



Measurement of Quality Infrastructure
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List of abbreviations and acronyms

BIPM	International Bureau of Weights and Measures
BMZ	Federal Ministry for Economic Cooperation and Development (Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung)
BRIC	Brazil, Russia, India and China
CABs	Conformity Assessment Bodies
CMC	Calibration and Measurement Capabilities
DAC	Development Assistance Committee
GlobalGAP	Global Partnership for Good Agricultural Practice
IAF	International Accreditation Forum
ILAC	International Laboratory Accreditation Cooperation
ISO	International Organization for Standardization
K&SComp.	Total Key and Supplementary Comparisons
LDC	Least Developed Countries
Membership	Number of Memberships of international QI system
MLA	Multilateral Recognition Agreement
MRA	Mutual Recognition Agreement
MSTQ	Metrology, Standardization, Testing and Quality assurance
NBT	Non-tariff Barriers to Trade
NMI	National Metrology Institute
NQS	National Quality System
ODA	Official Development Aid
OECD	Organization for Economic Co-operation and Development
POP	Country Population
PTB	Physikalisch-Technische Bundesanstalt [German Metrology Institute]
QI	Quality Infrastructure
SMEs	Small and Medium-sized Enterprises
TAB	Total Accredited Bodies
TBT	Technical Barriers to Trade
Tech.Comm.	Total Technical Committees participations
UNCTAD	United Nations Conference on Trade and Development
WTO	World Trade Organization

PREFACE

This paper is a research initiative of mesopartner, a consultancy firm which has been working for several years in private sector development and the support of quality infrastructure in developing countries. The elaboration of this document was supported by the Technical Cooperation of PTB.

The purpose of this paper is to present a methodological proposal for measuring the Quality Infrastructure (QI) of countries, and promote discussion on this little explored topic. The intention is not to provide definitive answers on the subject, but to ask questions that encourage the advancement of knowledge in this area. Specifically, we refer to QI with international recognition in its four areas: Metrology, Standardization, Certification and Accreditation.

Some benefits that will flow from achieving the aim of this paper are:

- a) the possibility of an international comparison between the Quality Infrastructure of countries;
- b) help in identifying to whom and where to channel resources from international cooperation with the aim of improving that infrastructure and;
- c) the promotion of discussion between technicians and academics to enable measurement methodologies to move toward more virtuous forms than those raised here.

The authors are grateful for the valuable contributions and comments made by several colleagues from the Technical Cooperation of PTB and consultant colleagues, especially Dieter Schwohnke, Marion Stoldt, Alexis Valqui, Manfred Kindler and Clemens Sanetra. Their practical experience in supporting QI throughout the developing world helped to provide a better understanding of the quantitative research results.

We hope this document will serve to encourage further discussion on the best methodologies to measure and compare QI and its performance internationally. Comments and critiques are welcome and appreciated.

EXECUTIVE SUMMARY

This paper gives an overview of the institutional framework of Quality Infrastructure (QI) with an international perspective. It develops a composite indicator to measure and compare the development and the performance of QI in a selection of 53 different nations worldwide. The indicator uses freely available data: Total Accredited Bodies of the National Quality System, number of Calibration and Measurement Capabilities certifications, ISO 9001 per country, key and supplementary comparisons carried out by National Metrology Institutes, participation in Technical Committees of International Standards Organization and membership of international organizations backing the credibility of the national QI.

The paper analyzes the correlation between the Quality Infrastructure development of a nation and key economic performance indicators like GDP (per capita), Exports and Global Competitiveness and Transparency. Positive correlations were found for all four variables, supporting the expected relationship between QI development and economic performance indicators.

The authors understand the proposed QI measurement indicator as just the first step in a more solid comparison between different national systems. The pragmatic approach of using only freely available data also makes the results dependent on sometimes unsatisfactory data quality. In addition, relevant qualitative differences between identical quantitative data were not analyzed in detail. Because of these limitations, the results of rankings should be interpreted carefully. Nevertheless, the quantitative comparison of national QI could be part of a broader Benchmarking and collective learning process to improve the development and performance of Quality Infrastructure bodies in the developing world.

Measure what is measurable, and make measurable what is not so.

Galileo Galilei

If you want it, measure it. If you can't measure it, forget it.

Peter Drucker

1 INTRODUCTION

The Physikalisch-Technische Bundesanstalt (PTB) is the National Metrology Institute of Germany and measures with the highest accuracy and reliability. It is part of a broader system of Quality Infrastructure which includes metrology, standards, testing laboratories, certification and accreditation bodies and quality management at the firm and organizational level itself.

The International Technical Cooperation of the PTB is engaged to promote Quality Infrastructure in developing countries. On behalf of the German Ministry of Economic Cooperation and Development (German acronym BMZ), it uses its technical expertise and excellence to support peer institutions and other QI related organizations in developing their own national QI.

Surprisingly, even though measurement is the core competence of the PTB, there are no clear indicators and tools to measure QI itself. Obviously the measurement of a complex institutional arrangement is not an easy task. It involves a multitude of different organizations, institutional regulations and, last but not least, humans, and thus also entails measuring social phenomena (i.e. trust, confidence or quality culture), which are not measurable with technical instruments. In addition, each economy has different requirements for the necessary QI, so evaluation of the level of development of a QI will depend on the specific needs of the countries.

Why is it important to measure QI?

Generally, what can be measured can be understood, controlled, predicted and changed.

In the case of entities responsible for supporting QI in developing countries, we may mention the following arguments to support the need for QI measurement. Measurements of national QI

- help to better understand the system dynamics of QI and improve interventions
- make possible the identification of best practices where QI develops and contributes to innovation, competitiveness and development
- could be a basis for a Benchmarking system which encourages improvement and mutual learning
- should be part of a broader monitoring and evaluation system which includes the final objective of the Technical Cooperation of PTB and other donors.

This paper uses the key components of QI (mainly Metrology; Standards; Certifications and Accreditation) to measure national QI. For each component we analyze statistical data at the country level. The selection of the data sources is pragmatic, using only data from international QI institutions which are freely available on the Internet. Based on the data of the different components, we create a joint indicator to measure QI at the national level.

In the second part of the paper we analyze the correlation between QI measures and economic performance measures (exportation, innovation, competitiveness, income). This helps us to see the efficiency of a QI system.

Our hypothesis is that a country with a well-developed QI is also economically successful and, inversely, countries lagging behind in QI are also economically less advantaged. For successful performance it is not sufficient to understand the evolution of GDP per capita; export performance, the level of competitiveness and transparency must be understood as well.

This study does not explain the causalities. The question of whether the development of a national QI causes economic progress or else economic progress helps to build a national QI is not part of the analysis. This and other issues will require further research and we outline some suggestions in the final chapter.

2 MEASUREMENT OF QI

2.1 Methodological questions

2.1.1 Data heterogeneity

When browsing websites of local accrediting and certification bodies, and NMIs, we found that the quality of information and its availability is quite heterogeneous. Examples of this include: the latest available data relate to different points in time in many cases, data sources are not necessarily primary or freely accessed, and the information they provide is not equally reliable. Furthermore, the information on websites is presented in very different ways which makes data collection for comparison purposes difficult. Initially, this significantly weakened the aim of this paper.

To reduce the impact of these problems, we decided to analyze only countries which are embedded in the international QI and trade system. Thus, the observed components of the national quality system would comply with certain international protocols that tend to homogenize the quality of their products (certification, standards, accreditations, measurements and calibrations certificates), improving information comparability.

We say that a country is integrated into the international quality system when it is a full member of at least one of the international accreditation, certification, standardization or metrology bodies with recognition worldwide. But we must bear in mind that the requirements for membership in each other's bodies are different, and only a few countries belong to all international quality system organizations. Hence, if we select countries according to membership, the sets are quite variable in number and members. A detailed analysis of how different groups are formed can be made from the table attached in the Appendix. In any case, the requirements imposed on bodies with regard to membership give a minimum guarantee in terms of transparency, accreditation and certification procedures, and consistency in the information they provide.

2.1.2 The international QI system

A brief introduction to some relevant international bodies considered in this paper was taken from their websites and is shown below.

Accreditation

The **International Accreditation Forum, Inc.** (IAF) is the world association of Conformity Assessment Accreditation Bodies and other bodies interested in conformity assessment in the fields of management systems, products, services, personnel and other similar programmes of conformity assessment. Accreditation Body Membership of IAF is open to Bodies conducting and administering programs by which they accredit bodies that declare their common intention to join the IAF Multilateral Recognition Agreement (MLA) recognizing the equivalence of other members' accreditations to their own.

The **International Laboratory Accreditation Cooperation** (ILAC) is an international cooperation of laboratory and inspection accreditation bodies formed more than 30 years ago to help remove technical barriers to trade. Accreditation bodies that meet the requirements for Associates and have also been accepted as signatories to the ILAC Mutual Recognition Arrangement (MRA) become Full Members. Associates of ILAC must: i) operate accreditation schemes for testing laboratories, calibration laboratories, inspection bodies, and/or other services as decided from time to time by the ILAC General Assembly; ii) can provide evidence that they are operational and committed to complying with: (a) the requirements set out in relevant standards established by appropriate international standards writing bodies such as the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) and ILAC application documents; and (b) the obligations of the ILAC Mutual Recognition Arrangement; iii) are recognized in their economy as offering an accreditation service. The cooperation between the two organizations is intense. In fact, they currently hold joint assemblies and there is the prospect of the two agencies merging in the future.

Standardization

The **International Electrotechnical Commission** (IEC) is the world's leading organization that prepares and publishes International Standards for all electrical, electronic and related technologies collectively known as „electrotechnology“. Full Membership allows countries to participate fully in international standardization activities. They are National Committees which represent their nation's electrotechnical interests in IEC management and standardization work.

International Communication Union (ITU) is the leading United Nations agency for information and communication technology issues, and the global focal point for governments and the private sector in developing networks and services. Membership of ITU is open to governments, which may join the Union as Member States.

The **International Organization for Standardization** (ISO) is the world's largest developer and publisher of international standards. A member body of ISO is the national body „most representative of standardization in its country“. Only one such body for each country is accepted for membership of ISO. Member bodies are entitled to participate and exercise full voting rights on any technical committee and policy committee of ISO.

In this case too, the cooperation between organizations of standardization is intense. One example is the Joint Technical Committee of the ISO and IEC, which deals with all matters related to information technology.

Certification

The emission of certificates based on standards is mainly a private business. The competence and impartiality of the certification bodies requires a conformity assessment by ISO/IEC 17021, which is carried out by national accreditation bodies.

We suppose that a developed national QI implies a large number of accredited certification bodies. On the other hand, the size of certification bodies differs when comparing the large international companies (i.e. SGS, Bureau Veritas and TÜV) with smaller firms with a national or a thematic focus. Also interesting is the emergence of international networks of smaller certification bodies¹.

However, there is no international statistic on the number of accredited certification bodies in every country. Only some accreditation bodies list the names of their accredited certification bodies on their Websites. Therefore we do not use the number of accredited certification bodies as part of our indicator.

In regard to the output of Certification, we are using the ISO statistic on ISO 9001 issued as a proxy variable. But this has two limitations: firstly, there are many more certification schemes than ISO, such as the Better Cotton Initiative, Fair Trade or GlobalGAP²; secondly, there are many more standards in ISO than ISO 9001³, for example, Environmental Management Systems (14001), Information technology (27001), and ISO 13485 which gives quality management system requirements for medical devices, among others. Nevertheless, ISO 9001 is by far the best seller.

1) i.e. IQNET (<http://www.iqnet-certification.com>)

2) As the number of private/ voluntary standards increase continuously, it is difficult to get an overview. The Standards Map is of the International Trade Center is an online tool that enables analyses and comparisons of private/voluntary standards (see <http://www.standardsmap.org/>).

3) ISO has developed over 18 500 International Standards on a variety of subjects and some 1100 new ISO standards are published every year (see <http://www.iso.org>).

Metrology

The **International Bureau of Weights and Measures** (BIPM) acts in matters of world metrology, particularly concerning the demand for measurement standards of ever increasing accuracy, range and diversity, and the need to demonstrate equivalence between national measurement standards. In 1999, the directors of the national metrology institutes of thirty eight Member States of the BIPM and representatives of two international organizations signed a Mutual Recognition Arrangement (CIPM MRA) for national measurement standards and for calibration and measurement certificates issued by NMIs. A number of other institutes have signed since then. This Mutual Recognition Arrangement is a response to a growing need for an open, transparent and comprehensive scheme to give users reliable quantitative information on the comparability of national metrology services and to provide the technical basis for wider agreements negotiated for international trade, commerce and regulatory affairs. The CIPM MRA has now been signed by 48 Member States and covers a further 122 institutes designated by the signatory bodies.

The **International Organization of Legal Metrology** (OIML) is an intergovernmental treaty organization whose membership includes Member States, countries which participate actively in technical activities. It was established in 1955 in order to promote the global harmonization of legal metrology procedures. Since that time, the OIML has developed a worldwide technical structure that provides its Members with metrological guidelines for the elaboration of national and regional requirements concerning the manufacture and use of measuring instruments for legal metrology applications.

2.1.3 Available information

Categorical and quantitative data can be gathered from websites.

Among the first things we found was basically that a country (or organization) can be classified by: membership or non membership; categories of membership (full or body member, associate, participant, partner, observer, etc); signatories or non signatories to some agreement (MRA, MLA); and participation in committees. This set of data will be used mainly to determine the sample of countries in the next section, and later will be part of the QI indicator itself. Membership and signatories' qualities could be considered as an *input* of the QI system. But QI performance is not guaranteed by this condition since it wouldn't be sufficient.

The quantitative information used in this paper relates to that performance and reveals some evidence about the stage of development achieved by each QI system. This second set of data is considered as the system *output*. Quantity of bodies and issued certificates are the most relevant statistics collected due to the fact that they are mostly freely accessed, and easy to interpret and compare.

The above considerations are summarized in the following table, from which the basic matrix for the measurement of the QI will be obtained.

QI system	Inputs	Outputs
Accreditation	<ul style="list-style-type: none"> · Membership of: IAF, ILAC · Signatories to: MLA, MRA · Regional agreements 	<ul style="list-style-type: none"> · Total Accredited Bodies (TAB) by national accreditation bodies
Metrology	<ul style="list-style-type: none"> · Memberships of: CIPM, OIML · Signatories to CIPM MRA 	<ul style="list-style-type: none"> · Calibration and Measurement Capabilities (CMC) issued and recognized · Key and Supplementary comparisons practiced
Standardization	<ul style="list-style-type: none"> · Membership of: ISO, IEC, ITU · Participation in ISO committees 	<ul style="list-style-type: none"> · Participation in Technical Committees · Number of standards by country (local and international)
Certification	<ul style="list-style-type: none"> · Accredited certification bodies (not used because of missing data) 	<ul style="list-style-type: none"> · Number of ISO 9001 certifications issued

2.1.4 Sample definition

2.1.4.1 Starting point: WTO members

The importance of quality infrastructure in trade is well accepted both nationally and internationally because it promotes the free movement of goods and services while reducing technical barriers and nontariff barriers (*ITC, WTO and UNCTAD 2005*). In turn, adherence to quality standards by producers of goods and services sold globally gives the consumer a better assurance of their safety, health and environment related aspects (*Guasch 2007*).

However, the number of technical regulations and standards adopted by countries has grown significantly in recent years. This has led to the creation of impediments to free trade due to the lack of harmonization in the quality standards of the countries engaged in global trade (*World Trade Organization 2005*).

The WTO, through its Technical Barriers to Trade Agreement (TBT), tries to ensure that regulations, standards, testing and certification procedures do not create unnecessary obstacles. This commitment includes the obligation for member states to establish national enquiry points and to keep each other informed about the new regulations. In addition, the WTO groups together 152 member states and 30 observer countries (which must start accession negotiations within five years of becoming observers). Of the 192 countries recognized by the UN, 182 belong to the WTO. Global trade is well represented by those members and observers.

Although not all WTO states will be sampled in this paper, this set will serve as a starting point for the definition of our target group.

2.1.4.2 Clustering criterion within the sample: development perspective

Every year through their Development Assistance Committee (DAC), the OECD countries approve the List of Recipients of Official Development Assistance (ODA). These countries are divided into income groups (Other low income, Lower Middle Income, Upper Middle Income) based on Gross National Income (GNI) per capita as reported by the World Bank, with the Least Developed Countries (LDCs) as defined by the United Nations. Coincidentally, there are also 152 countries in the 2009 list but only 83% of them are WTO members (*UNCTAD 2007*).

LDC in particular are hardly covered by the international quality system: only four members of ISO (Tanzania, Bangladesh, Ethiopia and Sudan), and one of OIML (Tanzania) are included. This time, these countries will not be covered by our radar.

So, three categories will be considered, depending on whether the country is a donor (DAC), recipient (ODA), or neither (non ODA).

2.1.4.3 The best set and the sample selection

As is shown in the table below, ITU and ISO sets represent quite well the proportions of our starting group (WTO) classified according to the ODA-DAC list, probably because of the large sample size of each. Both are better than any other set in terms of representativeness. If we look at the following sets (BIPM, OIML, IAF, IEC, ILAC countries) these are fairly homogeneous in their numbers but with a smaller sample size. Members of BIPM draw some advantage over these because they represent WTO members better. ONU countries are included only as a reference.

All WTO countries (members and observers) also belong to the ITU, so the sample choice is between members of ISO and BIPM.

The larger number of BIPM countries in the international QI system produces a more homogeneous set (98% of them belong to another international body). Indeed, if we take all ISO members, we find a significantly lower percentage (73%). Therefore, BIPM members will be chosen as the target group in this paper. So we intend to give more weight to the quality of information in terms of reliability and availability rather than the representativeness of the sample, at least on this occasion. Further research is needed to assess the quality of the information on a broader base of countries.

	ODA	non ODA	DAC	Total	Sample Size
WTO*	69%	19%	12%	100%	182
ITU	69%	19%	12%	100%	183
ISO	57%	21%	22%	100%	101
BIPM	43%	19%	39%	100%	54
OIML	41%	21%	38%	100%	56
IAF	40%	21%	40%	100%	53
IEC	38%	23%	39%	100%	56
ILAC	37%	23%	40%	100%	52
UNO Countries	79%	9%	11%	100%	192

*WTO Members and Observers included. For other organizations Full Member considered.

2.1.4.4 The sample

The table below shows the 54 members of the BIPM and their classification according to the aforementioned criterion. However, Australia and New Zealand will be taken as a single economy because of their degree of integration with regard to the QI system.

The abbreviations used are: (HI) High Income, (UMI) Upper Middle Income, (LMI) Lower Middle Income, (OLI) Other Low Income and refer to the World Bank classification.

DAC	ODA	Non ODA
Australia (HI)	Argentina (UMI)	Czech Republic (HI)
Austria (HI)	Brazil (UMI)	Hungary (HI)
Belgium (HI)	Chile (UMI)	Israel (HI)
Canada (HI)	Croatia (UMI)	Korea, Republic of (HI)
Denmark (HI)	Kazakhstan (UMI)	Singapore (HI)
Finland (HI)	Malaysia (UMI)	Slovak Republic (HI)
France (HI)	Mexico (UMI)	Bulgaria (UMI)
Germany (HI)	Serbia (UMI)	Poland (UMI)
Greece (HI)	South Africa (UMI)	Romania (UMI)
Ireland (HI)	Turkey (UMI)	Russian Federation (UMI)
Italy (HI)	Uruguay (UMI)	
Japan (HI)	Venezuela, Bolivarian Rep of (UMI)	
Netherlands (HI)	Cameroon (LMI)	
New Zealand (HI)	China (LMI)	
Norway (HI)	Dominican Republic (LMI)	
Portugal (HI)	Egypt (LMI)	
Spain (HI)	India (LMI)	
Sweden (HI)	Indonesia (LMI)	
Switzerland (HI)	Iran (LMI)	
United Kingdom (HI)	Thailand (LMI)	
USA (HI)	Kenya (OLI)	
	Korea, DPR of (OLI)	
	Pakistan (OLI)	

There are 45 signatories of the CIPM MRA among the sample countries. The vast majority of them are highly integrated into the international system of QI. Indeed, over 80% are full members of each of the following organizations: ISO, IAF, ILAC and BIPM. 74% of the world population and 95% of world GDP is represented by these economies according to data from the World Bank (2008).

2.2 Measurement of QI components

2.2.1 Metrology

As indicated by the BIPM, metrology is the science of accurate and reliable measurements. But not all countries have a quality infrastructure with the same measurement and calibration capabilities. A key criterion for evaluating these capabilities is not a precise measurement, but the highest reliability of measurement capabilities declared. These are called *Calibration and Measurement Capabilities*⁴ (CMCs) and are awarded to NMI through the CIPM MRA (International Committee of Weights and Measures - Mutual Recognition Agreement). The CMCs are issued in a database managed by the BIPM in Paris and published online⁵.

One approach to measuring development and reliability of the national metrology would be provided by the number of CMCs given to the NMI of the host country⁶. This statistic would measure three aspects of the system: firstly, the development achieved from the point of view of its size. We suppose that the greater the amount of declared capability, the greater the infrastructure needed to support it. Secondly, a greater number of CMCs would also show the *diversification* of skills. We assume that the system is at a more advanced stage of development when its supply of services is more diversified. Thirdly, recognition by other members of the club is incorporated into this proposed measure because CMC certificates are issued within the field of the agreement.

Additionally, we would consider the number of CMCs but in relation to population in an attempt to measure the metrology system relative to the domestic market. Here there is a significant “size effect” produced by the scale of economies, but there could also be an issue of system efficiency that may explain differences between countries.

The BIPM also gives information about the set of comparisons conducted by NMIs to test the principal techniques and methods in the field. These are called Key or Supplementary Comparisons and are carried out by two or more bodies organized by the Consultative Committees or the Regional Metrology Organizations (RMO). The first comparisons are open to laboratories with the highest technical competence and experience. The second set are carried out by RMOs to meet specific needs not covered by key comparisons, including comparisons to support confidence in calibration and measurement certificates. So, the larger the number of comparisons, the higher the degree of interaction with other members of the international quality infrastructure system, and possibly the better the metrological capacities that might be acquired or spread.

4) The highest level of calibration or measurement normally offered to clients, expressed in terms of a confidence level of 95 %, sometimes referred to as best measurement capability. (http://www.bipm.org/utis/en/pdf/mra_glossary.pdf).

5) In some countries, the NMI delegate some work to secondary calibration laboratories, which can be private or public entities. These use secondary standards traceable in NMI to calibrate the instruments of their consumers. The concept of traceability means an unbroken chain of comparison measurements with instruments of increasing accuracy (lower measurement uncertainty) starting with the instrument used in the industry and moving up to national standard (Sanetra 2007).

6) Our consultation of metrology experts confirmed the utility of the CMCs indicator. As CMCs require comparison measurements with similar uncertainty there are no better indicators. Nevertheless, the number itself may refer to different levels of metrological competence, i.e. a NMI may get 10 CMCs for mass pieces on a low level or get 10 CMCs on primary normals, but there is world of difference between the two.

2.2.2 Accreditation

Accreditation is defined as the procedure by which a body gives formal recognition that an organization or person is competent to carry out specific tasks (*Guasch 2007*). Once the accreditation is issued by the body, the organization becomes an Accredited Body. Accreditation is sought on a voluntary basis as proof of competence in a given area. Most countries have a single national accreditation body responsible for all areas of accreditation. It can be either a public or a private not-for-profit organization. Accreditation covers various areas such as: management system certification bodies, testing and calibration laboratories, Greenhouse Gas validation, verification bodies, personnel certification bodies, product and service certification bodies, and inspection bodies, among the most relevant examples.

Thus, a greater number of accredited bodies could lead to the diffusion of the competency, authority and credibility of those bodies.

We collected the Total Accredited Bodies (TAB) from each economy, using as a source the websites of all National Accreditation Bodies included in the sample. TAB will be the output of this QI component. We may recall that 10 of the 54 members of our group are members of neither IAF nor ILAC, however, their accreditation bodies provide information about the certificates issued (except for three: Mexico, Kenya and Korea DPR).

2.2.3 Standardization and Certification

As ISO pointed out, standards ensure desirable characteristics of products and services such as quality, environmental friendliness, safety, reliability, efficiency and inter changeability and at an economical cost. ISO launches the development of new standards in response to sectors and stakeholders that express a clearly established need for them.

The best selling standards are:

- ISO 9001:2008 Quality Management Systems
- ISO 14001:2004 Environmental Management Systems
- ISO/IEC 27001:2005 Information technology - Security techniques
- Information security management systems
- ISO 31000:2009 Risk Management

The most popular certification is ISO 9001 (2000 and 2008 editions), for which almost a million certificates had been issued in 176 countries and economies up to the end of December 2008.

This makes the number of issued ISO 9001 a relevant indicator to measure the penetration of the standardization in the economies. The ISO survey 2008 provides this information disaggregated by country. Again, the size of population is closely associated with the number of ISO issued. Thus, this data will be presented in relative terms.

ISO standards are developed by Technical Committees (TC) comprising experts from the industrial, technical and business sectors which have asked for the standards, and which subsequently put them to use. The experts participate as national delegations, chosen by the ISO national member institute for the country concerned. These delegations are required to represent not just the views of the organizations in which their participating experts work, but of other stakeholders too.

Information about the number of Technical Committees in which each country participates is available on the ISO website. It will be used as input in this work in order to measure the degree of participation in international development of quality standards.

2.3 The Indexes

2.3.1 The basic measure

Index (CMC, ISO, TAB)

It measures the *output* of three of the four sectors of the QI (Metrology, Standardization and Accreditation). The indicator is constructed from three different sources, all available on the Web: CMCs, ISO9001 and TAB. These outputs are not the only ones given by the system, but are freely available on the Internet, so they are easily observable. In all three cases, the value recorded in each variable is the number of certificates issued by the competent authority. As already mentioned, the CIPM issues the CMC certifications to the NMI; ISO 9001 certifications are given through an accredited member in the domestic economy; and TAB counted for each country comes from the websites (54 in total) of the national bodies responsible for that accreditation.

Due to the index composition, it gives better positions to the largest countries, from the point of view of their population and/or their production. Indeed, the three variables comprising it are positive but only moderately correlated with population and GDP. No wonder then that the top positions will generally be occupied by the most powerful countries and/or populations in the world, and the lower ones by the smaller and/or poorer countries. Furthermore, the three indicator variables are positively correlated with each other, so that countries with high records of one tend to have high registers in the other two. The same applies to intermediate and low levels. We think then that the effect of the size of economies significantly impacts the behavior of this composite indicator. It is important to take this into account in order to give a correct interpretation of the indicator and not overstate its explanatory power.

On the other hand, it has the advantage of being a „pure“ indicator which doesn't resort to using proxies, usually used to measure complex phenomena. In this case, the phenomenon is observed directly. But it is clear that this set of variables is far from exhaustive, and that the view they give us is direct, but partial.

Some relevant questions arise when we deepen our analysis of the information provided by this indicator.

To begin with, what does it mean for two countries to have equal values for this composite index? Well, as previously mentioned, it is to be expected that CMCs, ISO and TAB will have similar values, that is, all relatively high, or all low, or all three variables at intermediate levels. So, can we say that two countries such as the Korean Rep. (22.42) and Japan (23.18) have a similar QI? We cannot answer this question with the information available, but we can give some pointers towards clarifying the matter. Firstly, it is noted that Japan has a population of almost 128 million in contrast to the Rep. of Korea's 49 million, that is to say, two and half times larger. Its GDP is also higher: 4.4 billion as opposed to 1.4 billion (PPP). Here the ratio is approximately 3 to 1. It is clear that these QIs serve different needs, at least from the standpoint of the scale. However, as we said, the QI seems to be similar if we look at the number of certificates produced by each system. Some hypotheses to explain the above could be:

- a) *There is a difference in the efficiency of the systems.* Japan is more efficient than the Korean Republic despite the fact that it has equal QI, but produces more and has larger domestic markets. This hypothesis would make sense if we think that two countries can convey various stages of development of their QI. In turn, the market orientation of their internal or external production systems and opening of the economy to the flow of imports could determine a productivity differential because the exposure to international trade competition requires better and more efficient development of quality systems.
- b) *QI not recognized internationally.* We might think that a significant part of the product of a country is generated outside the international recognition platform considered in this paper. We are not saying that Japan produces products of low quality but that their quality is not recognized at all. This could relate to an economy that produces mainly for the domestic market.
- c) *Differential quality.* The previous point leads us to think of a more extreme situation. If two economies have the same QI (as measured) but one produces more than the other and is more populated, then, in the latter the quality of the infrastructure is not very widespread. The result would be a negative differential in quality. This could be true only if comparing equally efficient systems.

Perhaps the issue is even more complex, and in reality several of the factors mentioned above are operating simultaneously. Further research would be needed to shed light on this issue.

The above analysis suggests the need to relativize this way of measuring the QI if we are to do justice to the countries involved in the sample.

2.3.2 Measuring in relative terms

Index (CMC/POP, ISO/POP, TAB/POP)

Constructed in this way, the first indicator measures **the number of CMC, ISO, and TAB for each million inhabitants**. That is, each variable in terms of population. Countries with large populations and low QI will be punished with lower ranking positions. A large population must be accompanied by a well-developed QI if an economy wants to be highlighted in the field of quality infrastructure with international recognition. Countries that favor the internal versus external market are not expected to achieve the best scores in the rankings because they will need an internationally less well recognized QI to meet its demands. Small countries with large export profiles will be the best candidates for upper positions. Thus, the population size serves to relativize the QI and partially mitigate the problems of scale, efficiency, and quality of systems, but on the other hand, incorporates a bias which must be addressed later.

Index (CMC/GDP, ISO/GDP, TAB/GDP)

Another alternative to relativize the QI would use GDP. We are aware of the critique on the use of GDP as the weight or indicator, since it can be positively correlated with factors that diminish quality of life, and at the same

time may not reflect factors that are well developed in the economy and contribute to social welfare⁷. Despite this criticism, we use the GDP in this section since it is easy to observe and is an indicator universally taken for comparison in economic research.

The results in the ranking do not change substantially if we do both lists, with a few exceptions. Now the number of CMCs, ISO and TAB is divided by the value of GDP (billion of GDP: PPP World Bank 2008). Note that the comments made earlier also apply when we use GDP to relativize the QI. That is, the larger producers in the world require a high amount (comparatively speaking) of CMC, ISO and TAB to be located at the top of the ranking. The relative exposure of the economy to international trade could make the difference again between the two. The efficiency of the system could also partly explain the differentials.

We said recently that changes in rankings are not substantial if relativized to population or GDP, except for some countries. Let's consider these specific cases.

	QI relative to population ranking position	QI relative to GDP (PPA) ranking position	Rank difference
Romania	27	10	17
Chile	30	14	16
China	41	25	16
Serbia	21	7	14
Malaysia	33	21	12
Bulgaria	12	1	11
Croatia	26	15	11
USA	37	49	-12
Ireland	10	23	-13
Norway	16	36	-20

For the total sample, changes are on average of six positions, sometimes gained and sometimes lost. Only ten countries diverge from the average in more than one standard deviation above. That is, only the countries in the table above change more than ten places when moving from one list to another. The biggest change is for Norway, which drops 20 positions. So, when using population its place in the list is 16th, but in relation to GDP, it falls to position 36.⁸

Of the ten in the table, most gain positions when the QI is split between the GDP. Only countries with high GDP per capita such as the USA, Ireland and Norway lose ground so drastically. Indeed, these three countries are amongst the four highest GDP per capita in the world (all three are DAC). Moreover, those gaining positions are the countries that are mid-table and below on GDP per capita. This could skew the final results at the extremes of the list, just like when we use population. The problem should be solved somehow.

Finally, among the variables, population and GDP there is a very strong positive correlation (Spearman correlation = 0.83), so that the use of one or the other to relativize the QI does not generate large differences in the end. What should we use then? Population or GDP? The GDP of an economy is more volatile than the size of its population over time, so our indicator would be more sensitive to possible changes in the QI if we relativize by number of residents. This rationale finds support in the fact that the two variables are weakly associated (correlation 0.34), unlike GDP which maintains a direct and very close relationship with the level of Index (CMC, ISO, TAB) (correlation 0.80). In addition, GDP is not always comparable between OECD countries and least developed countries. For these reasons, we will use population to construct our leading indicator. However, in the Appendix we can see how countries are rated using both methods.

7) For example: GDP treats crime, divorce, and natural disasters as economic gain; GDP ignores the non-market economy of household and community; GDP treats the depletion of natural capital as income; GDP increases with polluting activities and again with clean ups; GDP ignores income distribution and the drawbacks of life in foreign assets.

8) A specific feature of Norway is the 80% of its GDP is due to oil production. This may explain why it falls in the ranking positions. Further research on sectoral effects is necessary.

2.3.3 The relational dimension

Index (Key and Supplementary Comparisons, TC Participation, Membership)

The data matrix presented earlier in this chapter shows different inputs and outputs of the quality system of a country that could be used for measurement of QI. All of them are observable via the Internet. From this matrix, three additional variables to those already considered were taken into account to enrich our indicator. These are:

- I. *Key and Supplementary Comparisons* carried out by the NMI in coordination with peer bodies in other countries. These field experiences are conducted under the auspices of the CIPM.
- II. *Participation in Technical Committees* of the International Standardization Organization. Those are given within the ISO and follow the interest in the development of standards in specific areas. The rule is that these groups include representatives from various countries.
- III. *Full membership* of international organizations committed to the development of QI at international level (WTO, IAF, ILAC, CIPM, OIML, ISO, IEC, ITU).

There is a common element in all three factors: the linkage or relationship between the participants. The systemic dimension appears again here. This allows us to group the new variables to form a second indicator of the quality infrastructure under the name of Participation in the international system of QI.

We assume that the greater the participation in these three areas, the greater the degree of development of the QI. The dissemination of good practices, learning spaces and knowledge sharing, and the benefits of being recognized by other club members, are elements that would support our assumption.

The new indicator will be summarized as Index (K&S Comp., TC Part., Member.). In general, one should not necessarily expect countries with high values for this index to also record high values for Index (CMC/POP, ISO/POP, TAB/POP), and vice versa. The evidence shows that the association between them is weak. This allows us to think that we are seeing a different dimension of the QI, which is quite evident if we look at the kind of information that is grouped into this new indicator. Therefore, we would be adding new information, which is not redundant, thereby increasing the explanatory power of the measuring instrument. To preserve this advantage it will not be appropriate to relativize the three components of the new indicator using population. If we did this, the correlation between them would reach 90%, which would greatly weaken the informational power of the new component. Moreover, when considering the absolute amounts of K&S Comp., TC Part. and Membership, we have a chance to partially resolve the problem of bias that we mentioned earlier.

2.3.4 The composite indicator

Index (QI/POP)

If we give equal value to the number of licenses per capita and participation in the international system of QI, we can construct a composite indicator, where the weight assigned to each component is the same. That is, we would be averaging both indices. We have no reason to assign different weights, so the equity criterion has been chosen.

The composite index is called Index (QI/POP). Below we can see the mathematics behind the indicator.

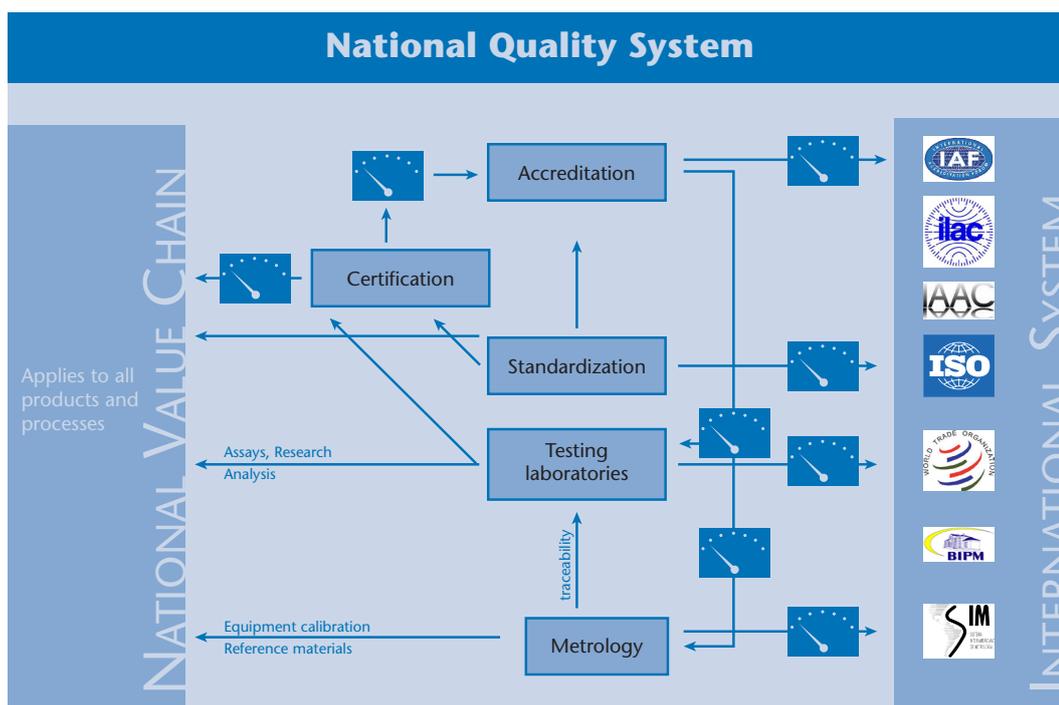
$$\text{Index(QI/Pop)} = \frac{\text{Index} \left(\frac{\text{CMC}}{\text{Pop}}, \frac{\text{ISO}}{\text{Pop}}, \frac{\text{TAB}}{\text{Pop}} \right) + \text{Index} (\text{K\&SComp.}, \text{Tech. Comm.}, \text{Membership})}{2}$$

- $$\text{Index} \left(\frac{\text{CMC}}{\text{Pop}}, \frac{\text{ISO}}{\text{Pop}}, \frac{\text{TAB}}{\text{Pop}} \right) = \left(\frac{\text{CMC}/\text{Pop}}{\text{max.value}} + \frac{\text{ISO}/\text{Pop}}{\text{max.value}} + \frac{\text{TAB}/\text{Pop}}{\text{max.value}} \right) \times \frac{100}{3}$$
- $$\text{Index} (\text{K\&SComp.}, \text{Tech. Comm.}, \text{Membership}) = \left(\frac{\text{K\&SComp.}}{\text{max.value}} + \frac{\text{TechComm.}}{\text{max.value}} + \frac{\text{Members hip.}}{\text{max.value}} \right) \times \frac{100}{3}$$

References:

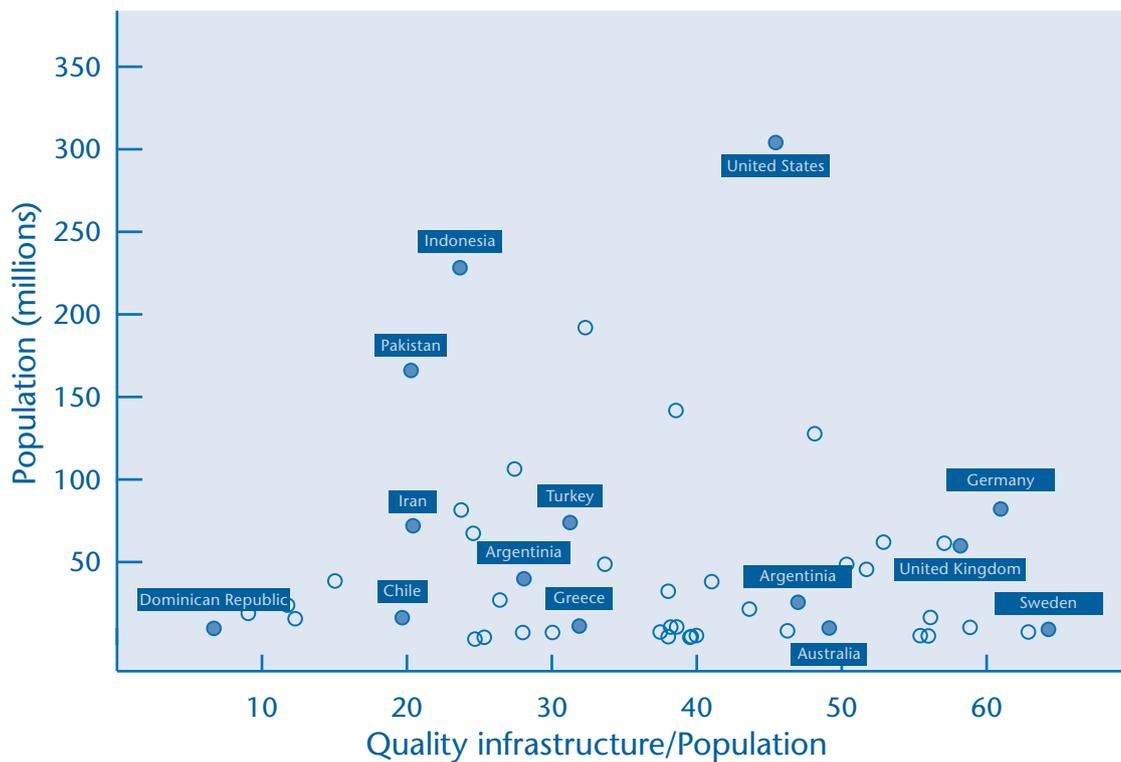
1. QI = Quality Infrastructure
2. POP = Country Population
3. CMC = Total Calibration and Measurement Capabilities
4. ISO = Total ISO9001 issued
5. TAB = Total Accredited Bodies
6. K&SComp. = Total Key and Supplementary Comparisons
7. Tech.Comm. = Total Technical Committees participations
8. Membership = Number of Memberships of international QI system

The diagram below is an adaptation of a graphic used frequently in PTB documentations on Quality Infrastructure and Value Chains (*Sanetra 2007*). It shows in the red area the location of the measures of our main indicator. Note that connections on the left side of the diagram were given little consideration because of the availability of information and our pragmatic approach, but future research should clarify this crucial issue.



The connection between the main indicator and the International System of QI is stronger. This is an advantage since the quality of data is higher and comparisons tend to be reliable. On the other hand, the measurement of the QI links with the national value chain represents a much greater challenge than the one proposed in this paper. Their study could reveal the specifics of each system and would assess their effectiveness in meeting the real needs in NQS.

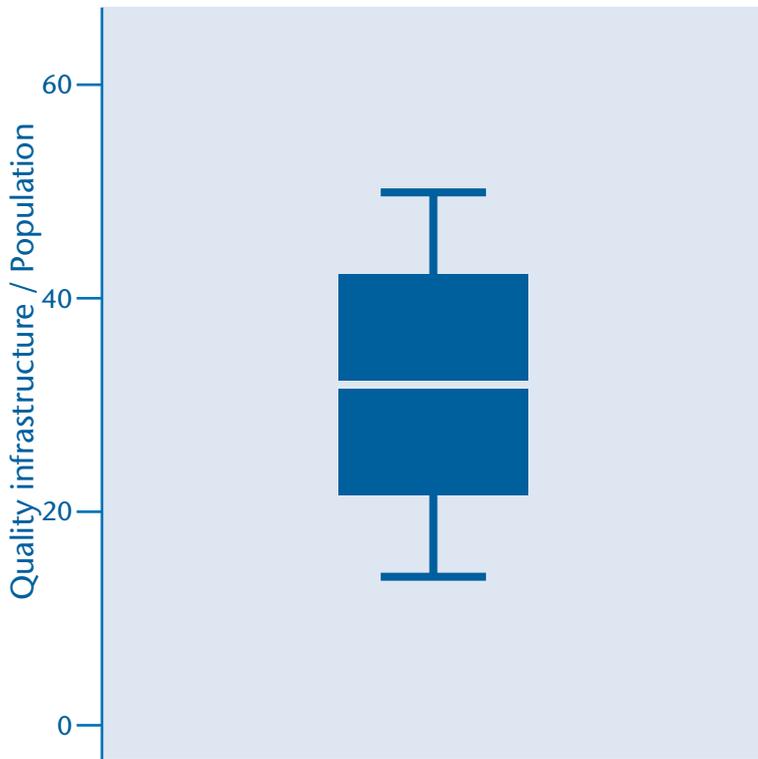
Coming back to the issue of bias, we can say that this composite indicator has the advantage of having eliminated the association with population size (correlation is close to zero). That is, countries with extreme values for population do not necessarily need to be located at the ends of the ranking. The reason for this is that we haven't relativized the participation in the international system of QI, which somehow compensates countries "punished" for having large populations, and in turn, does justice to those small countries that enjoyed good ranking positions, provided of course they actively participate in the scheme. Indeed, there doesn't seem to be a specific pattern among Index (QI/POP) and population. The scatter plot below illustrates this argument. Importantly, we have removed China and India for being extraordinarily populous so we can better see the lack of association between variables.



In summary, the advantages and disadvantages of the indicator can be stated as follows:

- a) It is simple in design, which facilitates comprehension and analysis, especially if we consider that one purpose of the paper is to propose a methodology to encourage discussion of the issue and make room for as much improvement as possible. It is also replicated, thus ensuring the transparency of the method.
- b) It is well behaved, in the sense that the distribution is relatively symmetric and homogeneous. This allows the mobility of the countries in the ranking, as long as enough of them change one or more variables. So, there are no "unattainable" positions in the ranking. The box plot illustrates this advantage. The 50th percentile of the distribution (the median) is quite centered, and there are no atypical or extreme outliers. Therefore, there is symmetry and homogeneity. These two qualities were observed in widespread indexes such as the Corruption Perception Index (Transparency International), Global Competitiveness Index (WEF) and Innovation Capacity Index also.

Box Plot for QI / POP scores



- c. It reflects two different and complementary dimensions of the QI system. One has to do with what happens locally, and another with what happens internationally. Indeed, the certifications ISO, TAB, CMC, are awarded to organizations that act locally (enterprises and public institutions typically), while K&S Comparison, Technical Committees Participation and Membership correspond to the international arena. And as we saw earlier, neither indicator is redundant.
- d. However, it is unclear whether the diffusion of QI reaches its final destination: the companies and individual users. For example, suppose that we know that a certain country has international recognition for its QI, which actively participates in the exchange of experiences and knowledge at international level, that the local members are accredited to practice their skills, and there are "guards" evaluating the technical compliance of those members, but in the end, we can't assess whether the ultimate purpose of QI is achieved. This is perhaps the main disadvantage of this methodology.

2.4 The Quality Infrastructure rankings

This section shows the global ranking according to the QI/POP measurement. In addition to the proposed measuring methodology, other composite indicators are incorporated for comparison purposes. This will help us to see the coherence and consistency of the proposed index. In the first column countries are ordered by our main indicator of QI in relation to Population–Index (QI/POP). The second and third columns show the rankings according to the sub-indicators that make up the composite index.

The last column presents the ranking for Index (QI/GDP) which was calculated in the same way as our main composite indicator, but this time GDP was used to relativize.

Included in the Appendix for detailed analysis are the multiple rankings for DAC, ODA and non ODA countries showing how they are sorted according to all variables considered in the composite indicator.

Rank	Index (QI/POP)	Score	Sub-Index (CMC/ Pop,ISO/Pop,TAB/ Pop)	Sub-Index (K&SC,TC,Mem)	Index (QI/GDP)	Score
1	Sweden	64.3	Sweden	Germany	Czech Republic	60.9
2	Switzerland	62.9	Switzerland	United Kingdom	Slovakia	59.6
3	Germany	61.0	Slovakia	France	Germany	58.6
4	Czech Republic	58.9	Czech Republic	USA	Sweden	58.4
5	Italy	58.2	Finland	Japan	Hungary	57.7
6	United Kingdom	57.1	Hungary	Korea, Rep.	Bulgaria	57.5
7	Netherlands	56.1	Netherlands	China	Italy	57.4
8	Finland	56.0	Singapore	Australia and NZ	United Kingdom	54.5
9	Slovakia	55.4	Italy	Italy	Switzerland	53.2
10	France	52.9	Ireland	Netherlands	Romania	51.9
11	Spain	51.7	Spain	Czech Republic	France	51.3
12	Republic of Korea	50.3	Bulgaria	Romania	Spain	50.6
13	Hungary	49.1	Uruguay	Spain	Republic of Korea	49.7
14	Japan	48.1	Austria	Poland	China	49.3
15	Australia and NZ	47.0	Denmark	Russian Fed.	Netherlands	48.6
16	Austria	46.3	Norway	Switzerland	Finland	47.6
17	USA	45.4	United Kingdom	India	Japan	47.2
18	Romania	43.6	Portugal	Finland	Australia and NZ	44.9
19	China	42.2	Germany	Sweden	USA	44.2
20	Poland	41.0	Greece	Austria	Poland	43.7
21	Denmark	40.0	Serbia	Slovakia	Serbia	43.3
22	Singapore	39.6	Republic of Korea	Canada	Portugal	41.3
23	Ireland	39.5	France	South Africa	Austria	41.2
24	Belgium	38.6	Israel	Brazil	Russian Federation	39.9
25	Russian Federation	38.6	Belgium	Belgium	India	38.4
26	Portugal	38.2	Croatia	Hungary	South Africa	37.7
27	Norway	38.0	Romania	Turkey	Belgium	37.6
28	Canada	38.0	Australia and NZ	Portugal	Denmark	35.8
29	Bulgaria	37.5	Canada	Denmark	Canada	35.7
30	India	34.9	Chile	Mexico	Brazil	34.6
31	South Africa	33.7	Poland	Norway	Uruguay	34.2

Rank	Index (QI/POP)	Score	Sub-Index (CMC/ Pop,ISO/Pop,TAB/ Pop)	Sub-Index (K&SC,TC,Mem)	Index (QI/GDP)	Score
32	Brazil	32.3	Japan	Argentina	Turkey	34.0
33	Greece	31.9	Malaysia	Egypt	Ireland	32.3
34	Turkey	31.3	Argentina	Ireland	Greece	32.1
35	Serbia	30.0	Russian Federation.	Indonesia	Norway	31.3
36	Argentina	28.1	Turkey	Thailand	Malaysia	31.1
37	Israel	28.0	USA	Greece	Argentina	31.0
38	Mexico	27.4	South Africa	Bulgaria	Singapore	30.6
39	Malaysia	26.4	Kazakhstan	Malaysia	Croatia	29.5
40	Croatia	25.3	Thailand	Serbia	Israel	29.2
41	Uruguay	24.7	China	Singapore	Thailand	28.9
42	Thailand	24.6	Brazil	Pakistan	Mexico	28.1
43	Egypt	23.7	Mexico	Israel	Chile	27.4
44	Indonesia	23.7	Korea, DPR	Iran	Indonesia	26.4
45	Iran	20.4	Iran	Croatia	Egypt	25.1
46	Pakistan	20.3	Dominican Republic.	Kenya	Iran	22.1
47	Chile	19.7	Indonesia	Chile	Pakistan	21.7
48	Kenya	15.0	India	Korea, DPR	Kazakhstan	16.2
49	Kazakhstan	12.3	Egypt	Kazakhstan	Kenya	16.1
50	Korea, DPR	11.8	Venezuela	Uruguay	Cameroon	9.1
51	Cameroon	9.1	Pakistan	Cameroon	Venezuela	9.0
52	Venezuela	8.7	Kenya	Venezuela.	Dominican Republic	8.2
53	Dominican Republic	6.7	Cameroon	Domin Rep.	Korea, DPR	n.d.

Our main indicator (QI/POP) shows that the top half of the table is dominated by 17 of the 20 DAC countries, interspersed with 8 of the 10 non ODA. All ODA countries except China are located in the lower half of the list.

Topping the list is Sweden, which stands out mainly in the area of accreditation. It has three times more bodies accredited relative to population than its immediate follower (Slovakia). This makes a significant contribution to its final score, which holds the best position in the ranking⁹.

Among the DAC list, Greece shows by far the worst performance in terms of QI development. In particular, its low level of participation in the international system concerning QI has relegated this economy.

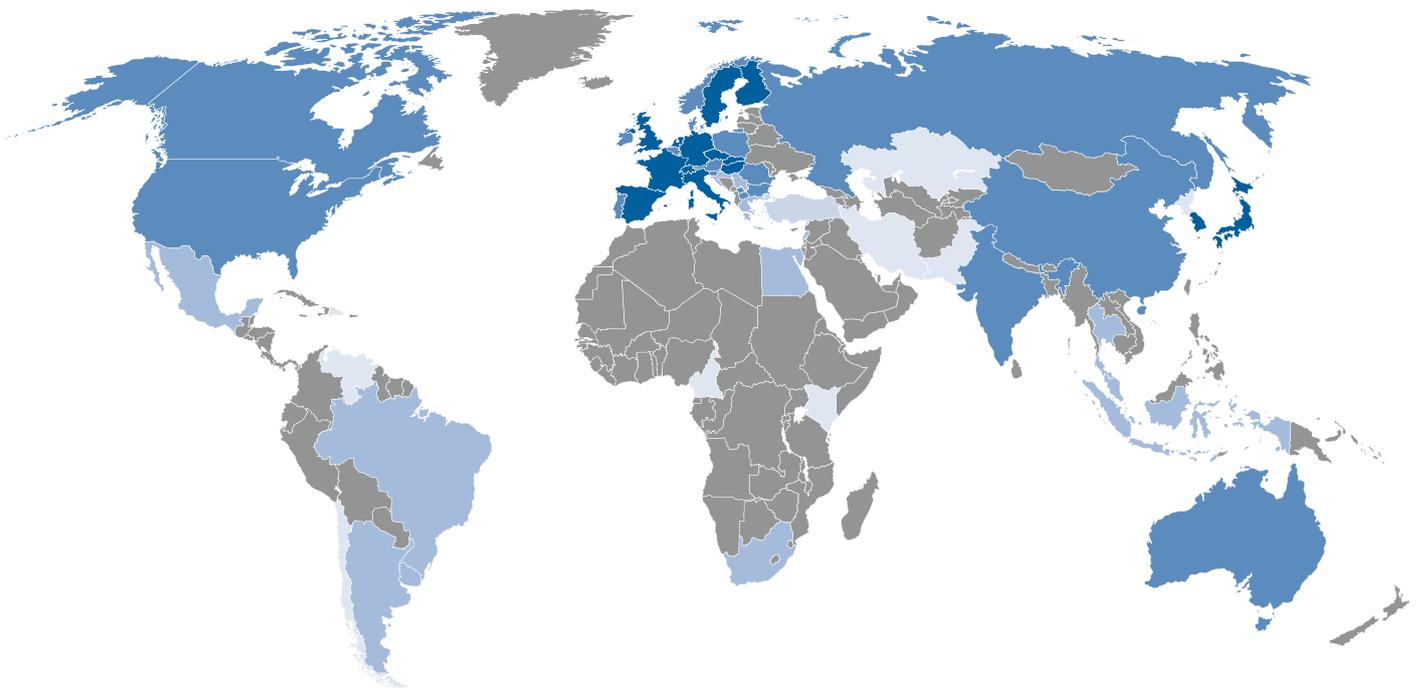
9) Sweden has accredited 1200 inspection bodies and is the world leader, but these mainly refer to tire-pressure testing at gas stations.

On the other hand, China stands out because, despite being considered an emerging economy that receives financial assistance from the international cooperation, it is the best ranked among the sample for the basic measure Index (CMC, ISO, TAB). The size of this economy could easily explain the position. China's transition can also be seen in the development of quality infrastructure. Participation in the QI international system is also outstanding, ranking seventh on the list. For the main indicator, China is the best ranked among the ODA countries.

As usual, BRIC countries present similar behavior. Indeed, if we look at the QI/Pop index, the best positioned is China (19), then Russia Fed (25), followed by India (30) and finally Brazil (32). Finally, the proximity is even greater if we remove the DAC countries between the best and worst ranked. Only eight positions then separate the first from the last BRIC.

The bottom of the main rankings is dominated mostly by the same countries: Pakistan, DPR Korea, Kenya, Kazakhstan, Cameroon, Dominican Republic, and the Bolivarian Republic of Venezuela. These are the countries with one or more indicators in absolute zero, either because the information is not available or because they record that value for the variable. These cases can be seen in the annexed database.

Below, countries are grouped into four different ranks according to the score obtained on the indicator. The grouping is done by an algorithm that looks for a natural separation of the cases (SPSS software). On the world map the countries are shown in different colors.



Ranges for quality infrastructure / population means

- 48,1 to 64,3 (14)
- 34,8 to 48,1 (16)
- 23,6 to 34,8 (14)
- 6,6 to 23,6 (9)
- no data available

2.5 Limitations and potential improvements

There are risks when measuring a complex phenomenon such as the QI with a general and simple indicator like the one presented here. For example, it could happen that an economy develops its QI but this has not immediately been reflected in the index. Furthermore, the amount does not guarantee quality. A large number of non-respected rules have no positive effect on the quality of services provided. In turn, certifications could be obtained without following all protocols and guarantees. Finally, an equal number of accredited members may offer very different skills.

In short, there has been a trade-off between the initial objective of the QI measurement (a pragmatic approach that is easy to replicate) and what has actually been achieved methodologically. However, if a comparison of the QI (as measured) is carried out within more homogeneous groups, then the proposed ranking will make more sense. This would be the case if we considered the developed countries on the one hand, and the less developed economies on the other. In fact, we will see later that the performance of the QI in relation to GDP, exports, competitiveness and transparency, groups countries mostly in the same way.

It is evident that much greater effort is required to investigate this issue, but we also must recognize that this index can be an exciting starting point which serves to stimulate debate and trigger new ideas.

Some of the potential improvements that could be incorporated into the methodology for measuring the QI have emerged from the valuable contributions and criticisms received during production of the document.

Specifically, the number of ISO 9000 may reflect very different realities in the case of one obtained in Germany rather than Guatemala or the Philippines. A certificate for using mechanical scales is not the same as one for using a high-precision measuring device. The same applies to the number of CMCs and accredited bodies (TAB). Regarding the former, a user can have easy access to foreign metrology services without any such offer locally. On the other hand, it could be the case that there is a relatively developed metrological infrastructure but it does not reach its full potential in relation to the final consumer. The number of accredited members is also subject to these problems and we cannot compare a laboratory doing basic tests with one that carries out sophisticated research. Finally, due to the normal flow of imports and exports of services, the amount of members may not fully reflect local realities.

One possibility to improve the indicator would be by making several distinctions that allow us to see more clearly what we are trying to measure here. For example: a) distinguish the local system's overall system of QI, since the productive specialization and scale of the countries differ greatly and this affects the type and quantity of services to be provided by the QI; b) expand the calculation of our main indicator in productive sectors, so that we can better capture the specificities of each economy (sectors and levels of difficulty linking the certification), c) distinguish QI from the scope of mandatory or volunteer practices; d) take into account which countries have benefited from the resources of international cooperation for the development of QI; and e) incorporate the net foreign balance of services related to the QI.

Another means of improvement is related to the database. It may be a task for international QI associations to agree standards and make more and better data available to the interested public. A best practice in this regard is the availability of development indicators provided by The World Bank (see <http://data.worldbank.org/>).

3 PERFORMANCE OF QI

In this chapter we analyze how the level of QI development is related to relevant economic performance indicators.

Competitiveness, GDP per capita, total Merchandise Exports and Transparency Index, were selected for comparison with QI measurement statistics. Below is a brief summary of the methodologies behind each indicator and also the evidence found about QI performance.

3.1 An overview

Correlation analysis is the appropriate methodology in these cases. The Spearman non-parametric coefficient will be used in this document. Somehow it is more powerful than the Pearson coefficient for detecting associations between variables since it is not limited to a linear relationship (*Canavos 1993*). Indeed, it works with the rankings of individuals according to two variables (i.e. the higher the position achieved by one variable, the better the ranking observed for the other).

The scale used to assess the degree of correlation is as follows: below 0.50 is weak; from 0.50 to 0.65 is moderate; from 0.65 to 0.80 is moderate-to-strong; from 0.80 to 0.95 is strong; and between 0.95 and 1 is very strong.

Our findings are summarized in the table below.

Spearman correlation	Quality infrastructure/ Population	Quality infrastructure/ GDP	GDP per capita (PPAWB2008)	Exports (merchandise in current USD WB2009)	Global Competitiveness (2009-2010)	Transparency (2008)
Quality infrastructure/ Population	1,000	,918(**)	,705(**)	,637(**)	,689(**)	,707(**)
Quality infrastructure/ GDP	,918(**)	1,000	,477(**)	,462(**)	,476(**)	,511(**)

**Correlation is significant at 0,01 level (bilateral)

Several observations can be made from the table above:

- i. All coefficients are significant at the 0.01 level. So, in every case conclusions are highly reliable.
- ii. All correlations are positive, supporting the expected relationship between QI development and economic performance variables. More competitive and transparent countries, with higher GDP per capita and better export performance, tend to have well-developed quality infrastructure in relative terms. This gives some coherence to the main QI indicator but also underlines the relevance of a developed QI. However, it would be incorrect to infer causality from QI to performance indicators, at least from this piece of evidence. A quality analysis would be required to reach that goal.
- iii. Looking at the last four columns of the correlation matrix, the QI/POP index shows stronger associations with the performance variables compared to the QI/GDP index. But if we look at the table by rows for both indicators, the coefficients are similar. This evidence could suggest that QI has similar behavior in relation to performance variables.

3.1.1 Competitiveness

One simple reason for considering the performance of a country in terms of its competitiveness in relation to the QI is the undisputed connection between the two. In *Guasch (2007)*, an exhaustive list is given of links with export growth, productivity, industrial upgrading, and diffusion of innovation, among others.

The main recommendation for developing countries is summarized as follows: *“As increased competition among developing countries in labor-intensive manufactures erodes economic returns, higher-quality markets and high-value goods are increasingly important to maintaining dynamic competitive advantage. Globally integrated production networks, typically governed by buyers from developed nations, have raised competitiveness to the top of developing countries’ policy agendas. Countries need to offer the high-quality products demanded by consumers and global supply chains and deliver them to markets to meet just-in-time production schedules”.*

The Global Competitiveness Index 2009-2010 (*Schwab 2009*) ranks 133 countries/economies. Developed based on twelve pillars and a total of 110 variables, this composite indicator is perhaps the most recognized in its field.

Pillars cover the following topics: Institutions; Infrastructure; Macroeconomic stability; Health and primary education; Higher education and training; Goods market efficiency; Labor market efficiency; Financial market sophistication; Technological readiness; Market size; Business sophistication; and Innovation.

A detailed analysis of incorporated variables in GCI shows that none of the variables we use in our leading indicator (QI/Pop) are part of GCI. This should be an advantage when interpreting the correlation coefficient as the relationships detected would be more pure.

An overview of the performance achieved by the 53 economies considered in terms of their QI and competitiveness can be seen below.

Figure for Quality Infrastructure and Competitiveness



The most competitive tend to be the best developed in terms of QI, and the lower the QI, the worse the performance observed. The relationship between QI and Competitiveness tends to be monotonous. Correlation is moderate-to-strong and positive (coefficient is almost 0.7).

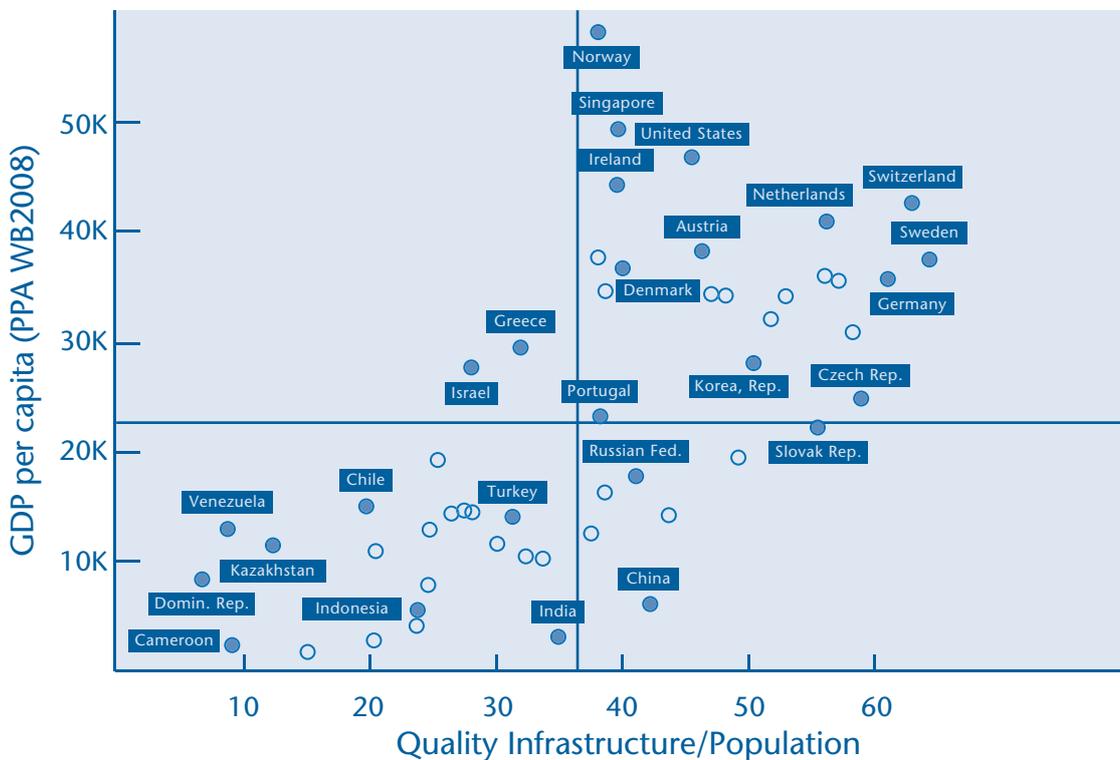
There are countries with large differences in the competitiveness index, which have a similar level of QI/POP, and vice versa (such as Romania - USA, Chile - Czech Republic, Canada - Sweden). This alerts us to some degree of uncertainty in the relationship between competitiveness and the development of the IQ (as measured).

3.1.2 GDP per capita

In this case, the information source is the World Bank database. Per GDP per capita is one of the most common indicators used in economic research since it represents standard of living.

QI development and GDP per capita are in the moderately-to-strongly correlated range. The Spearman coefficient is 0.705 for our main indicator. The tendency of countries to show similar ranking positions for QI and their performance remains. The following chart illustrates the situation.

Figure for Quality Infrastructure and GDP per capita



Large dispersions can be observed vertically and horizontally. For example, note the position of China and the Dominican Republic. Both countries have similar per capita income but a very different QI / POP level. It is obvious that these are two cases where one population is vastly greater than the other. On the other hand, if we look at China and Norway, which also differ tremendously in population, both have similar QI/POP but with a large gap in GDP per capita.

In general, high income countries are better developed in terms of QI, and upper-middle to lower income ones are distributed over the lower graph, mostly on the left-hand side.

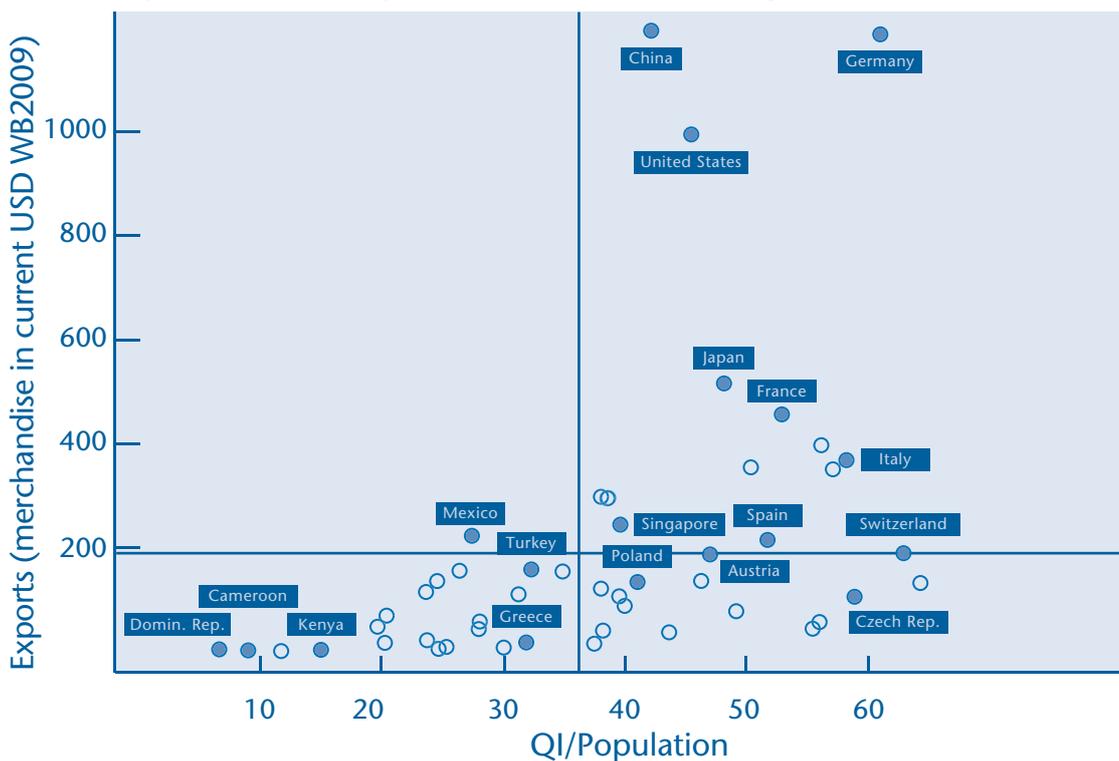
3.1.3 Exports

Breaking down technical barriers to trade is among the first targets of the national quality system. That's why we discuss export performance and its association with the development of QI through the proposed indicator.

Logic would dictate that the more developed the QI, the better the performance in foreign trade. The development of QI seems to contribute in this direction, but with distinct results. In fact, the literature suggests that this relationship does not follow that simple pattern. Other elements, such as the integration of economies, and natural or acquired advantages that give it a privileged position as a global supplier of certain products, can dramatically influence the export performance of a country.

The Spearman correlation is the lowest of those observed. It reaches the value of 0.637, so QI/Pop and Exports are related in a monotone way but to a moderate degree. The following dispersion chart illustrates this point.

Figure for Quality Infrastructure and Exports

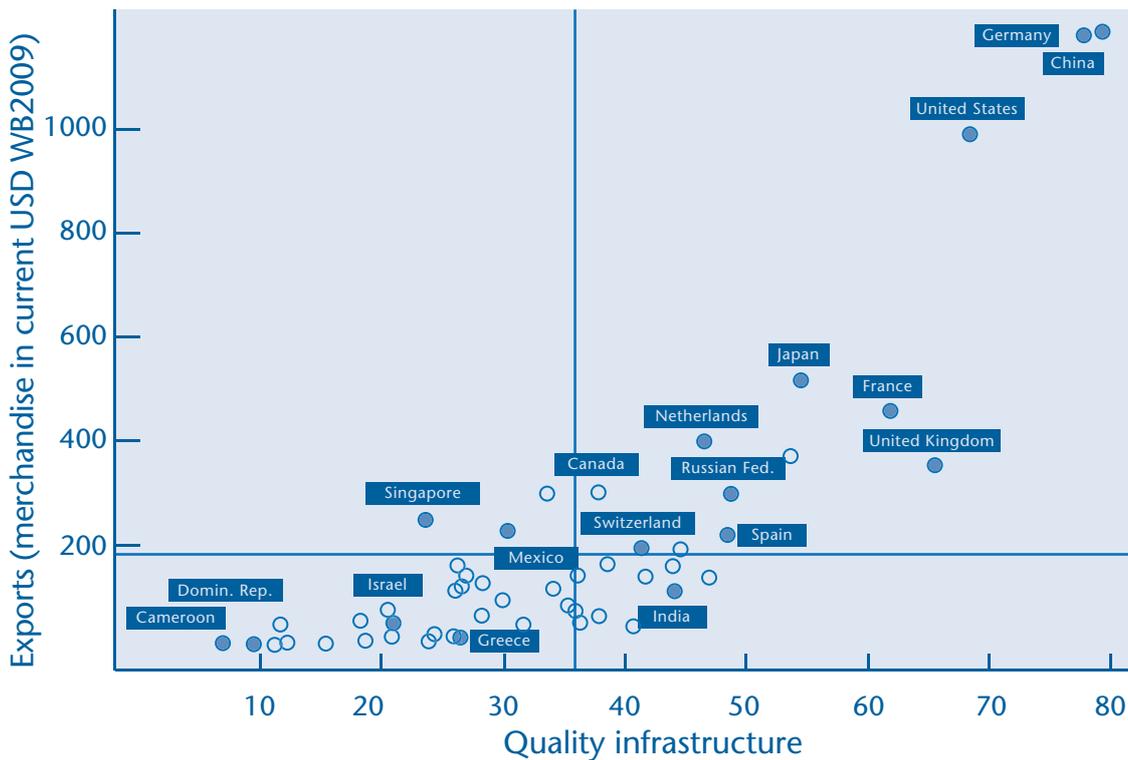


Looking vertically at the two quadrants on the right, we can see huge differences in export performance when considering similar quality infrastructure. Just look at the three largest exporters in the world (China, Germany, USA) in comparison to any country that is found in the chart below (Romania, Slovak Republic or Switzerland). An effect produced by the size of the economies could partially explain these gaps. However, if exports are made in relation to the population, the results do not improve either.

Once again, we are made to think of the efficiency of the system in meeting the needs of the productive sector, especially those with export profiles. A QI which is not able to address the needs of enterprises and involve them in quality management is not sufficient. Small and medium size (SME) enterprises are a special target group of the Technical Cooperation of PTB, because they are the main form of business in most countries and crucial for development. However, it is not our intention to include them here for measuring this important issue. Qualitative research should shed light on this topic.

To provide a better representation of the important link between QI and trade, we tried a different correlation. So on this occasion we will leave our main indicator – Index (QI/POP) - because it doesn't reveal the above link as well. Index (QI) does not consider population in the formula, so it relates better to the total exports since both are expressed in absolute terms. In fact, the Spearman correlation rises up to 0.81 (significant at 1%). Let's consider a graph.

Figure for Quality Infrastructure and Exports



As we can see, the behavior of countries is now more predictable and streamlined, and the degree of development of the QI better discriminates export performance. While we cannot quantify the impact of QI on merchandise exports, as no causal relationship has been demonstrated between the two, at least the evidence suggests the need to consider both terms together. In this case, the relationship between the export value and the size of the quality infrastructure becomes clearer.

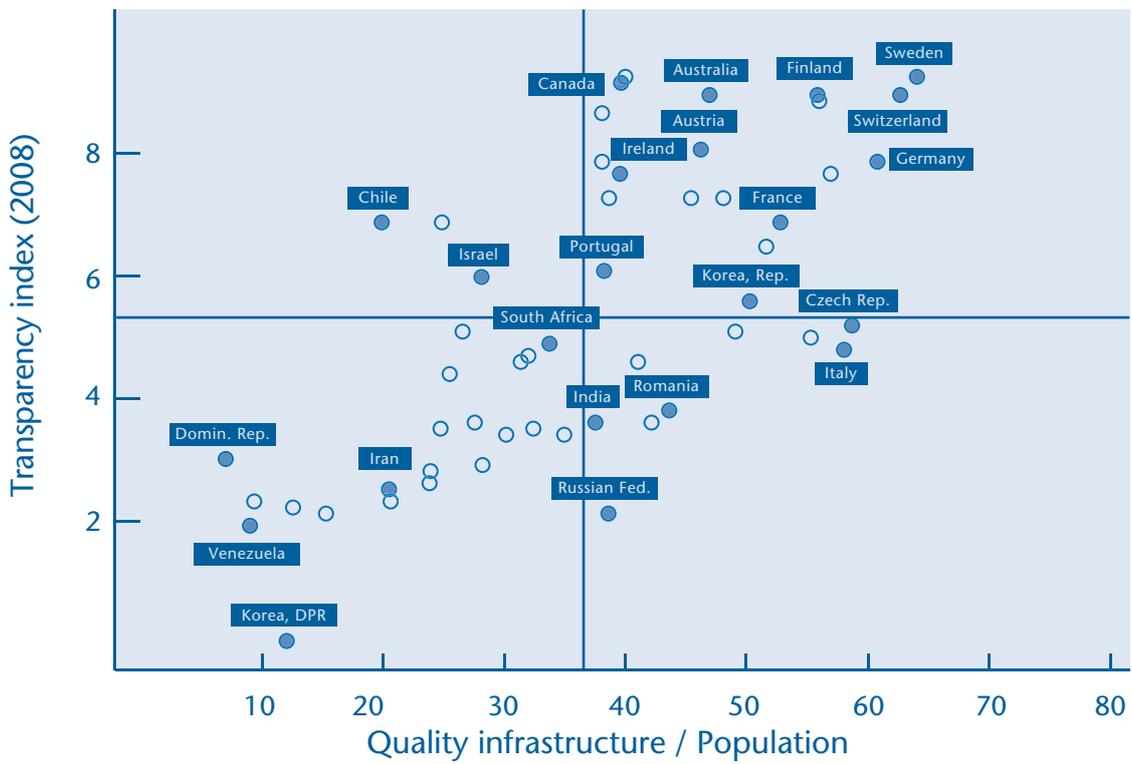
3.1.4 Transparency

The Corruption Perceptions Index (CPI) produced by Transparency International could play an important role in the evaluation of the QI. The CPI measures the perceived level of public-sector corruption in 180 countries and territories around the world. It is a "survey of surveys", based on 13 different expert and business surveys.

Regarding the relationship between the development of QI and the level of transparency, a reasonable expectation would be to find a positive correlation between them. In fact, the evidence is in that direction (correlation coefficient is positive and moderate to strong 0.707). One explanation for this finding would be: less corruption may be associated with a high degree of political stability, independent and effective judicial systems, adequate resources for audit, a climate of peace, and strong public institutions able to defend the legal framework and to exercise supervision. Bribery, influence peddling and unclear rules devalue critical assets such as trust and credibility. In no way could these practices contribute positively to the development of QI, as this is based essentially on the credibility of the system's members.

The following graph shows how the countries are located in relation to their QI / POP and the CPI. Again, the countries of the first and third quadrant are the same as in previous charts. If we look at the case of Canada and the Russian Federation, both have a similar level of QI but the degree of transparency is very different. Such cases may justify using the CPI as the weight of the QI for the purpose of improving the measurement capability of our indicator.

Figure for Quality Infrastructure and Transparency



4 FINAL CONCLUSIONS

Our initial hypothesis tells us that a country with a well-developed QI is also economically successful; and inversely, that countries lagging behind in QI are economically less advantaged. The evidence encountered enables us to keep our assumptions intact.

The best performances in terms of competitiveness, exports, GDP per capita and transparency were achieved in general by the same countries, which boasted the best positions in the rankings for QI development. In turn, the less advantaged countries corresponded to the least developed in terms of quality infrastructure.

Until now there was no methodology to measure QI which allowed comparison between countries. This is a virtue of this investigation and at the same time a necessary risk we have to assume if we want to promote the debate on this particular subject area. Moreover, since there are no other rankings with which to compare our work, it becomes necessary to deepen and disseminate this analysis in order to improve the effectiveness of the proposed indicator. But it should be noted that the composite indicator is well behaved in comparison with other indexes known as GCI.

Concerning the indicator itself, it proved to be a transparent and consistent methodology for measuring the development of quality infrastructure, but it is only a first approach to the difficult task of measuring the development of a system. Further research is needed to identify non-observed variables and ensure their inclusion in the index of QI development. It would also be desirable to increase the size of the sample, in particular by incorporating more ODA countries. A qualitative case study would be a fitting complement for this purpose. A specific survey for the purpose of obtaining that information could also shed light on aspects beyond the sensitivity of our indicator.

Finally, the indicator may serve as a starting point for a comparative assessment of the current state of development of QI in the world, enabling the design of policies to standardize quality of products and services. In particular, a methodology such as this would make it possible to identify the neediest countries in this field, both for technical and financial assistance.

Country	WTO member	ITU member states	IEC full member	ISO member body	OIML member states	CIPM member states	IAF member	ILAC member	Total
Australia	x	x	x	x	x	x	x	x	8
Austria	x	x	x	x	x	x	x	x	8
Belgium	x	x	x	x	x	x	x	x	8
Brazil	x	x	x	x	x	x	x	x	8
Canada	x	x	x	x	x	x	x	x	8
China	x	x	x	x	x	x	x	x	8
Czech Republic	x	x	x	x	x	x	x	x	8
Denmark	x	x	x	x	x	x	x	x	8
Egypt	x	x	x	x	x	x	x	x	8
Finland	x	x	x	x	x	x	x	x	8
France	x	x	x	x	x	x	x	x	8
Germany	x	x	x	x	x	x	x	x	8
Greece	x	x	x	x	x	x	x	x	8
India	x	x	x	x	x	x	x	x	8
Indonesia	x	x	x	x	x	x	x	x	8
Ireland	x	x	x	x	x	x	x	x	8

Country	WTO member	ITU member states	IEC full member	ISO member body	OIML member states	CIPM member states	IAF member	ILAC member	Total
Italy	x	x	x	x	x	x	x	x	8
Japan	x	x	x	x	x	x	x	x	8
Korea, Republic	x	x	x	x	x	x	x	x	8
Netherlands	x	x	x	x	x	x	x	x	8
New Zealand	x	x	x	x	x	x	x	x	8
Norway	x	x	x	x	x	x	x	x	8
Pakistan	x	x	x	x	x	x	x	x	8
Poland	x	x	x	x	x	x	x	x	8
Portugal	x	x	x	x	x	x	x	x	8
Romania	x	x	x	x	x	x	x	x	8
Slovak Republic	x	x	x	x	x	x	x	x	8
South Africa	x	x	x	x	x	x	x	x	8
Spain	x	x	x	x	x	x	x	x	8
Sweden	x	x	x	x	x	x	x	x	8
Switzerland	x	x	x	x	x	x	x	x	8
Turkey	x	x	x	x	x	x	x	x	8
United Kingdom	x	x	x	x	x	x	x	x	8
United States	x	x	x	x	x	x	x	x	8
Argentina	x	x	x	x		x	x	x	7
Israel	x	x	x	x	x	x		x	7
Malaysia	x	x	x	x		x	x	x	7
Mexico	x	x	x	x		x	x	x	7
Singapore	x	x	x	x		x	x	x	7
Thailand	x	x	x	x		x	x	x	7
Bulgaria	x	x	x	x	x	x			6
Croatia	x	x	x	x	x	x			6
Hungary	x	x	x	x	x	x			6
Iran		x	x	x	x	x			6
Russian Fed.	x	x	x	x	x	x	x		6
Chile	x	x		x		x		x	5
Kenya		x		x	x	x	x		5
Serbia	x	x	x	x	x	x			5
Cameroon		x		x		x			4
Kazakhstan		x		x	x	x			4
Korea, DPR	x	x		x		x	x		4
Uruguay	x	x		x		x			4
Venezuela	x	x		x		x			4
Dominican Rep.	x	x				x			3

Country Rankings based on different criteria

Rank	DAC	ODA	non ODA		CMCs/Pop	ISO9001/Pop	TAB/Pop	K&S Comparison	TC Participation	Population (thousands)	QI/POP	Rank
	CMCs	ISO9001	TAB									
1	USA	China	China	Finland	Italy	Sweden	Germany	France	China	1.325.640	Sweden	1
2	Germany	Italy	Germany	Slovak Rep.	Switzerland	Slovak Rep.	UK	UK	India	1.139.965	Switzerland	2
3	Russian Fed.	Spain	Sweden	Uruguay	Spain	Switzerland	USA	Germany	USA	304.060	Germany	3
4	UK	Japan	France	Netherlands	Hungary	Czech Rep.	France	China	Indonesia	228.250	Czech Rep.	4
5	France	Germany	UK	Sweden	Czech Rep.	Bulgaria	Japan	Romania	Brazil	191.970	Italy	5
6	Korea, Rep.	UK	USA	Czech Rep.	Singapore	Hungary	Russian Fed.	Korea, Rep.	Pakistan	166.040	UK	6
7	Netherlands	India	India	Switzerland	Israel	Portugal	Korea, Rep.	Japan	Russian Fed.	141.800	Netherlands	7
8	Japan	USA	Spain	Ireland	Netherlands	Chile	Australia,NZ	Italy	Japan	127.704	Finland	8
9	China	France	Chile	Singapore	Bulgaria	Serbia	Italy	Australia,NZ	Mexico	106.350	Slovak Rep.	9
10	Italy	Korea, Rep.	Czech Rep.	Austria	UK	Denmark	China	Poland	Germany	82.140	France	10
11	Canada	Russian Fed.	Brazil	Denmark	Slovak Rep.	Finland	Netherlands	USA	Egypt	81.527	Spain	11
12	Czech Rep.	Brazil	Switzerland	Hungary	Greece	Norway	Switzerland	Spain	Turkey	73.914	Korea, Rep.	12
13	Australia,NZ	Netherlands	Hungary	Norway	Germany	Belgium	Czech Rep.	Russian Fed.	Iran	71.960	Hungary	13
14	Mexico	Turkey	Portugal	Bulgaria	Sweden	Ireland	Canada	India	Thailand	67.390	Japan	14
15	Spain	Switzerland	Korea, Rep.	UK	Croatia	Greece	South Africa	Czech Rep.	France	62.050	Australia,NZ	15
16	Poland	Poland	Netherlands	Australia,NZ	Austria	Singapore	Hungary	Netherlands	UK	61.399	Austria	16
17	Sweden	Romania	Malaysia	Korea, Rep.	Ireland	Germany	Spain	Belgium	Italy	59.850	USA	17
18	Brazil	Canada	Romania	Germany	Romania	Netherlands	Mexico	Finland	South Africa	48.690	Romania	18
19	Finland	Hungary	Bulgaria	Serbia	Japan	France	Poland	Sweden	Korea, Rep.	48.610	China	19
20	Hungary	Czech Rep.	Slovak Rep.	Canada	Portugal	UK	Finland	Switzerland	Spain	45.568	Poland	20
21	Turkey	Australia,NZ	Indonesia	Portugal	Korea, Rep.	Austria	Slovak Rep.	Austria	Argentina	39.880	Denmark	21
22	Switzerland	Argentina	Greece	France	Belgium	Croatia	Brazil	Hungary	Kenya	38.530	Singapore	22
23	Thailand	Iran	South Africa	Poland	Australia,NZ	Romania	India	Slovak Rep.	Poland	38.123	Ireland	23
24	Slovak Rep.	Greece	Belgium	Spain	France	Spain	Sweden	Brazil	Canada	32.307	Belgium	24
25	South Africa	Israel	Poland	Romania	Finland	Malaysia	Austria	Serbia	Venezuela	27.940	Russian Fed.	25
26	Austria	Malaysia	Turkey	Croatia	Norway	Israel	Turkey	South Africa	Malaysia	26.990	Portugal	26
27	Argentina	Indonesia	Canada	Russian Fed.	Canada	Korea, Rep.	Denmark	Canada	Korea, DPR	23.860	Norway	27
28	Romania	Sweden	Japan	Italy	Uruguay	Kazakhstan	Romania	Turkey	Romania	21.510	Canada	28
29	Denmark	Bulgaria	Serbia	Greece	Poland	Canada	Singapore	Bulgaria	Australia	21.370	Bulgaria	29
30	Ireland	Thailand	Russian Fed.	Belgium	Denmark	Poland	Argentina	Portugal	Cameroon	18.900	India	30
31	Singapore	Portugal	Denmark	USA	Serbia	South Africa	Portugal	Norway	Netherlands	16.440	South Africa	31
32	India	Mexico	Austria	South Africa	Chile	Uruguay	Thailand	Argentina	Chile	16.297	Brazil	32
33	Bulgaria	Belgium	Finland	Argentina	Malaysia	Domin. Rep.	Malaysia	Denmark	Kazakhstan	15.670	Greece	33
34	Uruguay	Singapore	Italy	Japan	Argentina	Turkey	Indonesia	Mexico	Greece	11.240	Turkey	34
35	Portugal	Austria	Thailand	Malaysia	Turkey	USA	Bulgaria	Iran	Belgium	10.700	Serbia	35
36	Malaysia	Chile	Norway	Thailand	China	Italy	Norway	Thailand	Portugal	10.620	Argentina	36
37	Norway	South Africa	Kazakhstan	Turkey	Korea, DPR	Brazil	Belgium	Ireland	Czech Rep.	10.430	Israel	37
38	Serbia	Korea, DPR	Singapore	Mexico	Kazakhstan	Argentina	Greece	Malaysia	Hungary	10.040	Mexico	38
39	Greece	Slovak Rep.	Ireland	Chile	Russian Fed.	Thailand	Egypt	Egypt	Domin. Rep.	9.840	Malaysia	39
40	Belgium	Croatia	Argentina	Brazil	Iran	China	Ireland	Indonesia	Sweden	9.220	Croatia	40
41	Indonesia	Kazakhstan	Croatia	China	USA	Japan	Uruguay	Israel	Austria	8.344	Uruguay	41
42	Chile	Pakistan	Israel	Indonesia	Thailand	Australia,NZ	Chile	Greece	Switzerland	7.630	Thailand	42

	DAC	ODA	non ODA									
Rank	CMCs	ISO9001	TAB	CMCs/Pop	ISO9001/Pop	TAB/Pop	K&S Comparison	TC Participation	Population (thousands)		QI/POP	Rank
43	Croatia	Ireland	Australia,NZ	Egypt	South Africa	Russian Fed.	Israel	Kenya	Bulgaria	7.620	Egypt	43
44	Egypt	Serbia	Domin. Rep.	India	Brazil	Indonesia	Serbia	Croatia	Serbia	7.350	Indonesia	44
45	Pakistan	Finland	Egypt	Pakistan	Mexico	India	Croatia	Pakistan	Israel	7.310	Iran	45
46	Cameroon	Egypt	Pakistan	Cameroon	India	Venezuela	Kazakhstan	Singapore	Denmark	5.500	Pakistan	46
47	Domin. Rep.	Norway	Venezuela	Domin. Rep.	Indonesia	Egypt	Venezuela	Chile	Slovak Rep.	5.410	Chile	47
48	Iran	Denmark	Uruguay	Iran	Egypt	Pakistan	Kenya	Korea, DPR	Finland	5.244	Kenya	48
49	Israel	Uruguay	Iran	Israel	Venezuela	Iran	Pakistan	Kazakhstan	Singapore	4.840	Kazakhstan	49
50	Kazakhstan	Venezuela	Mexico	Kazakhstan	Pakistan	Mexico	Iran	Uruguay	Norway	4.770	Korea, DPR	50
51	Kenya	Kenya	Kenya	Kenya	Kenya	Kenya	Domin. Rep.	Cameroon	Ireland	4.460	Cameroon	51
52	Korea, DPR	Domin. Rep.	Korea, DPR	Korea, DPR	Korea, DPR	Korea, DPR	Cameroon	Venezuela	Croatia	4.430	Venezuela	52
53	Venezuela	Cameroon	Cameroon	Venezuela	Cameroon	Cameroon	Korea, DPR	Domin. Rep.	Uruguay	3.330	Domin. Rep.	53

Values of main indicators ordered by countries

Country	Member-ship	DAC	ODA	non ODA	CMCs (Jan. 2010)	Key Comp.	Suppl Comp (Jan. 2010)	ISO9001 (2008)	Tech Comm (Jan. 2010)	TAB (Jan. 2010)	GCI 2009-2010	Exports USD (2009)	PIB per cap PPA (2008)
Argentina	7		UMI		277	65	16	8812	319	154	3,91	58,87	14331
Australia,NZ	8	x			493	226	39	10001	625	71	5,065	187,75	34241
Austria	8	x			331	90	23	4272	506	259	5,13	139,80	38153
Belgium	8	x			97	32	10	4875	537	436	5,09	296,10	34506
Brazil	8		UMI		435	111	21	14539	435	751	4,23	158,90	10312
Bulgaria	6	x		x	191	29	17	5323	351	551	4,02	16,23	12398
Cameroon	4		LMI		0	0	0	12	31	0	3,5	3,41	2215
Canada	8	x			534	153	23	10506	376	391	5,33	298,50	37577
Chile	5		UMI		49	1	8	4103	105	943	4,7	48,85	14874
China	8		LMI		730	206	25	224616	706	4170	4,74	1194,00	5962
Croatia	6		UMI		45	12	2	2302	188	116	4,03	10,05	19102
Czech Rep.	8			x	503	139	42	10089	581	857	4,67	106,40	24707
Denmark	8	x			211	72	24	1574	308	263	5,46	88,87	36591
Domin. Rep.	3		LMI		0	0	0	63	0	61	3,75	5,37	8216
Egypt	8		LMI		23	25	8	1944	247	52	4,04	22,91	5416
Finland	8	x			431	91	43	1975	530	250	5,43	57,88	35892
France	8	x			980	287	60	23837	719	2050	5,13	456,80	34044
Germany	8	x			1537	407	114	48324	712	3212	5,37	1187,00	35613
Greece	8	x			107	29	10	6747	197	452	4,04	18,64	29356
Hungary	6			x	385	137	16	10187	487	681	4,22	78,61	19325
India	8		LMI		200	111	16	37958	594	1217	4,3	155,00	2972
Indonesia	8		LMI		83	41	6	5713	219	487	4,26	115,60	3975
Iran	6		LMI		0	0	2	7844	299	11	0	70,16	10791
Ireland	8	x			211	21	3	2237	251	180	4,84	107,30	44195
Israel	7				0	11	4	6438	199	107	4,8	44,35	27541
Italy	8	x			593	178	54	118309	655	240	4,31	369,00	30759
Japan	8	x			735	284	44	62746	668	379	5,37	516,30	34099

Country	Member-ship	DAC	ODA	non ODA	CMCs (Jan. 2010)	Key Comp.	Suppl Comp (Jan. 2010)	ISO9001 (2008)	Tech Comm (Jan. 2010)	TAB (Jan. 2010)	GCI 2009-2010	Exports USD (2009)	PIB per cap PPA (2008)
Kazakhstan	4		UMI		0	5	5	2295	70	201	4,08	41,64	11318
Kenya	5		OLI		0	1	4	257	190	0	3,67	4,48	1590
Korea, DPR	4		OLI		0	0	0	3543	94	0	0	2,06	0
Korea, Rep.	8			x	934	234	42	23036	696	654	5	355,10	27937
Malaysia	7		UMI		155	44	10	6267	247	558	4,87	156,40	14217
Mexico	7		UMI		479	115	26	4990	303	0	4,19	223,60	14495
Netherlands	8	x			824	162	50	13597	573	640	5,32	397,60	40857
Norway	8	x			150	34	10	1666	334	227	5,17	122,00	58129
Pakistan	8		OLI		0	2	2	2268	145	33	3,58	17,87	2644
Poland	8			x	461	111	26	10965	622	430	4,33	134,70	17625
Portugal	8	x			173	65	9	5128	342	675	4,4	41,43	23084
Romania	8			x	225	70	19	10737	700	551	4,11	38,10	14066
Russian Fed.	6			x	1413	229	51	16051	603	354	4,15	295,60	16139
Serbia	5		UMI		134	14	1	2091	430	373	3,77	8,82	11457
Singapore	7			x	208	66	22	4526	138	193	5,55	245,00	49277
Slovak Rep.	8			x	346	109	24	3476	438	530	4,31	45,05	22065
South Africa	8		UMI		345	132	30	3792	395	447	4,34	67,93	10108
Spain	8	x			478	119	32	68730	605	1008	4,59	215,70	31955
Sweden	8	x			446	94	30	5377	528	2527	5,51	132,80	37387
Switzerland	8	x			361	132	55	11724	521	706	5,6	190,10	42539
Thailand	7		LMI		356	53	16	5275	252	238	4,56	136,60	7702
Turkey	8		UMI		380	78	25	13217	363	406	4,16	111,10	13920
UK	8	x			1220	315	68	41150	714	1946	5,19	351,30	35445
Uruguay	4		UMI		189	12	8	999	56	21	4,1	6,32	12747
USA	8	x			2260	314	57	32400	612	1601	5,59	997,70	46716
Venezuela	4		UMI		0	2	3	448	0	29	3,48	51,99	12806

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