicators follow the standard methodology for calculating P-indicators, described in Section 3.1.

3.2.2

Signatories of IAF and ILAC arrangements

For IAF, a country's AB can be a signatory to the Multilateral Recognition Arrangement (MLA).8 Additionally, some countries have more than one AB, e.g. Japan has three and the USA has five. This indicator simply counts whether a country has an AB that is a signatory to the MLA, such that yes = 1 and no = 0. This does not give any extra consideration of having multiple ABs in the same country, since some countries may divide accreditation into multiple ABs and others may not.

For ILAC, the indicator is equivalent but regards the ILAC Mutual Recognition Arrangement (MRA) [9].

3.3 CONFORMITY ASSESSMENT

FIGURE 6: Conformity assessment indicators

DIMENSION	NAME	UNIT	ORGANISATION	TYPE	WEIGHT
CONFORMITY	Membership of IEC conformity assessment systems	Number	IEC	G	1
	Number of IECEE certificates recognised	Number	IEC	G	1
	Number of recognised certificates (IQNet)	Number	IQNet	P	0,5
	Membership of IQNet	Composite score	IQNet	G	1
	Number of recognised certificates (ISO)	Number	ISO	P	0,5

In the conformity assessment dimension, there are a total of five indicators. Three of these are general, and two are P-indicators, concerning recognised certificates. Regarding the latter two, they are conceptually the same but from different sources. Each covers a different set of certificates and has a different geographical coverage. Analysis indicates that they are correlated but not strongly enough that they are the same. Ideally, these two indicators would be merged, but this would require detailed access to the underlying databases. A compromise here is to include both indicators but to weight each at a half.

3.3.1

Membership of IEC conformity assessment bodies

The IEC has four conformity assessment systems:[10]

- The IEC System of Conformity Assessment Schemes for Electrotechnical Equipment and Components (IECEE)
- The IEC System for Certification to Standards Relating to Equipment for Use in Explosive Atmospheres (IECEx)
- The IEC System for Certification to Standards Relating to Equipment for Use in Renewable Energy Applications (IECRE)
- The IEC Quality Assessment System for Electronic Components (IECQ)

A single indicator is assembled as the number of these systems that each country is a member of (all = 4, none = 0, etc.). They are grouped like this, rather than having a separate indicator for each, because this seemed commensurate with the level of detail of the other indicators.

3.3.2

Number of IECEE certificates recognised

Each of the four IEC conformity assessment systems mentioned previously also has a database of certificates

[8] https://www.iaf.nu/articles/IAF_Members_Signatories/4

[9] https://ilac.org/signatory-search/

[10] https://www.iec.ch/conformity-assessment/ca-systems

issued in each country. However, the most extensive database of these four is the IECEE database.[11] For this reason, it was selected and retained as an indicator.

The indicator simply counts the number of IECEE certificates present in each country.

3.3.3

Membership of IQNet

The International Certification Network (IQNet) is composed of a global network of member certification bodies (CBs) "*which are accredited against ISO/IEC 17021-1 (at least for QMS and EMS) by an IAF MLA signatory, have the potential (e.g. the capabilities, resources, established services) and will to contribute to the purpose and strategy of IQNET, and have established a reputation for integrity and competence in their country or market of origin*". Available data shows the location of head and subsidiary offices of these CBs, as well as their origin.[12] A CB can have offices in its own country, as well as in other countries.

This data was condensed into an indicator aiming to represent the level of involvement in IQNet. It is calculated as:

Score = (Number of head offices hosted in country) x 2 +

(Number of subsidiary offices hosted in country) +

(Number of offices created by the CB in other countries)

This score assumes that a head office is "worth" twice as much as a subsidiary office. It also includes the presence of offices created in other countries by the country's CB(s).

3.3.4

Number of recognised certificates (IQNet database)

IQNet has a worldwide database of certificates collected from its member certification bodies, covering 40 different ISO standards (and others).[13] The IQNet data shows the number of each certificate present in each country – in this sense it is very similar to the ISO Survey.

This indicator is assembled by mapping each standard to SDGs, then summing the number of certificates in the country, for each standard, multiplied by the "value" of the certificate for each P (obtained from the SDG mapping). This methodology is explained in detail at the beginning of Section 3.

Number of recognised certificates (ISO database)

Similarly to the IQNet database, ISO collects annual information on the number of certificates present in each country, covering 12 management standards.[14] The methodology for this indicator follows exactly the methodology described in the previous indicator and at the beginning of Section 3.

3.4 METROLOGY

In the metrology dimension, there are a total of nine indicators. Seven of these are general, and two are P-indicators, concerning the number and breadth (coverage) of calibration and measurement capacities.

FIGURE 7: Metrology indicators

Dimension	Name	Unit	Organisation	Type	Weight
METROLOGY	Participation in CIPM Consultative Committees	Number	BIPM	G	1
	Participation in key and supplementary comparisons	Number	BIPM	G	1
	Number of CMCs	Number	BIPM	P	0,5
	Breadth of CMCs	Number of types	BIPM	P	0,5
	Membership of BIPM	Categorical	BIPM	G	1
	Membership of OIML	Categorical	OIML	G	1
	OIML-CS - number of services offered	Number	OIML	G	0,5
	OIML-CS - number of services recognised	Number	OIML	G	0,5
	Involvement in OIML project groups	Composite score	OIML	G	1

[11] https://www.iecee.org/certification/certificates/

[12] https://www.iqnet-certification.com/en/about-us/finding-us/

[13] https://www.iqnet-certification.com/

[14] https://www.iso.org/the-iso-survey.html

FIGURE 8: The ten consultative committees (screenshot from BIPM website[16])

3.4.1

Participation in CIPM Consultative Committees

The International Committee for Weights and Measures (CIPM) consisting of nominated scientists and metrologists, prepares and executes the decisions of the General Conference on Weights and Measures (CGPM) and is responsible for the management of the BIPM. The primary mission of the CIPM is to promote world-wide uniformity in units of measurement. There are a total of ten *consultative committees* (CCs) in the CIPM, which seek to increase collaboration between national metrology institutes in ten areas of metrology.[15] These areas are shown in Figure 8. Each country's national metrology institute can be either a member or observer of each CC depending on scientific capabilities.

The indicator for the QI4SD Index is constructed as the sum of overall participation in consultative committees, where for each CC, scores are assigned as:

Member = 2

Observer = 1

Neither = 0

The indicator is calculated as the sum of the scores for each CC. This results in a score between 0 (no participation of any kind in any CC) to 20 (member of all ten CCs).

[15] https://www.bipm.org/en/committees/cc

[16] CIPM Consultative Committees - BIPM

3.4.2

Participation in key and supplementary comparisons

The BIPM key comparison database gives details on the number of key[17] and supplementary[18] comparisons participated in by each country. For the key and supplementary comparisons, countries can either pilot them or participate in them, and scores are assigned as:

Pilot = 2

Participation = 1

Neither = 0

The indicator is calculated as the sum of the scores for the key and supplementary comparisons.

3.4.3

CMC number and breadth

The BIPM has detailed data on the number calibration and measurement capacities (CMC) of each country. The CMCs[19] are divided into nine metrology areas: acoustics, ultrasound and vibration (AUV), electricity and magnetism (EM), length (L), mass and related quantities (M), photometry and radiometry (PR), thermometry (T), time and frequency (TF), chemistry and biology (QM) and ionizing radiation (RI), and these are further divided into 47 metrology subareas.

[17] https://www.bipm.org/kcdb/comparison/statistics/key

[18] https://www.bipm.org/kcdb/comparison/statistics/supplementary

[19] https://www.bipm.org/kcdb/cmc/statistics/public

TABLE 5: Sample of CMC data from BIPM

	AUV					EM									
Country	A	W	V	Total	U-tables	DC	Imp	AC	HV	Other	Field	RF	Mat	Total	U-tables
Albania															
Argentina	7		7	**14**	1	43	17	12	6			10		**88**	34
Australia	13		10	**23**		17	6	16	28	9	4			**80**	32
Austria	19		6	**25**		15	3	21	7					**46**	30

The table of sample data (Table 5) shows that for each metrology area, the number of capacities is given. At an aggregated level, two indicators were constructed from this data.

1. The total number of CMCs in any area for each country
2. The total breadth (range) of CMC types with at least one capacity, for each country

These two distinct indicators are constructed because, according to BIPM, different countries have different ways of reporting the number of CMCs in each category. Therefore, the breadth is also important.

These indicators are correlated with a value of 0.85, which suggests that they are similar but still capture slightly different aspects of CMCs in the country. In order to keep both points of view in the index, the indicators are both included but half-weighted.

BIPM has mapped the CMCs to the 3Ps therefore these two indicators can be calculated as P-indicators. The 29 metrology subareas belonging to acoustics, ultrasound and vibration (AUV), electricity and magnetism (EM), length (L), mass and related quantities (M), photometry and radiometry (PR), thermometry (T), time and frequency (TF) contribute to the Prosperity indicator, while the remaining 18 subareas belonging to chemistry and biology (QM) and ionizing radiation (RI) are contributing to the 3P-indicators according to an SDG mapping (not published online) provided by BIPM. The methodology for this indicator follows the general methodology for calculating P-indicators described at the beginning of Section 3.

3.4.4

Membership of BIPM

Membership of the BIPM can be of two different levels,[20] either "full membership" or "associate membership". As with other similar indicators, we simply assign the following scores:

» Member State = 2

» Associate = 1

» Neither = 0

[20] https://www.bipm.org/en/member-states

3.4.5

Membership of OIML

OIML has two levels of membership: "full membership" and "corresponding membership".[21] This indicator simply assigns scores to the three possible categories:

» Full member = 2

» Corresponding member = 1

» Neither = 0

3.4.6

OIML-CS: number of services offered

The OIML certification system (CS) is "a system for issuing, registering and using OIML Certificates and their associated OIML type evaluation/test reports". Countries are effectively divided into those that *issue* certificates, and those that *recognise* them.[22]

We use OIML data that details the scope of OIML Recommendations and the Scheme (A and/or B) for which each organisation will accept and utilize OIML type evaluation and test reports[23] – a sample is shown below.

[21] https://www.oiml.org/en/structure/members

[22] https://www.oiml.org/en/oiml-cs/utilizers-and-associates

[23] https://www.oiml.org/en/oiml-cs/docs/oiml-util-and-assoc-summary-table.pdf

FIGURE 9: Sample of OIML-CS issuer data

1 = Scheme A only
2 = Scheme A and MAA
3 = Scheme A and B
4 = Scheme A, B and MAA
5 = Scheme B only

		R 21:2007	R 35:2007	R 46:2012	R 49:2006	R 49:2013	R 50:2014	R 51:2006	R 58:1998	R 59:2016	R 60:2000	R 60:2017	R 61:2004	R 61:2017	R 75:2002	R 76:1992	R 76:2006	R 81:1998	R 85:2008	R 88:1998	R 93:1999	R 99:2008	R 102:1992	R 104:1993	R 106:2011
AU	National Measurement Institute, Australia (NMIA)				1	1					1					1	1								
BE	Federal Public Service Economy	3		3		3	3	3			1		3		3		1		3			3			3
CA	Measurement Canada										2	1			1		2								
CH	Federal Institute of Metrology (METAS)			1	2	2	1	1			2		1		1		2								1
CN	State Administration for Market Regulation (SAMR)							1			2	1	1	1		2	2								
CO	Superintendencia de Industria y Comercio (SIC)	3		3	4	4	3	3			2		3		3	2	2		3			3			3
CU	Oficina Nacional de Normalizacion (NC)	3	3	1		1	3	1	3	3	1	1	3	3	3		1	3	3	3	3	3	3	3	3

3.4.7

OIML-CS: Number of services recognised

"Utilizers and Associates are organisations from OIML Member States and Corresponding Members respectively who have declared that they will accept and utilize OIML type evaluation and test reports, when associated with an OIML certificate issued by an OIML Issuing Authority."

This indicator shows the scopes of each OIML issuing authority with respect to OIML recommendations.[24] Our indicator simply counts the number of recommendations that are covered by each country's national issuing authority.

The table below is the complete data set for this indicator (only a few countries issue certificates). For example, the score of Australia is calculated as the number of recommendations for which it issues certificates. In this case, three.

The issuing and recognising indicators are more or less mutually exclusive in terms of countries; the only country that is listed as both issuing and recognising certificates is the Czech Republic. On the other hand, the two indicators measure different things therefore they cannot be combined. We chose to keep both indicators in the framework but to weight them at half.

3.4.8

Involvement in OIML project groups

The OIML has technical committees and project groups that draft and publish recommendations on various topics related to legal metrology.[25] Data is also available that shows which countries participate in each project group: countries can either be "conveners", "participating members", or "observers".

Since no mapping is currently available between OIML project groups and SDGs, our indicator currently consists of simply counting the number of project groups for which each country is a convener (C), participating member (P) and observer (O). We then calculate an overall score as:

$$\text{score}=3C+2P+O$$

In other words, convening a project group is worth three points, participating two points, and observing is worth one point.

FIGURE 10: OIML-CS – SCOPES OF ISSUING AUTHORITIES

		R 21:2007	R 46:2012	R 49:2006	R 49:2013	R 50:2014	R 51:2006	R 60:2000	R 60:2017	R 61:2004	R 61:2017	R 75:2002	R 76:1992	R 76:2006	R 85:2008	R 99:2008	R 106:2011	R 107:2007	R 117:1995	R 117:2007	R 117:2019	R 126:1998	R 129:2000	R 134:2006	R 137:2012	R 139:2014	R 139:2018
AU1	National Measurement Institute Australia (NMIA)					■							■	■													
CH1	Federal Institute of Metrology (METAS)							■						■			■							■			
CN2	National Institute of Metrology, China (NIM)						■	■	■	■	■		■	■													
CZ1	Czech Metrology Institute (CMI)				■		■				■			■	■					■	■			■	■		■
DE1	Physikalisch-Technische Bundesanstalt (PTB)				■		■	■	■	■		■		■													
DK2	FORCE Certification A/S				■	■	■	■	■	■	■			■			■	■					■	■	■	■	■
FR2	Laboratoire National de Métrologie et d'Essais (LNE)			■	■		■	■	■					■								■					
GB1	Office for Product Safety and Standards (OPSS) (formerly NMO)				■		■	■	■				■	■						■	■						
JP1	NMIJ/AIST							■	■				■	■					■	■	■						
NL1	NMi Certin B.V.	■	■	■	■	■	■	■	■	■	■		■	■	■		■	■	■	■	■		■	■	■	■	■
SE1	Research Institutes of Sweden (RISE)						■	■	■	■	■			■	■				■	■	■						
SK1	Slovak Legal Metrology (SLM)			■	■									■													

[24] https://www.oiml.org/en/oiml-cs/docs/oiml-ia-summary-table.pdf

[25] https://www.oiml.org/en/tc-sc-pg/tclist_view

3.5

POLICY

FIGURE 11: Policy indicators

Dimension	Name	Unit	Organisation	Type	Weight
POLICY	Participation in capacity building progammes	Number of types	UNIDO/ISO	G	1
	Quality policy in place	Yes/no	UNIDO/ISO	G	1
	Dimensions of QI addressed by quality policy	Number	UNIDO/ISO	G	1
	Support and funding for quality policy	Yes/no	UNIDO/ISO	G	1
	Government/political endorsement for quality policy	Yes/no	UNIDO/ISO	G	1
	Government approval of quality policy	Yes/no	UNIDO/ISO	G	1
	Stakeholder involvement of quality policy	Yes/no	UNIDO/ISO	G	1
	Consideration of diversity in quality policy	Yes/no	UNIDO/ISO	G	1
	Implementation plan for quality policy	Yes/no	UNIDO/ISO	G	1
	Monitoring and evalution for quality policy	Yes/no	UNIDO/ISO	G	1
	Reviewing and updating for quality policy	Yes/no	UNIDO/ISO	G	1

Policy indicators are all completely derived from a survey created by UNIDO and launched by ISO over the time period June-September 2021. The survey consisted of two parts: one on the adoption of ISO standards (mentioned in the next section), and a second part which asked questions on Quality Policy (policies aiming to develop Quality Infrastructure). More information about the survey is described in Section 4. The survey questions that led to indicators for Policy are listed in Table 6.

TABLE 6: Survey questions on Quality Policy

Nr	Survey questions on Quality Policy	Answer alternatives
Q6	Has your country participated in capacity building programs related to Quality Infrastructure from any of the following international organizations in the last two years?	BIPM, OIML, ISO, WTO, None, Don't know
Q8	Does your country have a National or Regional Quality Policy in place, i.e. a policy for developing and sustaining effective Quality Infrastructure?	Yes, No, Don't know
Q9	Which of the following dimensions of Quality Infrastructure are addressed by your Quality Policy or regulatory framework?	Metrology, Standards, Accreditation, Conformity assessment, Don't know
Q10	Is governmental support, including funding, stipulated in the Quality Policy or in the regulations and directions supporting Quality Infrastructure?	Yes, No, Don't know
Q11	Is the development and implementation of the Quality Policy being endorsed by the political level or led by the highest level of government?	Yes, No, Don't know
Q12	Has the Quality Policy been approved by your government or regional country grouping?	Yes, No, Don't know

Q13	Are stakeholders from the private and public sectors, consumers, producers involved in the Quality Policy process?	Yes, No, Don't know
Q14	Have gender balance and other diversity aspects been considered in the Quality Policy process?	Yes, No, Don't know
Q15	Is there an implementation plan for the National Quality Policy, i.e. a plan which sets out the steps for achieving the policy objectives?	Yes, the policy is already in place / Yes, it's in the process of implementation, No, Don't know
Q16	Is there a mechanism(s) for monitoring and/or evaluating the implementation/outcomes of the Quality Policy?	Yes, No, Don't know
Q17	Is there a mechanism(s) for periodically reviewing and updating the Quality Policy?	Yes, No, Don't know

These questions were chosen after a series of discussions with Quality Policy experts in UNIDO. All questions are yes/no answers with the exception of Q6 and Q9. For the former category, we assigned a simple yes=1 and no=0 conversion. "Don't know" answers were not included in the results. For the two exceptions, we counted, respectively, the number of organisations for which the country had participated in capacity building programmes (score 0-4), and the number of QI dimensions addressed by the Quality Policy (score 0-4). The questions are retained as separate indicators in the framework because conceptually it is difficult to group them. Moreover, each question response may be useful information outside of the context of the index. An issue with the policy indicators derived from the survey is the data availability, which is discussed in Section 4 Survey.

3.6

STANDARDS

The final dimension, standards, consists of seven indicators. There are three indicators which are related to the 3Ps, and the other four are general. Indicators are sourced from IEC, ISO and ITU.

3.6.1

Adopted ISO standards

This indicator comes from the survey launched by ISO and UNIDO in 2021. The aim of the survey was to see which ISO standards had been adopted as national standards, for each country. However, since there are a very large number of ISO standards, a small subset was chosen for the purposes of the survey. This subset of 22 standards is listed in Table 7. More information about the survey is described in Section 4.

FIGURE 12: Standards indicators

Dimension	Name	Unit	Organisation	Type	Weight
STANDARDS	Adopted ISO standards	Number	ISO	P	1
	Adopted IEC standards	Number	IEC	P	1
	Membership of IEC	Categorical	IEC	G	1
	Participation in IEC technical committees	Number	IEC	P	1
	Membership of ISO	Categorical	ISO	G	1
	Participation in ISO technical committees	Number	ISO	G	1
	Membership of ITU	Composite score	ITU	G	1

TABLE 7: ISO standards measured in UNIDO survey

Nr	ISO nr	Name of standard
1	ISO 9001	Quality management systems - Requirements
2	ISO 13485	Medical devices - Quality management systems - Requirements for regulatory purposes
3	ISO 14001	Environmental management systems - Requirements with guidance for use
4	ISO 14044	Environmental management - Life cycle assessment - Requirements and guidelines
5	ISO 14055-1	Environmental management - Guidelines for establishing good practices for combatting land degradation and desertification - Part 1: Good practices framework
6	ISO 14067	Greenhouse gases - Carbon footprint of products - Requirements and guidelines for quantification
7	ISO 15189	Medical laboratories - Requirements for quality and competence
8	ISO 15392	Sustainability in buildings and civil engineering works - General principles
9	ISO/IEC TS 17021-12	Conformity assessment - Requirements for bodies providing audit and certification of management systems - Part 12: Competence requirements for auditing and certification of collaborative business relationship management systems
10	ISO 18091	Quality management systems - Guidelines for the application of ISO 9001 in local government
11	ISO 20121	Event sustainability management systems - Requirements with guidance for use
12	ISO 20400	Sustainable procurement - Guidance
13	ISO 21001	Educational organizations - Management systems for educational organizations - Requirements with guidance for use
14	ISO 22000	Food safety management systems - Requirements for any organization in the food chain
15	ISO 24521	Activities relating to drinking water and wastewater services - Guidelines for the management of basic on-site domestic wastewater services
16	ISO 26000	Guidance on social responsibility
17	ISO 29993	Learning services outside formal education - Service requirements
18	ISO 37001	Anti-bribery management systems - Requirements with guidance for use
19	ISO 37101	Sustainable development in communities - Management system for sustainable development - Requirements with guidance for use
20	ISO 45001	Occupational health and safety management systems - Requirements with guidance for use
21	ISO 46001	Water efficiency management systems - Requirements with guidance for use
22	ISO 50001	Energy management systems - Requirements with guidance for use

The data was converted to P-scores using the same methodology applied to all P-indicators, which is detailed in Section 3.1. Data availability is an issue for the adopted standards indicator as for the policy indicators derived from the survey; this is discussed in Section 4 Survey.

3.6.2

Adopted IEC standards

This indicator is conceptually similar to the adoption of ISO standards and other P-indicators and follows the standard P-indicator methodology.

IEC has three data sets that are used to calculate this indicator:

1. Data on which IEC standards each country has adopted, although this data only covers IEC Affiliates.
2. A mapping of IEC technical committees to SDGs.
3. A mapping of IEC standards to IEC technical committees.

The last two data sets are used to map each IEC standard to SDGs, in the same way as with ISO standards. Each standard is mapped to SDGs, and this creates a "value" of each standard for each P, according to the methodology explained in Section 3.1. Each country's score, for each P, is calculated as the number of adopted standards each multiplied by their respective "values" in each P.

The problem with this indicator is that data is only collected for IEC Affiliates, which amounts to about 40% of the 137 countries in the QI4SD Index. Strictly, this could be a reason to exclude the indicator, but there are two good reasons to overlook this issue. First, it is conceptually important. Second, there is another IEC P-indicator that regards participation in TCs, and this nicely complements IEC standard adoption. This is explained in Section 3.6.4.

3.6.3

Membership of IEC

Membership of the IEC can either be "full membership", "associate membership", "affiliate", or "none". As with other similar indicators we simply assign the following scores:

Full = 3

Associate = 2

Affiliate = 1

None = 0

3.6.4

Participation in IEC technical committees

IEC has accessible data on the countries that participate in each of its technical committees (TCs). Since IEC also has a mapping of its TCs to SDGs, it is possible decompose IEC TC participation into the 3Ps (see the standard methodology described in Section 3.1).

IEC TC data gives the composition of each TC in terms of its participating (P) members and its observer (O) members. We follow a similar methodology to other indicators here and weight a "P" membership as worth twice an "O" membership. This leads to the following formula:

$$S_{c,i} = \sum_{TC \in TC_{c,P}} v_{TC,i} + \frac{1}{2} \sum_{TC \in TC_{c,O}} v_{TC,i}$$

where $S_{c,p}$ is the score for country for P-group (one of People, Planet and Prosperity), TC is a technical committee, $TC_{c,P}$ is the set of technical committees of which country c is a participating member, $TC_{c,O}$ is the set of technical committees of which country c is an observer member, and $V_{TC,i}$ is the "value" of the technical committee to the ith P-group. This all amounts to "summing the values of the TCs that each country is part of" for each P, and weighting P membership at twice that of O membership.

This indicator, and the indicator on adopted IEC standards (3.6.2), are quite complementary because whereas adopted standard data only covers Affiliate countries, participation in TCs requires countries to be full members of the IEC. Data shows that the overlap between these indicators is 8 countries[26] that have both data on adopted standards and participate in TCs. For this reason, both indicators are kept in the framework and are fully weighted.

3.6.5

Membership of ISO

ISO membership has three categories: "member body", "correspondent member" and "subscriber member. We simply assign scores in the following manner:

Member body = 3

Correspondent member = 2

Subscriber member = 1

None = 0

3.6.6

Participation in ISO technical committees

ISO has over 250 technical committees (TCs) that draft and develop its standards.[27]. The TCs are composed of representatives from ISO member countries. ISO data

[26] Albania, Cuba, Côte d'Ivoire, Ghana, Jordan, Lebanon, Nigeria and Peru

[27] https://www.iso.org/technical-committees.html

shows the composition of each of its TCs in terms of which country holds the secretariat, which countries are participating members, and which are observer members. This data can be used to compose a score that represents the level of a country's involvement in ISO technical committees.

While secretariat and chair information of TCs is relevant, in practice these positions are usually held by a small subset of countries. Therefore, the indicator is constructed as a weighted sum of the number of TCs in which a country participates, such that:

Participating member = 2

Observer member = 1

Neither = 0

And this score is summed over all TCs.

3.6.7

Composite score of membership of ITU

ITU membership is more complicated than ISO and IEC membership, in that members can be of different types, listed as follows:

» Member states

» Sectoral members (companies)

» Associate members (companies)

» Academic members (universities and research centres)

Both the sectoral and associate membership categories have three sectors in which companies can be members: Radiocommunication (R), Standardisation (T), and Development (D).

The ITU membership indicator is constructed as a composite score of these membership categories. Currently, whether a country is a member state or not is *not* included in this calculation since 193 countries are members states, which includes almost all countries.

The score is calculated as follows:

Score = no. companies with R-membership +
no. companies with T-membership +
no. companies with D-membership +
0.5 x no. companies with associate R-membership +
0.5 x no. companies with associate T-membership +
0.5 x no. companies with associate D-membership +
no. academic members

This effectively weights associate membership at half that of full membership. Academic membership is weighted the same as a company's sectoral membership. Note that companies can be members of more than one sector, and they are counted once for each sector they are members of.

This membership score is slightly complex but aims to reflect the different ways that countries participate in the ITU.

4. Survey

Following data collection, it was evident that there were some important gaps in the data coverage, in particular:

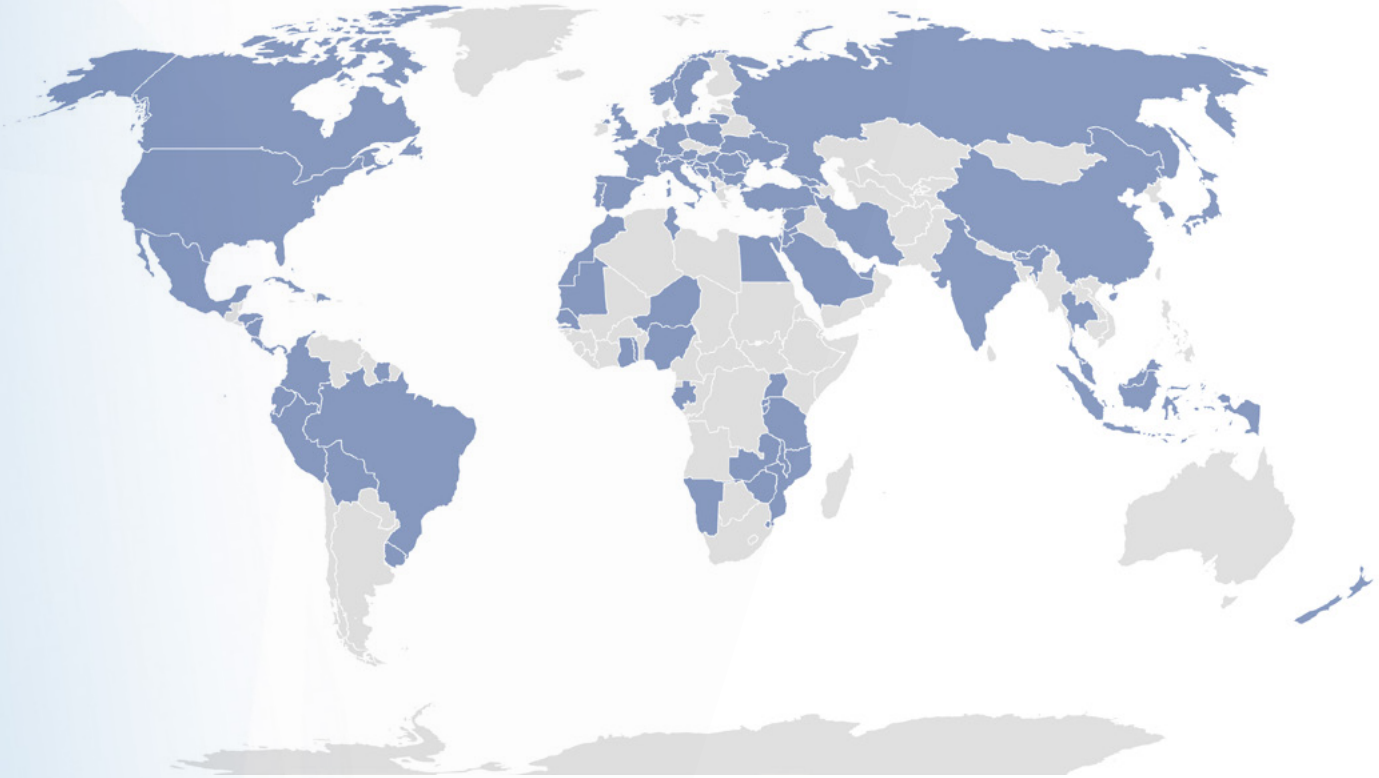
1. Data on adoption of international standards
2. Data relating to QI policies

As a result, a survey was launched in collaboration with ISO, which asked a series of questions relating to the adoption of ISO standards and the existence and types of policies in place at the national level that relate to QI. The survey was sent out to all 165 ISO members (national standards bodies) in the form of an electronic survey.[28] The survey was conducted during the period from June to September 2021 (18 June–10 September) and responses from 92 countries were collected, as illustrated in Figure 13. The Appendix includes a copy of the online survey.

The survey consisted of two parts: one on the adoption of ISO standards and a second part that asked questions on Quality Policy (policies aiming to develop Quality Infrastructure). The aim of the first part of the survey was to see which ISO standards had been adopted as national standards, for each country. A subset of 22 standards was chosen on the basis of being well-known standards that represent the 3Ps in different ways. For example, many are featured on ISO's SDG pages,[29] or on ISO's "popular standards" page,[30] or are cited as being important to the QI-SDG linkage in UNIDO's "Rebooting QI for a Sustainable Future" report.[31] The list was also adjusted following discussions with UNIDO and ISO experts.

The second part of the survey comprised eleven questions concerning Quality Policy. These questions were chosen after a series of discussions with Quality Policy experts in UNIDO. The survey also included fields in which respondents could leave comments or additional information.

FIGURE 13: Country responses of UNIDO survey (blue indicates that the country has responded)



[28] UNIDO QI4SD Index - Survey on Standards and Quality Policy (smartsurvey.co.uk)

[29] ISO - Sustainable Development Goals

[30] ISO - Popular standards

[31] https://hub.unido.org/news/rebooting-quality-infrastructure-sustainable-future

The response rate was 56% (92/165) for the ISO member countries. For the ranked QI4SD Index countries the response rate was higher, namely 65% (89[32]/136[33]), as illustrated in Table 8. An issue with the indicators derived from the survey is data availability. The indicator data availability ranges from at best 64% for Q3–Q5 to as low as 27% for Q14, when the answer alternative "don't know" has also been taken into account. This is due first to the response rate of the survey (65%), compounded by the fact that some countries replied to the first part of the survey regarding standards but did not reply (left blank) or responded "don't know" to questions on Quality Policy (Table 8).

The low data availability for the policy indicators would normally be grounds for excluding these indicators, but it would exclude the entire Policy dimension. Instead, we opted for an intermediate approach in which, for any dimension in the index, a country's score is only calculated if at least 60% of the indicator data is available within that dimension. That means that for example, any countries with less than 60% of data available in the Policy dimension do not receive a Policy score. Note that this approach could be altered by changing the data availability threshold.

TABLE 8: UNIDO survey questions and response rates of QI4SD ranked countries

Nr	Survey questions	Answer alternatives	No. of replies (Y,N,DK)	Response rate (136 countries)	No. of Don't know	No. of Blanks
Q3-Q5	Adoption of 22 ISO standards	Yes, No, Don't know	89	65%	2	0
Q6	Has your country participated in capacity building programs related to Quality Infrastructure from any of the following international organizations in the last two years?	BIPM, OIML, ISO, WTO, None, Don't know	89	65%	9	0
Q8	Does your country have a National or Regional Quality Policy in place, i.e. a policy for developing and sustaining effective Quality Infrastructure?	Yes, No, Don't know	89	65%	9	0
Q9	Which of the following dimensions of Quality Infrastructure are addressed by your Quality Policy or regulatory framework?	Metrology, Standards, Accreditation, Conformity assessment, Don't know	85	63%	3	4
Q10	Is governmental support, including funding, stipulated in the Quality Policy or in the regulations and directions supporting Quality Infrastructure?	Yes, No, Don't know	72	53%	11	17
Q11	Is the development and implementation of the Quality Policy being endorsed by the political level or led by the highest level of government?	Yes, No, Don't know	72	53%	9	17
Q12	Has the Quality Policy been approved by your government or regional country grouping?	Yes, No, Don't know	72	53%	9	17

[32] The total number of survey responses are 89 and not 92 since the three countries Dominica (DMA), Honduras (HND) and Syrian Arab Republic (SYR) are not part of index ranked countries.

[33] The number of QI4SD Index ranked countries are 136 and not 137 since Suriname (SUR) is not an ISO member and hence did not receive the survey.

Q13	Are stakeholders from the private and public sectors, consumers, producers involved in the Quality Policy process?	Yes, No, Don't know	71	52%	7	18
Q14	Have gender balance and other diversity aspects been considered in the Quality Policy process?	Yes, No, Don't know	71	52%	34	18
Q15	Is there an implementation plan for the National Quality Policy, i.e. a plan which sets out the steps for achieving the policy objectives?	Yes, No, Don't know	71	52%	10	18
Q16	Is there a mechanism(s) for monitoring and/or evaluating the implementation/ outcomes of the Quality Policy?	Yes, No, Don't know	71	52%	17	18
Q17	Is there a mechanism(s) for periodically reviewing and updating the Quality Policy?	Yes, No, Don't know	71	52%	17	18

5. Index construction

With the final set of indicators, the index was constructed following the methodology found in the JRC and OECD Handbook on Constructing Composite Indicators,[34] which is the main reference for composite indicator construction. This consists of the following main steps:

1. Denomination: dividing indicators by other indicators to adjust for country-size effects (if needed)
2. Imputation (estimating any missing data points, if needed)
3. Outlier treatment (treating any outlying/ extreme values that may have negative effects on the aggregation)
4. Normalisation (bringing indicators onto a common scale)
5. Weighting and aggregation

These steps are explained in a little more detail here, and the implementation is given in the following Section 6.

As mentioned elsewhere, the QI4SD Index is unusual in that it actually consists of four indexes: the General, People, Planet and Prosperity Indexes. In general, the methodology is applied to match across the four indexes; for example, we ensure that countries that are removed for low data reasons are the same countries for all four indexes, for comparability.

5.1 DENOMINATION

Denomination is the process of dividing one indicator by another, to be able to "fairly" compare countries of different sizes.

Quantities pertaining to a country can be thought of as either *intensive* or *extensive* variables. Intensive variables are not (or only weakly) related to the size of the country. Extensive variables, on the contrary, are strongly related to the size of the country.

Extensive variables are "intensified" by dividing by the appropriate denominator. For example, GDP (extensive) can be converted to GDP per capita (intensive) by dividing by population. Volume of international trade (extensive) can be converted to "intensity of international trade" (intensive) by dividing by GDP. The quantities here have very different meanings.

This distinction is important because if only extensive variables are used, typically the countries with the greatest size will be at the top. Denomination is an important step because it can completely change the meaning of the indicator.

In the QI4SD Index, denomination of the indicators was given careful thought. Four main considerations were:

1. On a conceptual level, is the indicator likely to be strongly related to the size of the country?
2. From a statistical point of view, is the indicator strongly correlated with any common denominator variables, such as GDP, population or country size?
3. What is more relevant to the aims of the QI4SD Index?
4. What is easier to interpret and is most useful to end-users?

Each indicator was carefully examined and statistically correlated against denominator data. The result was that most indicators were *not* strongly correlated with denominator variables, although some few were.

This presented a choice: either to denominate some indicators but not others, or to leave all indicators "un-denominated". Regarding the first option, it required selecting *which* indicators to denominate, and then *by what*. This turned out to be a complex undertaking, because often it was not clear whether it would be more relevant, for example, to examine the number of ISO-accredited sites per population, or per GDP, or something else. Moreover, some indicators were moderately correlated with denominators and it was unclear where to draw the line.

These considerations, as well as consultations with experts, led to the conclusion that in the case of the QI4SD Index, it would be clearer to *not* denominate any indicators, because doing otherwise would impose too many subjective choices on the index and likely render it hard to interpret and therefore less useful.

This choice was also supported by the fact that:

- The only other QI index, the Global Quality Infrastructure Index,[35] also does not denominate indicators, for similar reasons.

[34] JRC, OECD, 2008. JRC/OECD Handbook on constructing composite indicators: methodology and user guide. OECD publishing. Handbook on Constructing Composite Indicators: Methodology and User Guide (oecd.org)

[35] Harmes-Liedtke, U., Oteiza Di Matteo, J.J., 2021. Global Quality Infrastructure Index Report 2020. GQII Report 2020 – Global Quality Infrastructure Index (GQII) Program

» Although preliminary results were found to be related to GDP, meaningful results can be obtained by presenting rankings by GDP groups and other size groupings, as well comparing to conditional means.

5.2

MISSING DATA IMPUTATION

Imputation is the process of estimating missing data points. This is usually done by replacing missing data points with, e.g. the indicator mean, or the mean of a certain group, or by a more complex method such as expectation maximisation or similar.

After some investigation, imputation was not applied to the QI4SD Index, for several reasons:

» In some cases, the indicators did not correlate very strongly within groups. This means that indicators would not be good predictors of other indicators in many cases.

» Some indicators have large data gaps: imputing would create a false impression of knowing what we do not actually know.

» In any case, when aggregating, missing values are excluded from the aggregation. This is mathematically equivalent to replacing the value with the mean of the normalised scores of the other indicators. In other words, by aggregating, a form of implicit imputation is anyway performed. We recall that to avoid over-reaching, a data availability limit of 60% was assigned, below which aggregate scores were not calculated.

Although imputation is not specifically used, missing data is dealt with in the index in several ways. We first begin with a full set of 249 countries, and we then remove any of these countries if they either have:

» Less than 60% data availability, OR

» More than 66% zero values across all indicators

This reduces the number of countries to 137 (excluding mostly very small countries – see figure below), and has the effect of improving data availability for indicators.

Next, indicators are considered on an individual basis and some are removed if they have low data and are not essential to the index.

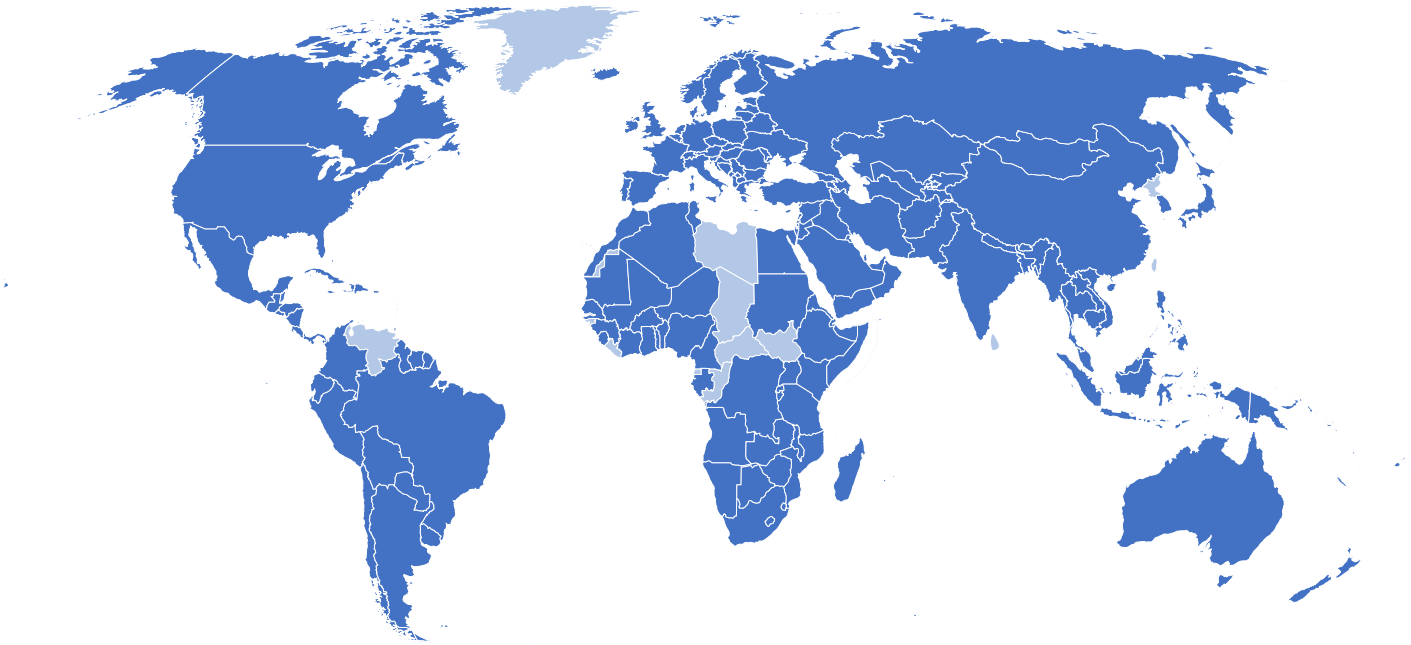
Finally, when aggregating the index, a data requirement rule is invoked. For any QI dimension, a country's score is only calculated if it has at least 60% data availability. This is also true at the index level: the index score is only calculated if 60% of the QI dimensions (3 out of 5) have a score. This threshold was set to give a compromise between a basic level of data availability, and including as many countries as possible.

5.3

OUTLIER TREATMENT

In composite indicators, it is fairly common practice to treat outliers. Outliers are data points that stand apart from the distribution of the remaining points. Sometimes this may be due to an error in measurement or calculation, but often it is simply the reality – for example, Luxembourg is often seen as an outlier in terms of GDP/capita, being a small wealthy country.

FIGURE 14: : Country coverage of the QI4SD Index (dark blue indicates that the country is included in the index)



The problem with outliers is that they dominate the scale of the indicator, and cause important differences between other countries to be largely obscured. This can be rectified, if desired, by a treatment method called *Winsorisation*, or transformations such as the logarithm and Box Cox.

Following a fairly standard procedure, outliers were detected using a skew/kurtosis rule: if the absolute skew exceeded 2, and the kurtosis exceeded 3.5, the indicator was treated by successively Winsorising points up to a limit, followed by a nonlinear (log) transformation if necessary.

For full details of this process, see, for example, the online documentation of the R Package[36] used to create the QI4SD Index.

5.4 NORMALISATION

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

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

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

where and are the normalised and un-normalised values of the *i*th indicator, respectively.

The reason that indicators are normalised with a minimum value of 1 (and not 0) is that assigning a zero score to a country is risky and can be misleading. Taking the Accreditation dimension as an example, each indicator is normalised onto [1, 100] and the Accreditation score is calculated as the mean of these scores. If a country has the minimum score on all accreditation indicators, it will also receive the minimum normalised score, i.e. 1 in this case. If the boundary minimum is set as 0, it will receive a zero. However, our measurement of Accreditation is only based on available indicators, and having minimum values on those indicators does *not* mean that the country has no capacity for Accreditation.

5.5 WEIGHTING AND AGGREGATION

In order to get a composite measure, i.e. the index, the normalised indicators are hierarchically aggregated, following the conceptual framework and by taking weighted means of each aggregation group:

$$X_{\mathrm{DIM}} = \frac{1}{\sum w_i} \sum_{i=1}^{N_{\mathrm{DIM}}} w_i \tilde{x}_i$$

where is the dimension score for dimension DIM (e.g. the Accreditation score), are the normalised indicators bellowing to dimension DIM, are the associated weights, and is the number of indicators in dimension DIM.

The overall index score is assembled equivalently, by taking the average of the scores of the five dimensions (dimensions are equally weighted).

By default, indicators were also equally weighted. This represents the assumption that indicators are more or less equally important. This is a common approach in composite indicators because although in principle unequal weights could be used, different stakeholders will have different perceptions of how indicators could be weighted. Therefore, equal weighting represents a simple and conservative option that can be relaxed if needed in a sensitivity analysis, and/or allowing end-users to adjust weights in an online portal.

In some particular cases, half-weighting was used. This was in cases where two indicators capture different angles of the same concept – for example, in measuring the number and breadth of CMCs in metrology. The weights of each indicator can be found in Table 1.

[36] https://bluefoxr.github.io/COINrDoc/data-treatment.html

6. R Code

This chapter gives the basic operations used to build the QI4SD Index and the 3P-Indexes. In effect, it is a practical implementation of the methodology in the previous section.

The following text is an R Markdown Notebook,[37] which gives a reproducible record of the construction of the QI4SD Index. From the point of having a set of screened indicators, the QI4SD Index was constructed following these basic steps:

1. Individual indicators were constructed separately, mostly in Excel with some work done in R.
2. Processed indicator data and metadata was brought together in a single Excel spreadsheet.
3. The indicator data set was read into R, where it was used to aggregate the indicator data into the QI4SD Index and the 3P-Indexes.
4. Results were exported back to Excel for easy readability.
5. Visualisation and analysis were performed in both R and Excel.

This notebook records Step 3, the processing work done in R to construct the index. Other R Notebooks were built for indicator screening and data processing but are not given here (they would be available on request). R is a very widely-used open-source programming language which focuses on statistics and data analysis. The processing here, and some of the analysis, makes use of the recent COINr[38] package, which is an extension to R for developing and analysing composite indicators. Since the heavy lifting is done inside the COINr package, we leave the code visible here for full reproducibility.

6.1 Data input

The indicator data is available in a single spreadsheet called "Indicator_Input.xlsx". With this spreadsheet in the working directory, we can read in the tables of indicator data as separate data frames in R.

```
library(dplyr)
library(COINr)
library(readxl)

# read in indicator data
fname <- "Indicator_Input.xlsx"
# IndData
Full_IndData <- read_excel(fname, sheet = "Full_IndData")
Pp_IndData <- read_excel(fname, sheet = "Pp_IndData")
Pl_IndData <- read_excel(fname, sheet = "Pl_IndData")
Pr_IndData <- read_excel(fname, sheet = "Pr_IndData")
# IndMeta
Full_IndMeta <- read_excel(fname, sheet = "Full_IndMeta")
Pp_IndMeta <- read_excel(fname, sheet = "Pp_IndMeta")
Pl_IndMeta <- read_excel(fname, sheet = "Pl_IndMeta")
Pr_IndMeta <- read_excel(fname, sheet = "Pr_IndMeta")
# AggMeta
Full_AggMeta <- read_excel(fname, sheet = "Full_AggMeta")
P_AggMeta <- read_excel(fname, sheet = "P_AggMeta")
```

6.2 Assembling COINs

The COINr package works by "assembling" indicator data, metadata and index structure into an object called a "COIN". The object is in fact a hierarchical list of data frames (tables), parameters and other information which encapsulates all parts of a composite indicator.

Since the QI4SD Index is actually a collection of four indexes (the General, People, Planet and Prosperity indexes), we have to assemble four COINs. In R, the most convenient way to do this is by creating a list of COINs. This is done in the following code chunk.

```
# assemble list of COINs
QI <- list(
  Full = assemble(Full_IndData, Full_IndMeta, Full_Agg-
Meta),
  Pp = assemble(Pp_IndData, Pp_IndMeta, P_AggMeta),
  Pl = assemble(Pl_IndData, Pl_IndMeta, P_AggMeta),
  Pr = assemble(Pr_IndData, Pr_IndMeta, P_AggMeta)
)

# we also tidy up the workspace
rm(list=setdiff(ls(), "QI"))
```

We now have a list of COINs (the four composite indicators). However, at this point the COINs only contain the indicator data, metadata, and details of the structure of the index. To obtain the index results, we have to go through a series of operations including country screening, data treatment, normalisation, and aggregation.

[37] https://rmarkdown.rstudio.com/
[38] https://cran.r-project.org/package=COINr


mirror_mod = modifier_ob.
mirror object to mirror
mirror_mod.mirror_object
operation == "MIRROR_X":
mirror_mod.use_x = True
mirror_mod.use_y = False
mirror_mod.use_z = False
operation == "MIRROR_Y"
mirror_mod.use_x = False
mirror_mod.use_y = True
mirror_mod.use_z = False
operation == "MIRROR_Z"
mirror_mod.use_x = False
mirror_mod.use_y = False
mirror_mod.use_z = True
selection at the end -add
ob.select= 1
ier_ob.select=1
ntext.scene.objects.active
("Selected" + str(modifier
irror_ob.select = 0
bpy.context.selected_o
ata.objects[one.name].s
int("please select exactl
OPERATOR CLASSES ----
types.Operator):
X mirror to the selected
ject.mirror_mirror_x"
rror X"
context):
ext.active_object is not

6.3

Country screening

Before data treatment, we can see which countries to include in the index. There are two issues here. First is missing data—any countries that have a high proportion of missing data—should be removed. The second is also the issue of zeroes: if a country has zero values for all or most indicators, it could also be removed. This is because having a large proportion of countries with zero values creates very skewed indicator distributions which is often not desirable.

To check this, we will use COINr's checkData() function. Importantly, we want the same set of countries for each of the four indexes. To do this, we perform country screening on the General index, and then filter countries of the P-indexes to match the countries in the General index. Note that at this point, we also manually exclude two countries, Syria and Taiwan, because they no World Bank GDP data therefore cannot be assigned a GDP group.

```
QI$Full <- checkData(QI$Full, dset = "Raw", unit_screen = "byNAandzeros",
            ind_thresh = 0.6, zero_thresh = 1/3,
            Force = data.frame(UnitCode = c("TWN" ,"SYR"), Status = "Exclude"))
```

```
QI$Full$Analysis$Raw$RemovedUnits
##  [1] "ASM" "AND" "AGO" "AIA" "ATA" "ABW" "BLZ" "BEN" "BMU" "BES" "BVT" "IOT"
##  [13] "BFA" "CPV" "CMR" "CYM" "CAF" "TCD" "CXR" "CCK" "COM" "COD" "COG" "COK"
##  [25] "CUW" "DJI" "DMA" "GNQ" "ERI" "FLK" "FRO" "FJI" "GUF" "PYF" "ATF" "GMB"
##  [37] "GIB" "GRL" "GRD" "GLP" "GUM" "GGY" "GIN" "GNB" "GUY" "HTI" "HMD" "VAT"
##  [49] "HND" "IMN" "JEY" "KIR" "PRK" "LAO" "LSO" "LBR" "LBY" "LIE" "MAC" "MDV"
##  [61] "MHL" "MTQ" "MYT" "FSM" "MCO" "MSR" "MMR" "NRU" "NCL" "NIU" "NFK" "MNP"
##  [73] "PLW" "PNG" "PCN" "PRI" "REU" "BLM" "SHN" "KNA" "LCA" "MAF" "SPM" "VCT"
##  [85] "WSM" "SMR" "STP" "SLE" "SXM" "SLB" "SOM" "SGS" "SSD" "SJM" "SYR" "TWN"
##  [97] "TJK" "TLS" "TKL" "TON" "TKM" "TCA" "TUV" "UMI" "VUT" "VEN" "VGB" "VIR"
## [109] "WLF" "ESH" "YEM" "ALA"
```

This has checked how many missing data points and how many zero values each country has, across all indicators. Using the function defaults, countries are excluded if they either have:

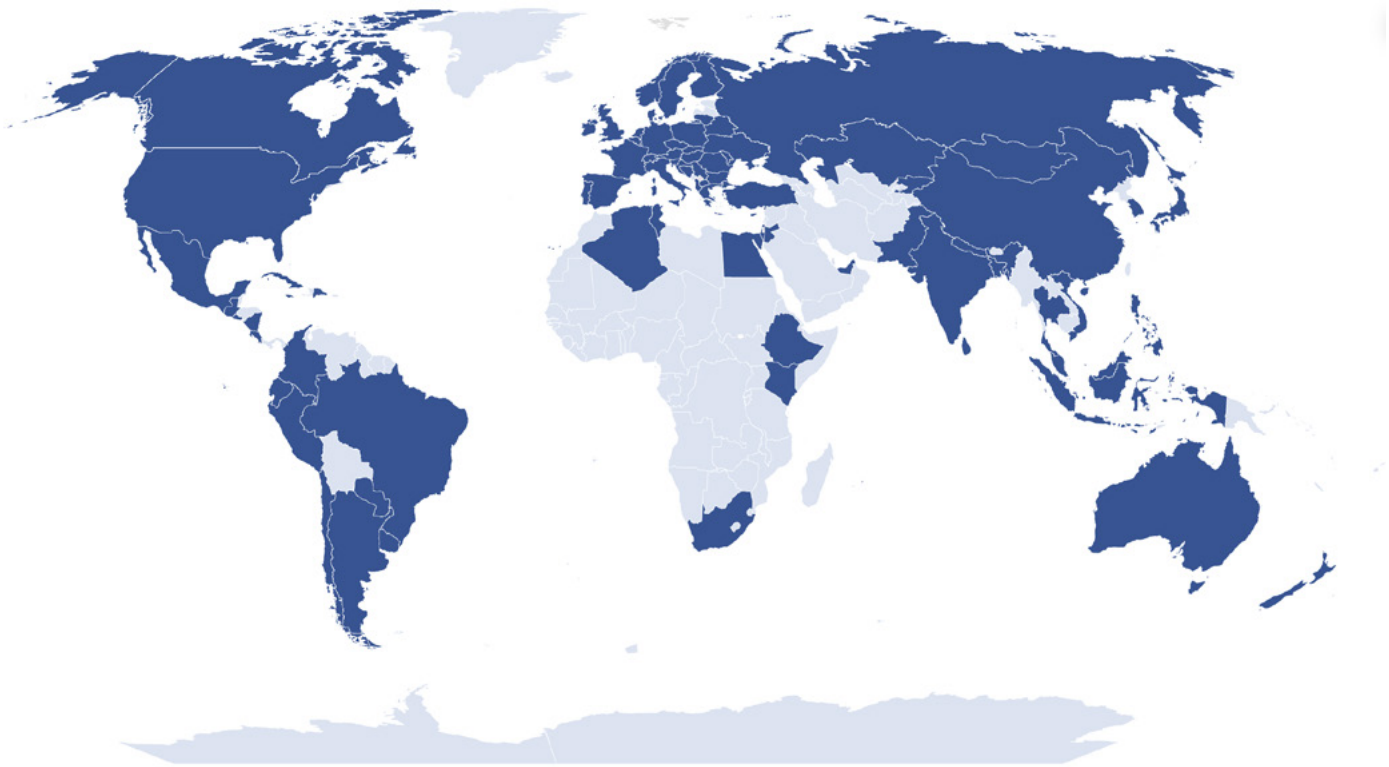
» Less than 60% data availability, OR

» More than 66% zero values across all indicators

The result is that we now have a total of 137 countries in the index.

To see which countries are actually included in the index, we can plot a map. This shows that the majority of countries are included, with some omissions in central Africa and also Venezuela.

```
# make new column in the indicator data - this is a bit of a hack
QI$Full$Data$Raw$x_Included <- ifelse(QI$Full$Analysis$Raw$MissDatSummary$Included, 1, 0)
# plot
iplotMap(QI$Full, dset = "Raw", isel = "x_Included")
```



Let us now use the same filtered set of countries for the P-indexes.

```
library(purrr)
# remove countries - use Input$Original
QI[2:4] <- modify(QI[2:4], ~{
  # this matches the countries in the P indexes with those in the full index
  .x$Input$Original$IndData <- .x$Input$Original$IndData |>
    filter(UnitCode %in% QI$Full$Data$Screened$UnitCode)
  # regenerate
  regen(.x, quietly = TRUE)
})

# check
stopifnot(identical(
  QI$Full$Data$Screened$UnitCode,
  QI$Pp$Data$Raw$UnitCode))
```

6.4 Data treatment

The next step is to see whether the indicators need to be treated. A simple way to look at this is to check skew and correlation values.

Indicator	Skew	Kurtosis	Frac.Zero	Prc. Unique
IECEEcert	5.02	27.86	0.78	0.22
IQNETcert	8.80	87.50	0.08	0.80
IQNETMemb	4.32	21.57	0.39	0.14
ISOcert	9.75	104.28	0.00	0.99
BIPMKSCs	2.45	6.54	0.28	0.55
BIPMCMCs	2.84	8.64	0.42	0.53
OIMLCSI	5.49	35.90	0.91	0.07
OIMLCSU	2.79	7.40	0.77	0.18
QP	-4.21	16.12	0.03	0.02
QPStake	-3.22	8.64	0.04	0.02
ITUMemb	5.60	37.41	0.24	0.25

At this point, we will proceed to treat the indicators using a default approach, which is to Winsorise a small number of points, then take a log transformation if that does not sufficiently correct the skew problems. We will also check the effects of these decisions in a robustness analysis later on. This is done using the **COINr** package and Winsorising up to ten points (less than 10% of the total number of countries). We also exclude from indicator treatment any indicators that have less than 10% unique values (such as binary indicators).

Let us now see what the properties of the distributions are, again focusing on skew and kurtosis.

Indicator	Skew	Kurtosis	Frac.Zero	Prc.Unique
IECEEcert	5.02	27.86	0.78	0.22
IQNETMemb	4.32	21.57	0.39	0.14
OIMLCSI	5.49	35.90	0.91	0.07
OIMLCSU	2.79	7.40	0.77	0.18
QP	-4.21	16.12	0.03	0.02
QPStake	-3.22	8.64	0.04	0.02
ITUMemb	5.60	37.41	0.24	0.25

We are therefore left with seven indicators that still exceed the recommended thresholds. However, all but one of these was deliberately excluded from data treatment due to the low number of unique values. The only remaining indicator is the Number of IECEE certificates recognised, which still exceeds the thresholds despite being treated. However, this seems unavoidable.

Let us also apply the same data treatment to the remaining P-indexes.

```
QI[2:4] <- modify(QI[2:4], ~{
  .x <- treat(.x, dset = "Raw", winmax = 10, deflog = "CTlog",
          individual = data.frame(IndCode = IndCode_NoTreat,
                                  Treat = "None",
                                  Winmax = NA),
          indiv_only = FALSE)
})
```

6.5 Normalisation

A very common approach to normalisation is simply to scale the indicators onto an interval of [1, 100]. This is called *min-max* normalisation. Normalisation is essential in building an index because it brings the indicators onto a common scale. We can apply this to the indexes as follows.

```
QI <- modify(QI, ~{
  # normalise using min max onto [1,100]
  normalise(.x, dset = "Treated", ntype = "minmax", npara = list(minmax = c(1,100)))
})
```

This has now generated a new data set with values scaled onto [1, 100]. We use 1 as the lower bound because in most cases, having the minimum score does not mean that the country has no capacity in the indicator or dimension of QI.

6.6

Weighting and aggregation

The weights have already been assigned the IndMeta input. Essentially, indicators are equally weighted, except for particular cases where two indicators are similar and highly correlated but still retain an added value between themselves. These cases are half-weighted.

To aggregate, we will use the simple arithmetic mean. We will also specify that for a country to have an aggregate score in any given dimension, at least 60% data availability is required.

```
QI$Full <- aggregate(QI$Full, agtype = "arith_mean",
dset = "Normalised", avail_limit = 0.6)

QI[2:4] <- modify(QI[2:4], ~{
  # aggregate using arithmetic mean and pre-assigned
weights
  aggregate(.x, agtype = "arith_mean", dset = "Nor-
malised")
})
```

6.7

Initial visualisation of results

Let us begin by checking the ranks and scores for the general index.

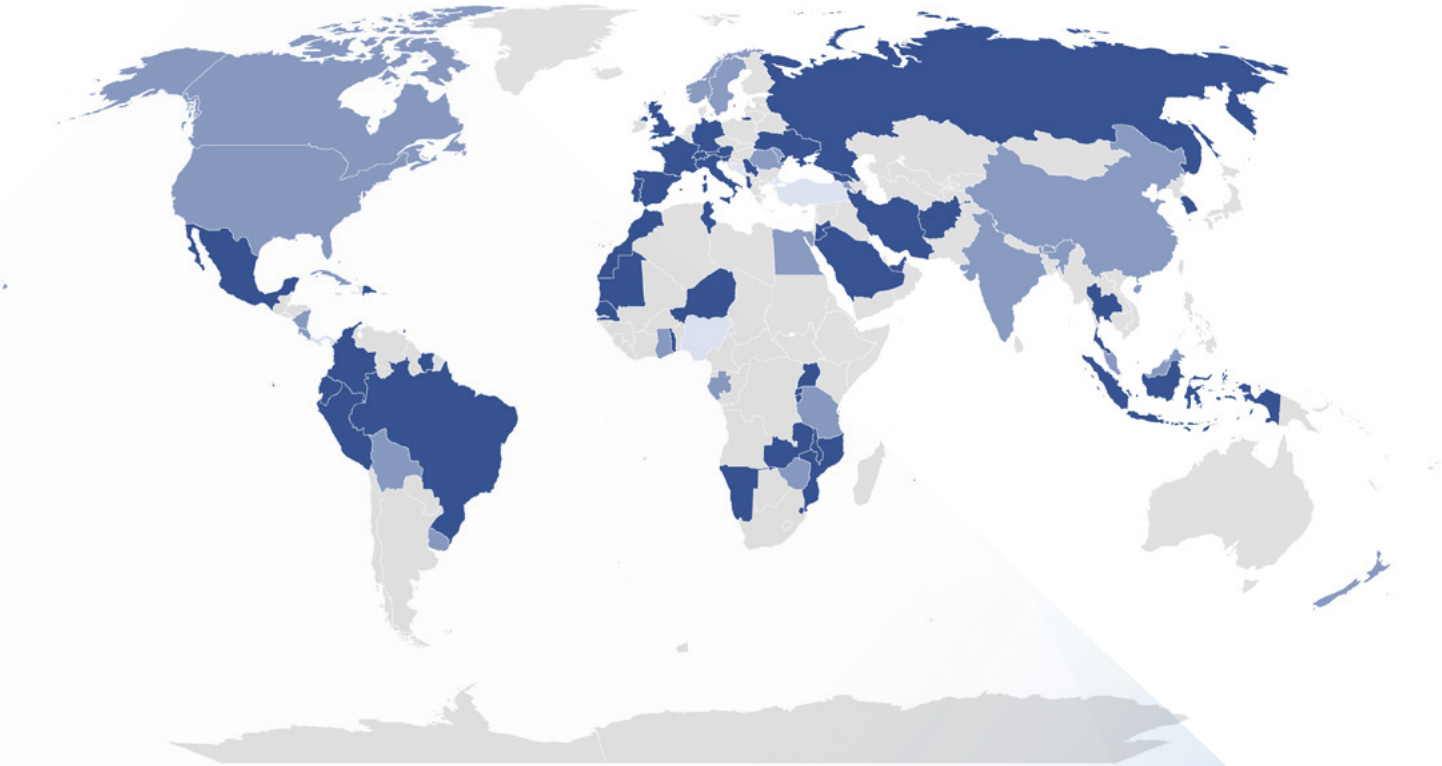
```
QI <- modify(QI, ~{
  # get summary results table plus full table, for each
index
  .x <- getResults(.x, tab_type = "Full", use = "scores",
out2 = "COIN")
  .x <- getResults(.x, tab_type = "Full", use = "ranks",
out2 = "COIN")
  .x <- getResults(.x, tab_type = "Full", use =
"groupranks", use_group = "Group_GDP",
                out2 = "COIN")
  .x
})

compTableMulti(QI, dset = "Aggregated", isel = "Index")
|>
  head(20) |>
  knitr::kable()
```

UnitCode	UnitName	Full	Pp	Pl	Pr
DEU	Germany	1	1	1	1
CHN	China	2	3	3	3
FRA	France	3	2	2	4
USA	United States of America	4	6	5	5
GBR	United Kingdom	5	4	6	6
JPN	Japan	6	5	4	9
ESP	Spain	7	8	7	7
KOR	South Korea	8	9	16	20
NLD	Netherlands	9	10	17	14
CHE	Switzerland	10	20	19	13
IND	India	11	11	15	8
ITA	Italy	12	7	8	2
AUT	Austria	13	19	21	22
NOR	Norway	14	28	34	31
CZE	Czechia	15	17	11	11
TUR	Turkey	16	12	13	10
AUS	Australia	17	14	22	24
CAN	Canada	18	23	29	44
ROU	Romania	19	16	10	12
ZAF	South Africa	20	22	23	23

We can also see this in map format (for the general index):

```
iplotMap(QI$Full, dset = "Aggregated", isel = "Index")
```



The final chunk here saves the results as an R Data file, and exports the four COINs to Excel spreadsheets.

```
# save(QI, file = "QI_Results.RData")

# write to Excel
# coin2Excel(QI$Full, fname = "results_Full.xlsx")
# coin2Excel(QI$Pp, fname = "results_Pp.xlsx")
# coin2Excel(QI$Pl, fname = "results_Pl.xlsx")
# coin2Excel(QI$Pr, fname = "results_Pr.xlsx")
```

Appendix: UNIDO survey

This appendix contains the online survey[39] created by UNIDO and launched by ISO over the time period of June–September 2021.

UNIDO QI4SD Index - Survey on Standards and Quality Policy

This survey aims to collect data on standards and Quality Policy, which will form the basis for the development of the Quality Infrastructure for Sustainable Development (QI4SD) Index.

The responses to the survey, with the exception of the email addresses, will be shared with other organizations with which ISO is collaborating in the context of the Sustainable Development Goals (SDGs), including UNIDO and IEC.

The ISO Member Data Protection Policy and Declaration on copyright and data protection for participants in ISO activities are applicable to this survey. It is run via SmartSurvey, a UK-based provider which assures GDPR compliance. For more information concerning SmartSurvey's privacy policy, please click here

1. Identification data *

Which country do you represent *

Name of your ISO member (NSB) *

Email address *

2. Gender *

- ☐ Male
- ☐ Female
- ☐ Prefer not to answer

Part 1/2: Questions concerning Standardization

3. Which of the following ISO standards have been adopted as national standards in your country? [ISO standards nr 9001:18091 (1/3)] *

- ☐ ISO 9001, Quality management systems - Requirements
- ☐ ISO 13485, Medical devices - Quality management systems - Requirements for regulatory purposes

[39] UNIDO QI4SD Index - Survey on Standards and Quality Policy (smartsurvey.co.uk)

- [ ] ISO 14001, Environmental management systems - Requirements with guidance for use
- [ ] ISO 14044, Environmental management - Life cycle assessment - Requirements and guidelines
- [ ] ISO 14055-1, Environmental management - Guidelines for establishing good practices for combatting land degradation and desertification - Part 1: Good practices framework
- [ ] ISO 14067, Greenhouse gases - Carbon footprint of products - Requirements and guidelines for quantification
- [ ] ISO 15189, Medical laboratories - Requirements for quality and competence
- [ ] ISO 15392, Sustainability in buildings and civil engineering works - General principles
- [ ] ISO/IEC TS 17021-12, Conformity assessment - Requirements for bodies providing audit and certification of management systems - Part 12: Competence requirements for auditing and certification of collaborative business relationship management systems
- [ ] ISO 18091, Quality management systems - Guidelines for the application of ISO 9001 in local government
- [ ] None of the above
- [ ] Don't know

4. Which of the following ISO standards have been adopted as national standards in your country? [ISO standards nr 20121:29993 (2/3)] *

- [ ] ISO 20121, Event sustainability management systems - Requirements with guidance for use
- [ ] ISO 20400, Sustainable procurement - Guidance
- [ ] ISO 21001, Educational organizations - Management systems for educational organizations - Requirements with guidance for use
- [ ] ISO 22000, Food safety management systems - Requirements for any organization in the food chain
- [ ] ISO 24521, Activities relating to drinking water and wastewater services - Guidelines for the management of basic on-site domestic wastewater services
- [ ] ISO 26000, Guidance on social responsibility
- [ ] ISO 29993, Learning services outside formal education - Service requirements
- [ ] None of the above
- [ ] Don't know

5. Which of the following ISO standards have been adopted as national standards in your country? [ISO standards nr 37001:59004 (3/3)] *

- ☐ ISO 37001, Anti-bribery management systems - Requirements with guidance for use
- ☐ ISO 37101, Sustainable development in communities - Management system for sustainable
development - Requirements with guidance for use
- ☐ ISO 45001, Occupational health and safety management systems - Requirements with guidance for use
- ☐ ISO 46001, Water efficiency management systems - Requirements with guidance for use
- ☐ ISO 50001, Energy management systems - Requirements with guidance for use
- ☐ None of the above
- ☐ Don't know

6. Has your country participated in capacity building programs related to Quality Infrastructure from any of the following international organizations in the last two years? *

- ☐ BIPM, Bureau International des Poids et Mesures
- ☐ OIML, Organisation Internationale de Métrologie Légale
- ☐ ISO, International Organization for Standardization
- ☐ WTO, World Trade Organization
- ☐ None of the above
- ☐ Don't know

7. Further comments on questions in Part 1 (please leave any comments or additional information you may have for questions 3-6):

Part 2/2: Questions concerning Quality Policy

What is a Quality Policy?

"The national Quality Policy is the basic government instrument that sets out the objectives of the Quality Infrastructure system in relation to Metrology, Standardization, Accreditation and Conformity Assessment, to build the foundation for effective trade"
Some countries may already have as well established system of Quality Infrastructure and accompanying regulations, legislation, etc., which is not necessarily labelled as a "Quality Policy". If this is the case, please check the second box in Question 8.

8. Does your country have a National or Regional Quality Policy in place, i.e. a policy for developing and sustaining effective Quality Infrastructure? *

- [ ] Yes
- [ ] No, but my country has regulations and/or directives which define functions and responsibilities of the different areas of Quality Infrastructure.
- [ ] No
- [ ] Don't know
- [ ] Additional information you would like to share

9. Which of the following dimensions of Quality Infrastructure are addressed by your Quality Policy or regulatory framework? *

- [ ] Metrology
- [ ] Conformity Assessment
- [ ] Accreditation
- [ ] Standardization
- [ ] Don't know

10. Is governmental support, including funding, stipulated in the Quality Policy or in the regulations and directions supporting Quality Infrastructure? *

- [ ] Yes
- [ ] No
- [ ] Don't know

11. Is the development and implementation of the Quality Policy being endorsed by the political level or led by the highest level of government? *

- [ ] Yes
- [ ] No
- [ ] Don't know

12. Has the Quality Policy been approved by your government or regional country grouping? *

- [ ] Yes
- [ ] No
- [ ] Don't know

13. Are stakeholders from the private and public sectors, consumers, producers involved in the Quality Policy process? *

- ☐ Yes
- ☐ No
- ☐ Don't know

14. Have gender balance and other diversity aspects been considered in the Quality Policy process? *

- ☐ Yes*
- ☐ No
- ☐ Don't know

(*) If yes, please provide some details:

15. Is there an implementation plan for the National Quality Policy, i.e. a plan which sets out the steps for achieving the policy objectives? *

- ☐ Yes, the policy is already in place
- ☐ Yes, it's in the process of implementation
- ☐ No
- ☐ Don't know

16. Is there a mechanism(s) for monitoring and/or evaluating the implementation/outcomes of the Quality Policy? *

- ☐ Yes
- ☐ No
- ☐ Don't know

17. Is there a mechanism(s) for periodically reviewing and updating the Quality Policy? *

- ☐ Yes
- ☐ No
- ☐ Don't know

18. Further comments on questions in Part 2 (please leave any comments you may have for questions 8-17):

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