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The Relevance of Quality Infrastructure to Promote Innovation Systems in Developing Countries

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Glossary

BRIC	Brazil, Russia, India and China
BMZ	Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung [Federal Ministry for Economic Cooperation and Development]
EFQM	European Foundation for Quality Management
GDI	German Development Institute
GlobalGAP	Global Partnership for Good Agricultural Practice
IS	Innovation Systems
LDC	Least Developed Countries
MSTQ	Metrology, Standardization, Testing and Quality assurance
NIS	National Innovation Systems
NMI	National Metrology Institute
ODA	Official Development Aid
OECD	Organization for Economic Cooperation and Development
PTB	Physikalisch-Technische Bundesanstalt [German Metrology Institute]
QI	Quality Infrastructure
QMS	Quality Management System
R&D	Research and Development
SI	International System of Units
SMEs	Small and Medium-sized Enterprises
TBT	Technical barrier to trade
TT	Technology Transfer
UNCTAD	United Nations Conference on Trade and Development
WTO	World Trade Organization

Preface

This paper has been prepared to support the Working Group on "Promoting Innovation Systems" of the German Development Cooperation and to help better understand the potential of Quality Infrastructure (QI) for innovations in developing countries. It was funded by the International Technical Cooperation of PTB.
The aim of this paper is to encourage a discussion about the relevance of QI within the promotion of innovation systems. It is based on a review of relevant literature, which links the topics of innovation, standards and quality infrastructure and relates its academic debate to practical experience in development cooperation. It should provide suggestions for the German Development Cooperation about how to integrate the issue of QI into the debate of supporting innovation systems and how to cooperate more efficiently and effectively within the network of the different actors in this field.

Executive summary

QI refers to all aspects of metrology, standardization, testing, quality management, certification and accreditation that have a bearing on conformity assessment and quality. Developing countries lack adequate QI to meet the needs of the fast-growing global economy. Because of high costs, weak quality culture and low availability of mainly public QI services, the use by private enterprises is rather limited.

Linkages between innovation, standards and QI are multiple. In contrast to the perfect market, consumers and producers are not always provided with full transparency about prices and quality of products. Malfunction of markets provokes the phenomenon "low quality drives out high quality". Standards are a way to overcome market failure. The embedded technology helps SMEs to gain access to markets that are more profitable.

In the early years, PTB was much in accord with the science push model, financing metrology facilities and the training of QI personnel. Later, PTB included the demand-pull perspective in their approach and involved business associations and private enterprises in their projects. Today, there is a need for a systems approach, which integrates both approaches. Here, the cluster and value chain approach (i.e. Calidena) is one appropriate way of intervention.

For PTB with its technical background it is important to be aware of the economic and social aspects of innovation.

The QI of each country needs to be developed according to its size, economic structure and idiosyncrasies and will therefore differ from other systems. This differentiation of a national QI could be part of the competitive advantage of a developing country.

1. Introduction

"Creativity and innovation contribute to economic prosperity as well as to social and individual wellbeing," is the key message of the European Year of Creativity and Innovation 2009.[1] This statement is not only relevant for the advanced countries in the European Union. Innovation is en vogue all over the world, including in developing countries and in international donor agencies.

The current debate can build on considerable innovation research, which has been conducted over the past three decades. The key concept of Innovation Systems (IS) is inspired by the Schumpeterian evolutionary understanding of this phenomenon. The OECD was one of the early promoters of this new approach and published a series of key publications about the topic (Organization for Economic Cooperation and Development OECD 1999; Organization for Economic Cooperation and Development OECD 2002; Box 2009).

In the industrialized countries the debate had its repercussions in the community of development studies and aid agencies. A path-breaking publication was The Least Developed Countries Report 2007 (United Nations Conference on Trade and Development UNCTAD 2007) which stated that "unless the LDCs adopt policies to stimulate technological catch-up with the rest of the world, they will continue to fall behind other countries technologically and face deepening marginalization in the global economy" (UNCTAD 2007, 2). In that sense, it generates hope to follow up on the achievements of emerging countries – like the BRIC economies – which expand their market shares more and more in the global economy by knowledge-intensive activities (National Endowment for Science 2008).

In the current academic and political innovation debate, Quality Infrastructure (QI) is only noted in the margin, if at all.[2] This may be explicable, due to the fact that the activities of metrology institutes, accreditation bodies and testing laboratories have a very technical flavor and specialists in this field are usually not so very interested in economic or social topics. Nevertheless, there is evidence that – with the increase of global trade and sourcing – the growing need for exact measurement and trustable standards for products and services is evolving.

This paper aims to provide arguments for further discussion of the relevance of QI and the promotion of innovation systems. It is based on desk research using relevant literature, the empirical experience of the author working as a consultant in this area and comments of practitioners and academics knowledgeable on this topic. A literature search did not yield many articles that dealt with the relationship between quality infrastructure, innovation and the promotion of innovation systems. Thus, this report should be seen as a discussion paper and readers should feel free to contribute or even question assertions being made.

1 www.create2009.europa.eu/about_the_year.html.

2 Literature on the role that QI plays in value chain formation in developing countries is also scarce, see Grote/, U. and A. Stamm (2007). Quality Requirements and Quality Infrastructure in Value Chains Reaching Out to Developing Countries. Examples from the Fish/Shrimps, Spices, Wood, and Leather Sectors. A. Stamm. Braunschweig, PTB, International Technical Cooperation.

2. Key Terms

2.1 Innovation

In this paper we use a definition of innovation coined by fellows of the GDI as "the process by which firms master and implement the introduction of product, process or organizational improvements which are new to them, irrespective of whether or not they are new to their competitors, domestic or foreign." (Rippin 2008, 96). In contrast to an invention, innovation does not have to be very new to the world, but can also be an improvement, an adaptation or an imitation of something already existing.

The process of innovation differs in varying stages of development. In advanced countries, enterprises are innovative by pushing the knowledge frontier through technological innovation, research and development (R&D). Meanwhile, the developing countries' innovation primarily takes place through firms learning to master, adapt and improve technologies that already exist in more technologically advanced countries (United Nations Conference on Trade and Development UNCTAD 2007; Box 2009, 3). According to the World Bank, improving the capacity to absorb foreign technology is critical in low-income countries, as well as in those middle-income countries that have exploited low-wage comparative advantages rather than strengthened domestic competencies (The World Bank 2008). The challenge for low- and middle-income countries is growing faster than for those with high-income levels and it is becoming increasingly difficult to catch up. If catch-up potential diminishes, countries need to expand their indigenous science and technology base (Box 2009, 46).

2.2 Innovation System

Even though innovations materialize mainly at the company level, they are normally a product of the interaction of various actors. In that sense, innovation is a systemic phenomenon of interacting enterprises, institutions, research bodies and policy-making agencies that share knowledge, and jointly and individually contribute to the development and diffusion of new technologies. Organizations which deal with technology diffusion and extension (metrology, standards, testing, quality assurance – MSTQ) are especially relevant for these systems in developing countries (Pietrobelli and Rabellotti 2008, 88).

Innovation systems are identified at the local, sectoral and national level. Developing countries' scholars see local and sectoral innovation systems as the adequate research and intervention level (Meyer-Stamer 2009). Establishing a national innovation system seems premature in most of the countries (United Nations Conference on Trade and Development UNCTAD 2007, 58). Even the OECD, pioneers of NIS research, characterizes the concept as being unhandy, difficult to apply, and from the 90s on, the research was concentrated on the territorial and sectoral perspective, mainly industrial clusters (Meyer-Stamer 2009).

2.3 Quality Infrastructure

Quality Infrastructure was coined by the International Technical Cooperation of PTB, replacing the formerly used acronym MSTQ: "Quality infrastructure refers … to all aspects of metrology, standardization, testing, quality management, certification and accreditation that have a bearing on conformity assessment (abbreviated as MSTQ). This includes both public and private institutions and the regulatory framework within which they operate."(BMZ 2004)

The new designation was not only helpful in making the terminology easier to understand beyond the circles of experts, but it has also helped to embrace the systemic character of QI. Therefore, at the country level, it is also called National Quality System (NQS), which is a constitutive part of a broader National Innovation System (NIS).

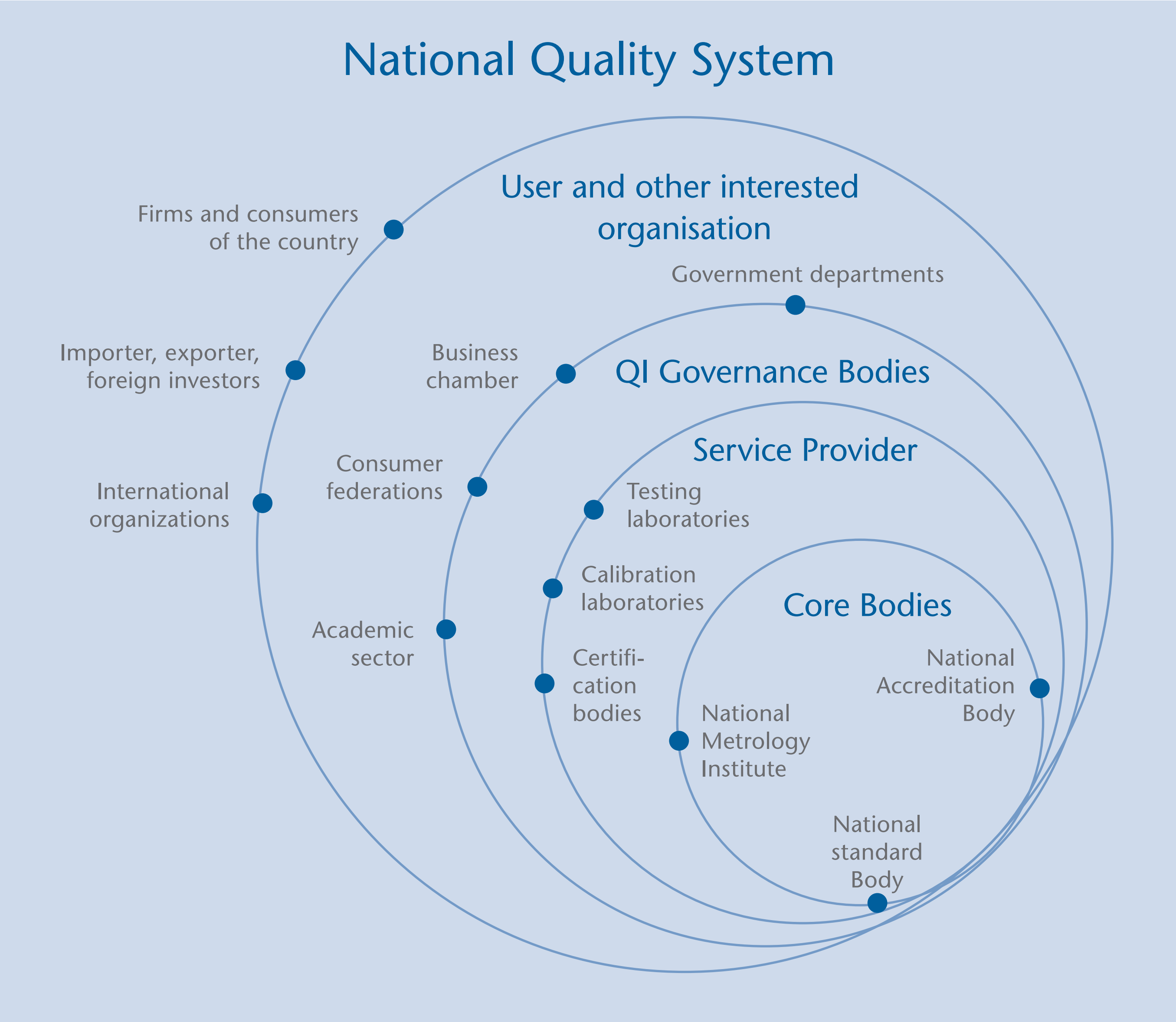

Figure 1: The National Quality System
Source: own illustration

The figure above shows the QI of a nation constituted as a system of several circles. In the inner circle, the core bodies are located: the national metrology institute, the standards and accreditation body. In a second broader ring, we find service providers such as testing and calibration laboratories, certification bodies. These bodies usually have direct contact with the firms, which require their services to back the quality of their products and management system. In the third circle, we find a series of organizations from the public and private sector who usually govern the NQS, such as government departments, business and consumer associations and the academic sector. In the widest ring of the QI system, we have to include firms, which certify their products, processes and quality systems, and the consumers who require safe and quality products. In the same ring, we locate the bodies, which support and recognize the NQS internationally.

In most advanced countries, the QI has evolved over a longer period. For example, in Germany the National Metrology Institute (what today is PTB) was founded in 1887, the National Standardization Body (today, DIN) in 1917. From the beginning, private industry has been a driving force for QI in Germany and other developed countries.

In contrast, the creation of metrology and standardization institutes in developing countries is much more recent and incomplete. Even emerging countries with internationally recognized QI systems often have old and insufficient facilities (such as metrology and testing labs), a shortage of qualified staff and a lack of adequate capacity (such as for accreditation and conformity assessments) to meet the needs of fast-growing, modernizing countries. SMEs are usually not aware of the benefits of QI services. Relatively high costs and low availability of services economy-wide and poor customer service orientation hinder their involvement. Often, the QI services are dominated by the public sector, whereas the use by private enterprise is rather limited (Dutz 2007).

The gap between QI in advanced and developing countries is still huge.[3] To catch up, developing countries need to accelerate, to build or to improve their QI. To achieve this goal, technical cooperation with institutions in advanced countries (like PTB, which began its International Technical Cooperation almost fifty years ago) is necessary.

3 A proxy indicator for the development of a national QI could be the membership in IAF. An accreditation body is only admitted after a most stringent evaluation of its operations by a peer evaluation team which is charged to ensure that the applicant member complies fully with both the international standards and IAF requirements. Today there are accreditation bodies of 53 member countries of IAF and only 21 are developing countries. This means that only 14% of all 146 ODA recipients have an internationally recognized accreditation body. (Own calculation based on www.iaf.nu and www.oecd.org/dataoecd/32/40/43540882.pdf).

3. Interrelation between Quality Infrastructure and Innovative Firm

The following figure helps to understand how QI and innovation are related at the firm level:

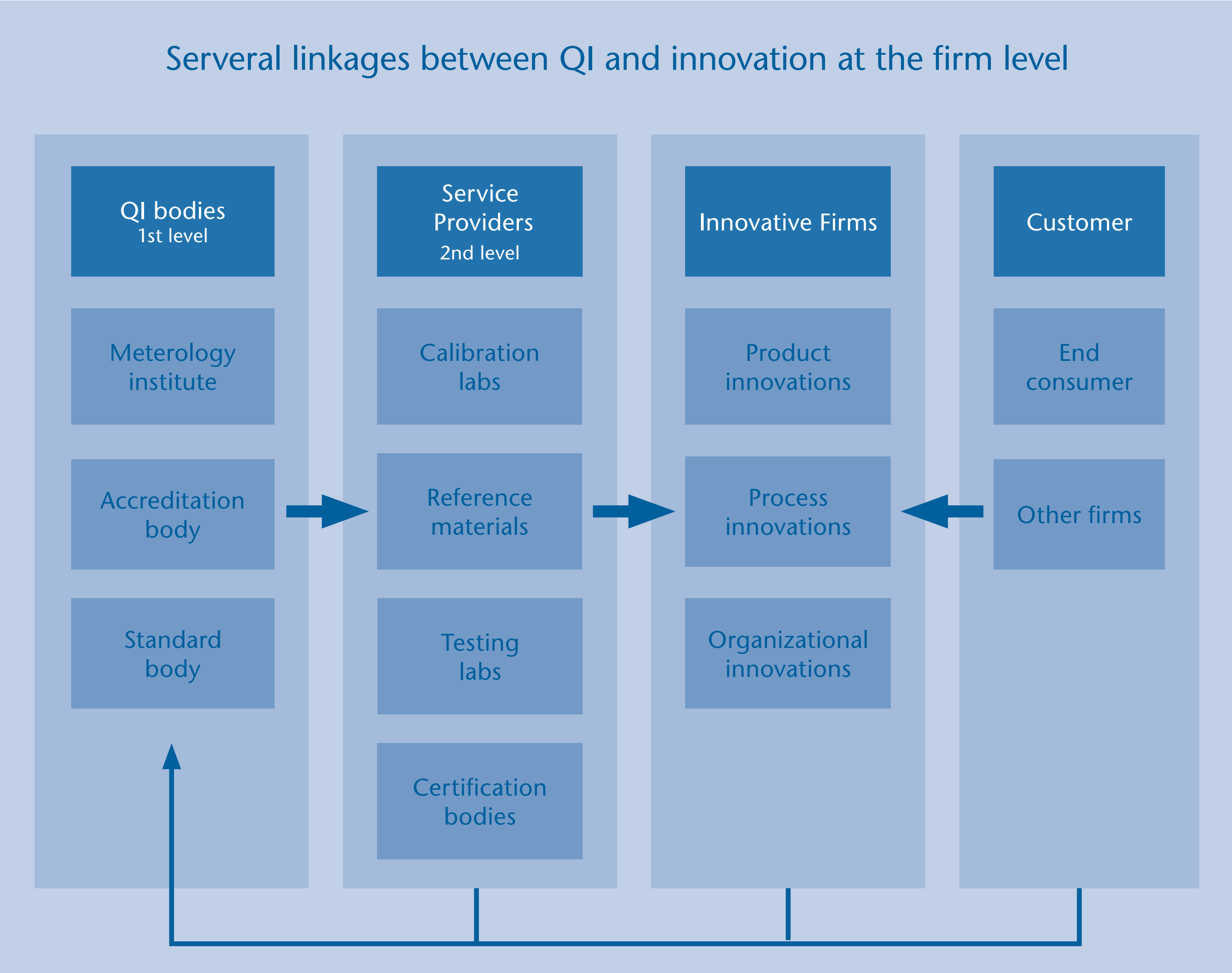

Figure 2: Serveral linkages between QI and innovation at the firm level
Source: own illustration

The centerpieces of the model are the innovative firms. These firms are located between their customers and the providers of quality services.

In many developing countries with a smaller QI the distinction between the 1st and the 2nd level of service providers does not exist, i.e. the national metrology institute directly provides calibration services to the firms. Nevertheless, there is always less commercial interaction between the firms and the core bodies of the QI, which consist of the metrology laboratory, accreditation and standards bodies (see left column in Figure 2). At the same time, the private sector participates in the development of standards and supports the accreditation bodies and metrology institutes in technical committees and other institutional forms.

This relative distance from the innovative firm may be the reason for QI – if at all – generally being seen as part of the business environment and not part of the innovation process itself.[4] On the contrary, QI bodies could also be important sources of innovation, as the following example, the illustrative technology transfer of the German Metrology Institute, shows (see box):

PTB Technology Transfer

PTB understands Technology Transfer (TT) to be defined by all activities which lead to an economic exploitation of its work results. As early as the foundation of the PTB, the aim has been to promote economic development through the development of modern metrology, in close collaboration with industry. The main tasks of PTB TT are:

a) Exploitation of patents - as investment protection for the German and European industries
b) Increasing the number of research cooperation agreements with partners from industry and society
c) Short-term staff exchanges between industry and PTB

The value of this work is revealed in the fact that PTB was awarded the Technology Transfer Prize of the Braunschweig Chamber of Industry and Commerce (IHK) several times. The latest awarded innovation was a joint development of a revolutionary new implant system by a PTB scientist and the Precious Metals and Technology Company at PTB. The implant and restoration are simply clicked together, preventing rotation. Through the clip mechanism a closed, stress-free implant is created.

Source: www.ptb.de/en/technologietransfer/techtrans/uebersicht.html

In a less institutionalized form we probably also find technology transfer from national metrology institutes in developing countries. Many founders of private calibration laboratories started their profession in NMIs where they acquired the necessary know-how. The loss of a qualified professional can be painful for an NMI. On the other hand, the creation of competent private calibration services is complementary and helps the NMI to concentrate on their core business as primary metrology laboratory (Sanetra 2007, 68). Observing this kind of spin-off could be a starting point to create a more systematic approach to the promotion of entrepreneurship.

4 "Metrology, standards, testing and quality control centers are not directly involved in the process of innovation. However, they can contribute to the promotion of innovation since reliable metrology systems and testing laboratories are needed for the access of products to large OECD markets". Rippin, N. (2008). Promoting Economic Innovations in Sub-Saharan Africa. Eschborn, GTZ: 72.

3.1 Market Failure

A justification for the necessity to promote QI is what economists call *market failure*. A market economy without any regulatory framework would not create the necessary information by itself to provide quality products for the consumers.

Markets do not always work efficiently by themselves. In contrast to the perfect market of an economic textbook, in reality market consumers and producers are not provided with full transparency about prices and the quality of products. Economists call this a market failure. In such a situation markets malfunction and the low quality drives out high quality.[5]

A thought experiment by the economist George Akerlof illustrates this dynamic:

"Imagine it costs a seller $1.00 to supply a quart of high-quality milk, and $.60 to supply a quart[6] of watered down milk. A typical buyer would willingly pay up to $1.20 for good milk and $.80 for inferior milk. In either case, mutual gains could be obtained from trade. If the buyer could recognize the milk's quality, both buyer and seller would benefit from a sale at a price somewhere between $.60 and $.80 for low-quality milk and between $1.00 and $1.20 for high-quality milk. If the buyer is unable to distinguish quality, however, both grades of milk would sell for the same price. Suppose all vendors look alike to the buyer, and he believes that 60 percent of them water down their milk. Then the most he would pay for a quart of milk is $.9,6 and probably less. (The arithmetic of this is that there is a 40 percent chance the milk is worth $.20 to the buyer and a 60 percent chance it is worth $.80, so on average it is worth $1.20 x 0.4 + $.80 x 0.6, which equals $.96). But this situation is not sustainable. It costs $1.00 to supply good milk. An honest seller charging the price that covers her costs will not make sale because of the buyer's well-grounded fear of being cheated. Honest sellers go out of business. The fraction of sellers watering their milk rises 100 percent. Gresham's law rules in this marketplace: low-quality goods drive out high quality" (McMillan 2002).

This kind of situation is still common in many poor countries. India solved the problem of adulterated milk in the 1970s by a campaign of the National Dairy Development Board. It provided inexpensive machines to measure butterfat content of the milk at each stage of the distribution chain, from farmer to wholesaler to vendor, and set up payment schemes under which prices paid for milk reflect its measured quality. In the end, consumer stage, brand names were created to give buyers trust in what they were getting. Quality improved and consumption rose. Consumers and honest producers benefited. (McMillan 2002, 101)

Informing the consumers about different product qualities also is in the interest of (a least parts of) the business sector itself. The producers of better quality have an intrinsic interest to demonstrate to the consumers their superior quality. Traditionally, the larger firms did this mainly by labeling and through trade marks, which helped the consumer to identify credible brands. For small firms this was less an option, because their relative costs for branding and marketing were higher and too expensive.

Jörg Meyer-Stamer illustrates the dilemma within the creation of workable metrology services in developing countries (Meyer-Stamer 2005). The pressure on entrepreneurs and other producers to measure their products regularly and to certify their products and services increases continuously, especially in the export orientated sectors. Also, a relevant demand on metrology services emerges, even though the firm's disposition to pay adequately for these services is rather small. It could be expected that the market would provide such a supply relatively quickly. But this expectation is in most cases ungrounded.

5 Another example of how bad products drive out good ones is Akerlof's example of the market of used cars, see Akerlof, George A., "The Market for 'Lemons': Quality Uncertainty and the Market Mechanism." Quarterly Journal of Economics, 84 (3), pp. 488-500, 1970.

6 The quart is an outdated unit of volume which equals approximately to 1/3 litre. Today in the USA, in India and all countries, the metric system is mandatory.

The function of markets for metrology service is a practical example of market failure. On the one hand, the market for metrology services is very transparent, because of the existence of comprehensive systems of certification and accreditation. On the other hand, the barriers to access are high in many market segments:

- The qualification requirement of the laboratory and service personal is very high and specialized. Metrology rarely employs unskilled labor, although it creates positive effects (externalities) on industry.

- The investment for measurement and testing instruments is high. The amortization period is relatively long, which could be a too high risk in unstable environments, which are typical in developing countries.

- The costs for certification and accreditation are high. In addition, the preparation process to obtain an ISO 17025 accreditation could take at least one year, even if the laboratory is quite competent. Prior to accreditation, the laboratory will not be able to offer the demanded recognized service, and thus it will not be able to realize this income possibility. Without accreditation, there is less work; reduced work means less income to finance the accreditation process.

Furthermore, the development of standards often involves a negotiation process, in which different competing technologies and firms have to agree on entirely new standards. Therefore, it is unrealistic to only see the market as being in charge of the development of a workable metrology infrastructure. In some areas, i.e. two-dimensional measurement technique where the entrance barriers are low, the market may work properly. In many other more sophisticated areas, like three-dimensional measurement technique, the market will not work.

3.2 Connecting Standards

Standards are documents which establish technical specifications, criteria, methods, processes, or practices which are measurable and have voluntary character.[7] They are elaborated by committees of interested parties (producers, consumers, government, NGO, etc.) and specify the use of quality services. Standards connect the QI with the innovative firms.

Standards are a way for SMEs in developing countries to gain access to markets that are more profitable. The requirement of global buyers combine the carrot and the stick: The international standards and certification schemes embed knowledge which helps the local SMEs to upgrade (pull). At the same time, it requires that SMEs innovate to fulfill the requirements (push). All in all, the compliance of standards improve productivity at the firm and industry level. Moreover, quality certification can be a stepping stone to new technologies (Haven 2008).

The information contained in standards is principally accessible to everybody. Firms in developing countries have access and acquire this knowledge. Whereas some technology that has now become an industry standard may not be on the technological frontier, one can imagine a situation in which technological know-how differs among firms in developed and in developing countries. Mature technology, which is adopted as an industry standard in developed countries, may still mean huge progress for firms in developing countries. Such standards can be adopted by firms in poor countries and can represent an important mechanism of technology diffusion (WTO 2005, 41).

Standards might be barriers to foreign markets for small firms or they can complicate access for suppliers of large corporations (Osorio 2008, 126). A first problem is the lack of awareness and of information of local firms regarding opportunities and specific requirements of international buyers. Another barrier is the cost of the certification process, which normally includes a profound organizational change process within the firm.

7 The WTO terminology differentiates between (voluntary) standards and (mandatory) technical regulations or sanitary and phyto-sanitary measures. Even as QI focuses mainly on the voluntary part there is also an overlap to the mandatory regulation, as i.e. public inspection bodies could demonstrate their technical competence by accreditation through ISO 17020.

If the barriers are vincible for SMEs, the opportunities after complying could be a relevant incentive for improvement and upgrading. If the gap between the possibilities of the SMEs and the requirements is too deep, support will be needed. This could be through direct support of large buyers by development agencies and support programs, or a combination of both.

In Figure 3, Guasch provides a summary of positive and negative economic effects of standards according to their function (Guasch 2007, 26). He emphasizes that few standards fit clearly into a single functional category and that a combination of functions will result in some combination of economic effects.

	Positive effects				Negative effects	
Function	Exploitation of network effect	Innovative and productive effiency	Reduction of imperfect information	Innovation diffusion	Constraints on innovation	Constraints on competition
Compatibility and interface	X	X		X	X	X
Minimum quality and safety			X	X	X	X
Variety reduction		X		X	X	X
Information and reference			X	X	X	X

Figure 3: The Economic effects of Standards According to their Function
Source: Guasch 2007, 26

3.3 Systemic Dynamic Framework

A traditional explanation of innovation is the science push model (United Nations Conference on Trade and Development UNCTAD 2007). Scientists in universities and research institutes produce knowledge, which is transferred to enterprises, which, in turn, bring these innovations to the market (LDCR 2007, 57 ff.). In the early years, the International Technical Cooperation of PTB was very much in accord with this approach. In various countries PTB and other NMIs financed metrology facilities, beginning with buildings and the provision of measurement equipment. Later, PTB also supported the training of QI personnel, while still maintaining its focus on the supply side.

A weakness of this approach has been the lack of relevance of public research and offered services to the needs of the productive sectors and the limited relevance of scientific research efforts to commercial market needs. This leads to an alternative approach of innovation, called the demand pull model, which identifies the expressed demand of the private sector as the motor of technological change. This strengthens the role of the private sector, mainly benefiting from technology development projects and training. It also includes the promotion of private-sector service providers, thus facilitating the emergence of a technological service market (United Nations Conference on Trade and Development UNCTAD 2007, 57).

The International Technical Cooperation of PTB and others followed the trend and started to involve business associations and private enterprises in their projects. Representative in that sense are projects to introduce Quality Management Systems (QMS) with ISO 9001 at the firm level (i.e. Honduras) or to promote the accreditation of private certification bodies (i.e. Biolatina in organic certification) and testing laboratories (i.e. AGACE project in Central America). Additionally, PTB followed the trend in the development community to work with the value chain approach, following a particular focus on a company's needs for quality services and infrastructure (Sanetra 2007).

Today, the supply-push and the demand-pull models are seen as an oversimplification of how innovation occurs (United Nations Conference on Trade and Development UNCTAD 2007, 58). Both models paraphrase innovation as a linear cause-effect relation. Instead, the system's approach emphasizes multiple sources of innovations, including interactions among enterprises and sectors. This leads to the hypothesis that the relationship between QI and innovations could be seen as an interaction that works in two ways. The demand of innovative firms pulls the QI and the supply pushes the innovation of the firms. At its best, both phenomena create a self-reinforcing mechanism or a victorious cycle.

The promotion of IS requires a deep understanding of the system dynamics. At the same time, the most appropriate way to analyze and change an IS is methods of action research. In numerous projects, the German Development Cooperation accumulated appropriate knowledge to promote innovation systems. Two examples illustrate useful methods of analysis.

3.3.1 Example 1: Systemic Dynamics

The systemic competitiveness concept is a well-known framework in the German Development Cooperation. It differentiates between four levels of economy: firm level (micro), business support (meso), generic interventions (macro) and competitive mind set (meta) (Esser, Hillbrand et al. 1996, 2008).

The interventions of the QI are mainly located at the meso level to support firms. The justification for this intervention is mainly to overcome market failures or other inefficiencies (i.e. state or network failure). The support of technical services or training activities could be specific responses.

Sometimes development cooperation also supports interventions at the macro level, like the composition of a legal framework (quality policy) or a legislation which requires all laboratories to provide services to official entities, which must be accredited by the national accreditation body.[8]

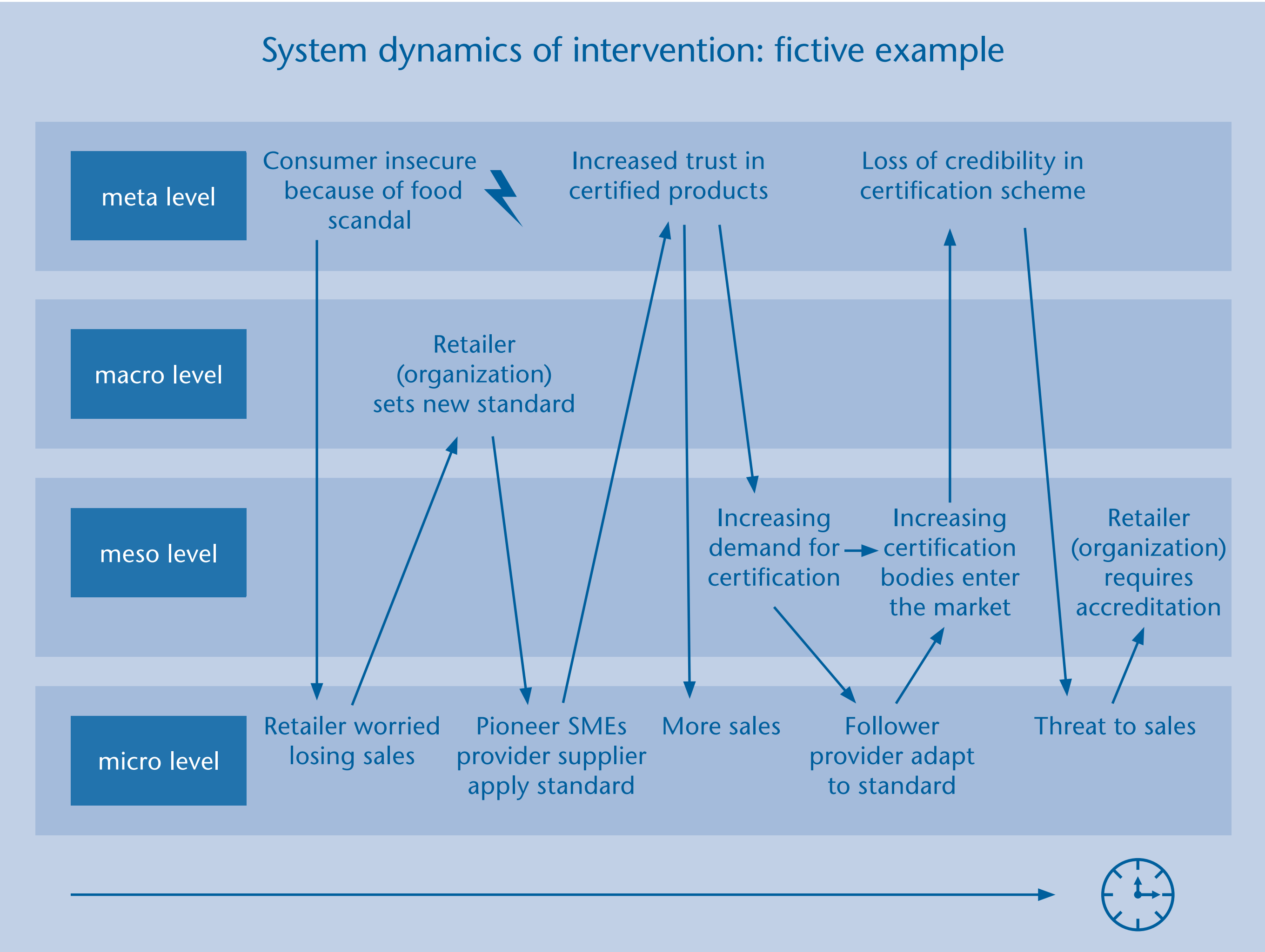

Figure 4: System dynamics of intervention

8 This was the case in Costa Rica Haven, T. (2008). Innovation, Skills, and Quality: 119-144.

All activities of sensitization and marketing are located at the meta level. Their aim is to promote a "culture of quality". The informing and education of consumers are also located at this level. Actually, consumers in developing countries are increasingly aware of consumer standards, improved labeling, and improved product value. These aspects are often communicated through higher standards in food quality (such as HACCP and ISO 22000), labeling or compulsory regulations.

The distinction of different layers helps obtaining a bigger picture of an IS and its variables. It also helps to identify market failure and intervening leverage points.

To comprehend the dynamic character of an IS it is useful to amplify the tool and introduce the time variable. The following figure shows a hypothetical case.

Many standards are elaborated as a reaction to certain scandals or even as a preventive action to avoid dissatisfied customers. All in all, groups of exigent consumers usually are the driving force for new requirements, products, processes and organizational innovations.

The figure (above) presents a hypothetical case of how different layers of systemic competitiveness could be interrelated over time. This mapping could be used to identify critical events or interventions and their implication for the development of the whole system.

A real case – similar to the fictive example – is the development of GlobalGAP by European retailers.[9] The large retailers reacted to growing concerns of the consumers regarding product safety, environmental and labor standards and decided to harmonize their own, quite often very different, standards. The development of common certification standards involved their whole supply chain, including farmers from developing countries. GlobalGAP is a pre-farm-gate standard, which means that the certificate covers the process of the certified product from farm inputs like feed or seedlings and all the farming activities until the product leaves the farm.

The GlobalGAP standard implies innovations at different levels: First, the product is characterized by the information the standard gives the customer. Second, the production process at the farm is improved by introducing the principles of Good Agricultural Practices (G.A.P.). Third, the introduction of GlobalGAP requires reorganization at the firm level, but also within the whole value chain.

From the perspective of the QI it is especially relevant that GlobalGAP requires the accreditation of its certification bodies. This linkage with the QI increases the consumer's trust in the standard and lowers the costs of inspection for the standard body itself. At the same time, each new standard is a product innovation within the QI and normally also requires changes at the process and organizational level.

The example shows how different types of innovation are closely interrelated and confirms why a systemic perspective is required at all.

9 www.globalgap.org.

3.3.2 Example 2: Calidena

Value chains or networks are innovation systems on their own.[10] The focus on a specific product (or group of products) makes the analysis easier in order to manage an entire NIS. The difficulty, though, could be that lead firms are not present in the country of intervention and are difficult to involve. As the foreign buyers' perspective often is decisive for the analysis, there is a need to rely on secondary information or to make additional efforts to involve them.

The International Technical Cooperation of PTB developed the Calidena methodology to improve the quality of processes and products in a value chain.[11] This methodology views a value chain and the related quality services as a system, and enables all the actors to innovate. It helps to identify and promote practical activities to strengthen quality services for a value chain in order to increase the competitiveness of SMEs in developing countries. Calidena begins with a workshop that combines training with an initial diagnosis, generating a precise picture of the chain and a plan of action for overcoming the given situation. Once a Calidena process has been initiated, the workshop results are followed up, which includes consultancy from specific experts, supported by the PTB.

The Calidena method is a complement to the increasing number of value chain analysis methodologies (i.e. ValueLinks of GTZ) within the donor community. Calidena does not present a common value chain analysis which looks at the economic and the governance dimension. It much rather involves the representatives of quality infrastructure and services who are not participating in the usual value chain analysis. Bringing together two groups, value chain stakeholders and QI representatives, who normally do not interact together, creates an innovative atmosphere itself. The VC stakeholders obtain a deeper understanding of the opportunities and threats of quality requirements involved in their competitiveness. The representatives gain a better understanding of the real demand of the VC and valuable inputs to improve each service and the QI system as a whole. By doing a rapid appraisal, the practical interaction aids the understanding of the complexity of the chain and overcoming the typical fragmentation of IS in developing countries. A series of Calidena initiatives in process could be foundation stones in the creation or further development of a NIS.

10 The link between value chain promotion and the systems of innovation approach is broadly analyzed in the working paper Cunningham, S. and F. Wältring (2010). Value chain promotion from a Systems of Innovation perspective. Pretoria and Dortmund.

11 For the Spanish version of the Calidena handbook see www.ptb.de/de/org/q/index.htm.

4 Promotion of Quality Infrastructure and Innovation Systems

The promotion of QI, formerly MSTQ, is a consolidated subsector in (German) Development Cooperation (BMZ 2004). PTB with its technical excellence is the leading institution, also GTZ and other specialist institutions, such as BAM, DIN, DGQ, VDE and the TÜV, have many years of wide-ranging experience in the implementation of MSTQ projects in developing countries. The downside of this specialization is that the QI promotional activities are only occasionally integrated into other private sector promotional activities. In other words, the way QI is currently supported is part of the fragmentation of the promotion of the innovation systems by the development cooperation.

4.1 Four Pillar Model

To overcome the fragmentation of private sector and innovation system promotion it would be useful to have a generic model which illustrates the position of QI within a broader IS. As reference point we choose the Four Pillar Model of Innovation Systems (Hillebrand, Messner et al. 1994; Meyer-Stamer and Schoen 2007), a synthesis between the more generic perspective of the National Innovation Systems approach and the more narrow analysis of innovation pattern in sectoral or local systems:

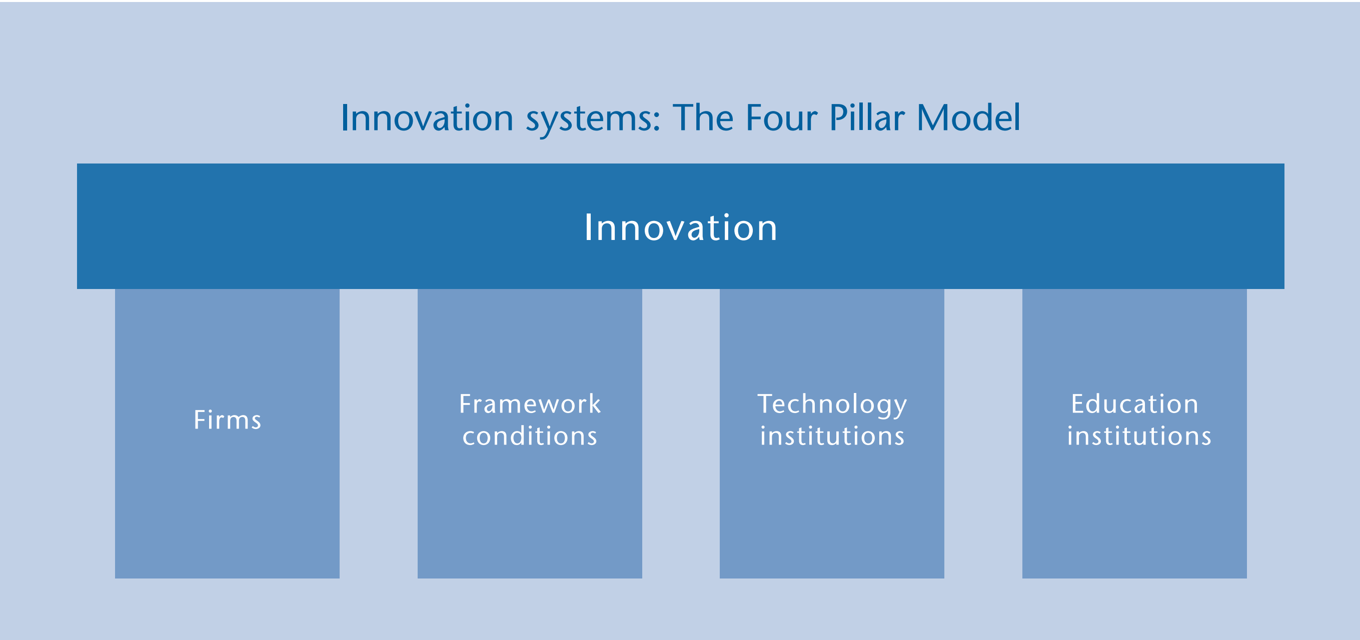

Figure 5: Innovation Systems: The Four Pillar Model
Source: Hillebrand, Messner et al. 1994

The model positions the firm as the most important place of innovation. In a competitive environment a firm has to be innovative to be competitive and survive in the long run. The firm has to adapt to changes in customer preferences, new technologies or regulations. At the same time, it benefits from the support of technology and educational institutions.

The following figure looks in some more detail at the factors that are relevant with respect to each of the pillars. For the purpose of this article we highlight the aspects related to QI:

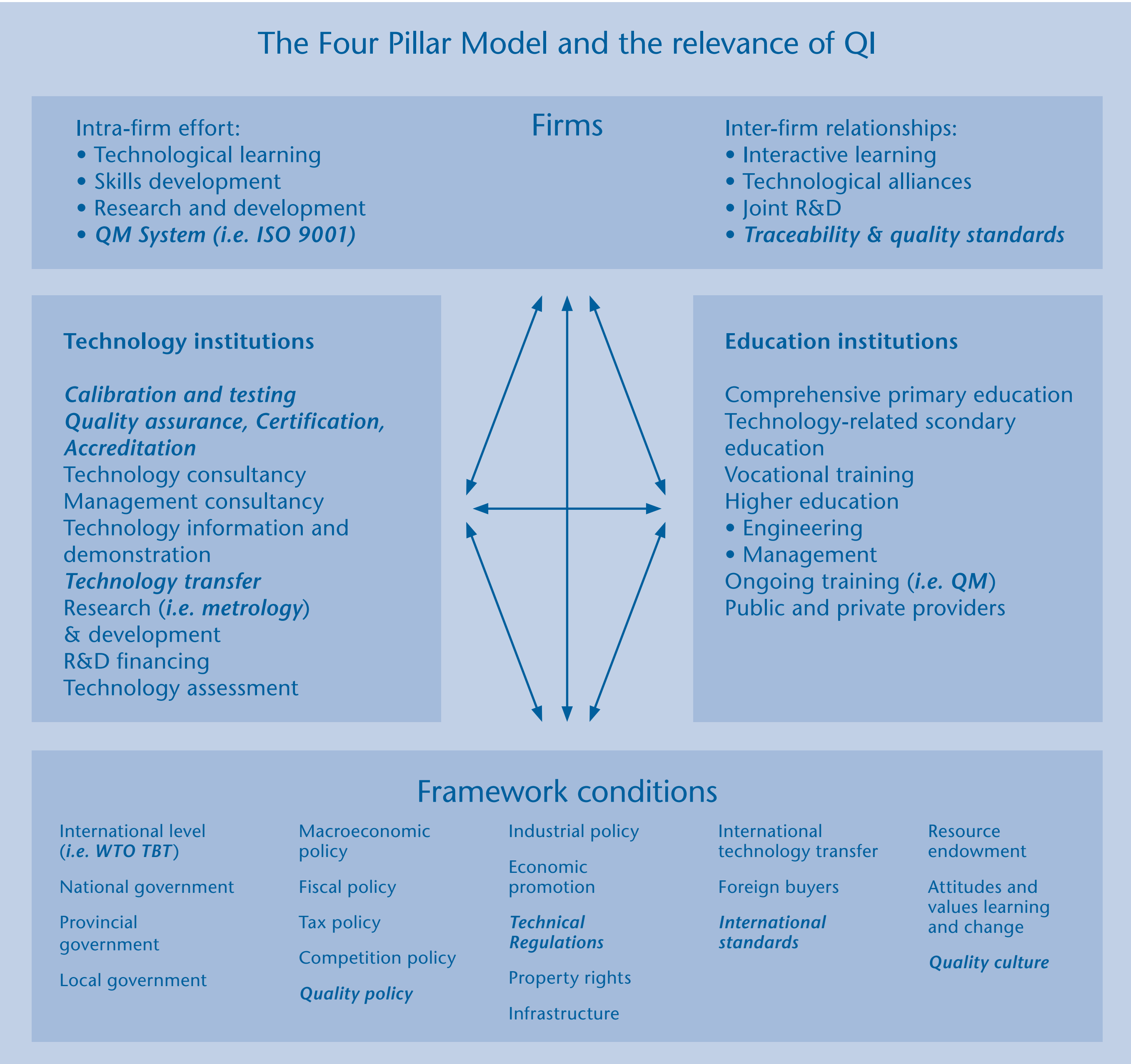

Figure 6: The Four Pillar Model and the relevance of QI
Source: Based on Meyer-Stamer and Schoen 2007, 18 and adopted by the author

The first pillar is the *firm*. This is where a large part of innovation takes place, and firms are the target of efforts to stimulate innovation. The measure of effectiveness of an innovation system is the extent to which firms use innovation to create a competitive advantage. Within the firm the implementation of a QM System, such as ISO 9001, Six Sigma or the EFQM, is the backbone of a continuous improvement and learning process. Interaction with other firms, in particular suppliers and customers, is also a key driver of technological learning and innovation. Benchmarking or the application of traceability standards in value chains is an example of quality issues in the inter-firm relationship.

The second pillar is established through the macroeconomic, regulatory, political and other *framework conditions*. They define the set of incentives firms are facing. More specifically, they establish whether or not firms have to innovate. For instance, technical regulations for consumer protection or quality requirements of global buyers push the firms to adapt and innovate. The legal framework and the endowment of the QI itself shows the level of culture of quality in a given country. The embeddedness in the global economy by joining bilateral or multilateral trade agreements also implies quality issues (especially in the section of TBT or SPS measures).

The third pillar refers to *technology institutions*. In a developing economy, the diversity of such institutions is quite limited. There will be some public research institutions (i.e. agriculture extension) including university research, but their agendas and outcome are rarely related to the needs and absorption abilities of local firms. More relevant for developing countries are service providers of the QI, like calibration and testing laboratories or certification bodies (Pietrobelli and Rabellotti 2008, 219). Nevertheless, as the demand of such services is still small, it requires a lot of support by the government and the development cooperation to make these services accessible especially to the local SMEs in developing countries.

Finally, there is the fourth pillar which consists of *education and training institutions*. Other entities, such as vocational training institutes or sometimes business associations, have their own training provider. QM and other quality-related topics often are part of the training curricula. There is certainly some overlap with the third pillar: some research institutions will do some training, and some training institutions (especially universities) may be involved in research and development. However, it is crucial to understand that even in the case of universities, their core mission is training. Another overlap may occur as specialized training providers offer quality-related consultancy and support in the implementation of QMS.

Highlighting the quality issues within the model shows its relevance in all of the four pillars. It makes clear that the QI affects the entire innovation system and cannot be reduced to the framework conditions as some scholars have done (Rippin 2008). On the other hand, the existence of QI elements within the whole system does not mean that these elements are already connected with each other and with the rather distant elements of the innovation system. The task of the innovation system promotion is therefore to bridge within and between each pillar, in order to overcome the current fragmentation.

It is important to point out that the relevance of different elements of an innovation system depends on the stage of development. In a country where "catch-up innovation" is the predominant pattern, a highly specialized, leading edge research and development institution will have to battle to find clients for its services. A cluster of leading edge high technology firms, a technology demonstration center will in all likelihood not need a technology demonstration center. In other words, the examples mentioned in the figure above are illustrations rather than a blueprint. The structure of an innovation system, and the organizations that are part of it, will change over time and according to the level of economic development.

4.2 QI Economic Sector

The bodies of QI are usually seen as part of the support services for the firms at the micro level. At the same time QI may be seen as a service sub-sector itself. Looking at the budget of the QI-related public bodies (metrology institute, standard body and accreditation body) and also at the turnover of calibration and testing laboratories, certification bodies and specialized training and consulting providers, we discover an increasingly relevant sector, also in terms of usually highly qualified employment.

Most of the services are related to home demand. Nevertheless, many services (especially certification, laboratories, training and consulting) do compete with foreign providers. Providers of more advanced economies export their services. At the same time, local service providers have to deal with foreign competitors in their home market.

As the knowledge of the internal economic dynamics of the QI service provider is very limited, it could be helpful to apply a cluster analysis to this support sector itself. Within this analysis, an innovation process within the quality service itself might be discovered. An increased competitiveness of quality service providers in developing countries may additionally create qualified employment, lower the costs for local firms and therefore enhance the competitiveness of the national economy itself.

4.3 Beyond NIS

The national level is not always the most adequate for innovation system promotion. We have already highlighted the appropriateness to intervene at a more specific level, such as local or sectoral innovation. At the same time, especially for smaller and less advanced countries, it is helpful to collaborate with more advanced neighboring countries in the same area. This should always be considered a serious option. For example, the current projects of PTB in Latin America have already begun to follow the regional integrated approach (Miesner 2009). The benefits of collaboration should be mutual. While the more advanced country supports the neighboring market's development efforts, new opportunities for interregional trade are opening up for both.

As the economies of developing countries are mostly divided between a stronger export sector with larger companies and a sector of micro and small enterprises, many of them informal, it will be important to look at how to connect the excluded part of the economy with the QI. Even those firms which do not aspire to export are affected by the increased international competition of imports. A working QI could inform the consumers about different product qualities which can be an incentive for local firms to innovate and differentiate by responding to this improved demand.

5. Conclusions and Recommendations

This paper shows the relevance of standards and quality issues for the promotion of innovation systems in developing countries. The reduced characterization of QI - as part of the enabling environment of firm innovations - misses out on its key functions within an innovation system. As the linkages between innovation and QI are multiple, it is necessary to understand even better the interaction between both phenomena. Further research should be focused on the system dynamics and the leverage points to support innovation systems. In that sense, the identification of market failures could be helpful to identify appropriate leverage points for system interventions. The aim is to overcome the fragmentation and over-specialization of private sector and innovation promotion and integrate the support of the QI support in a more systemic approach.

As innovation systems are highly interdependent, it is recommended that its complexity be reduced by starting the analysis with specific innovation systems at the sectoral or territorial level. Case studies using the value chain and cluster approach should be appropriate to better understand the individual pattern of innovation. This paper refers to various proved and immediately applicable methodological tools (market failure analysis, value chain or cluster mapping and the four pillar approach) which could help to include QI issues in current private sector and innovation promotion. At the same time it is useful to have a closer look at the innovation within QI projects of PTB itself.

Action research may be the appropriate form to combine interventions in the IS with structured reflection about its results and impact. This kind of learning involves all relevant stakeholders, including the technical development cooperation in a participatory way. In that sense, research results are not the endpoints, but rather part of a learning cycle which enables the involved parties to change their own reality and, in our case, to improve the productive interaction between QI and innovation at the firm level.

Empirical research should also address the micro-economic benefit analysis of firms adjusting to new and more demanding markets. Grote and Stamm state that there is little known about the willingness of lead firms to help suppliers adapt to new quality requirements, providing them with relevant training, advice and access to QI services (Grote/ and Stamm 2007, 48). Their question is how to assure that SMEs in developing countries have access to testing laboratories at a non-prohibitive cost.

As the countries themselves and the development cooperation have already put much effort into promoting the private sector, the local economies, or their business development services in these developing countries, there is no need to start from scratch with this new approach. It should be helpful to use existing best (and worst) cases of the promotion of QI and IS to figure out the system dynamics. Visual mapping may be a helpful instrument to systemize such experiences.

A better understanding of quality-driven innovation processes at the local and sectoral level should help to contribute from the bottom up the creation of a national innovation system in developing countries. Therefore, it is also important to facilitate a cross-sectoral exchange of experience and process of mutual learning. The collaboration across sectoral boarders can award mutual benefits, as the less advanced sector does receive knowledge and service support, whereas the more advanced sector gets a higher demand for its own quality service supply and thereby reduces fix costs.

For PTB with its technical background it is important to be aware of the non-technological aspects of innovation. New forms of organizational models, managerial practices and working methods are often prerequisites for the effective use of technology. In addition, the increase of non-measurable requirements like "fair trade" and "decent work" in standards deserve even more special attention. Beyond that, it is important to understand that innovation is a social process, which needs a holistic approach.

Finally, it is important to understand the development of QI as an innovative and evolutionary process itself. There are certain elements and principles which are universal and need to be applied. At the same time, the QI of each country needs to be developed according to its size, economic structure and idiosyncrasies, and will therefore differ from other systems. In summary, one can say that the QI of a country should, at the same time, be differentiated and compatible with international systems.

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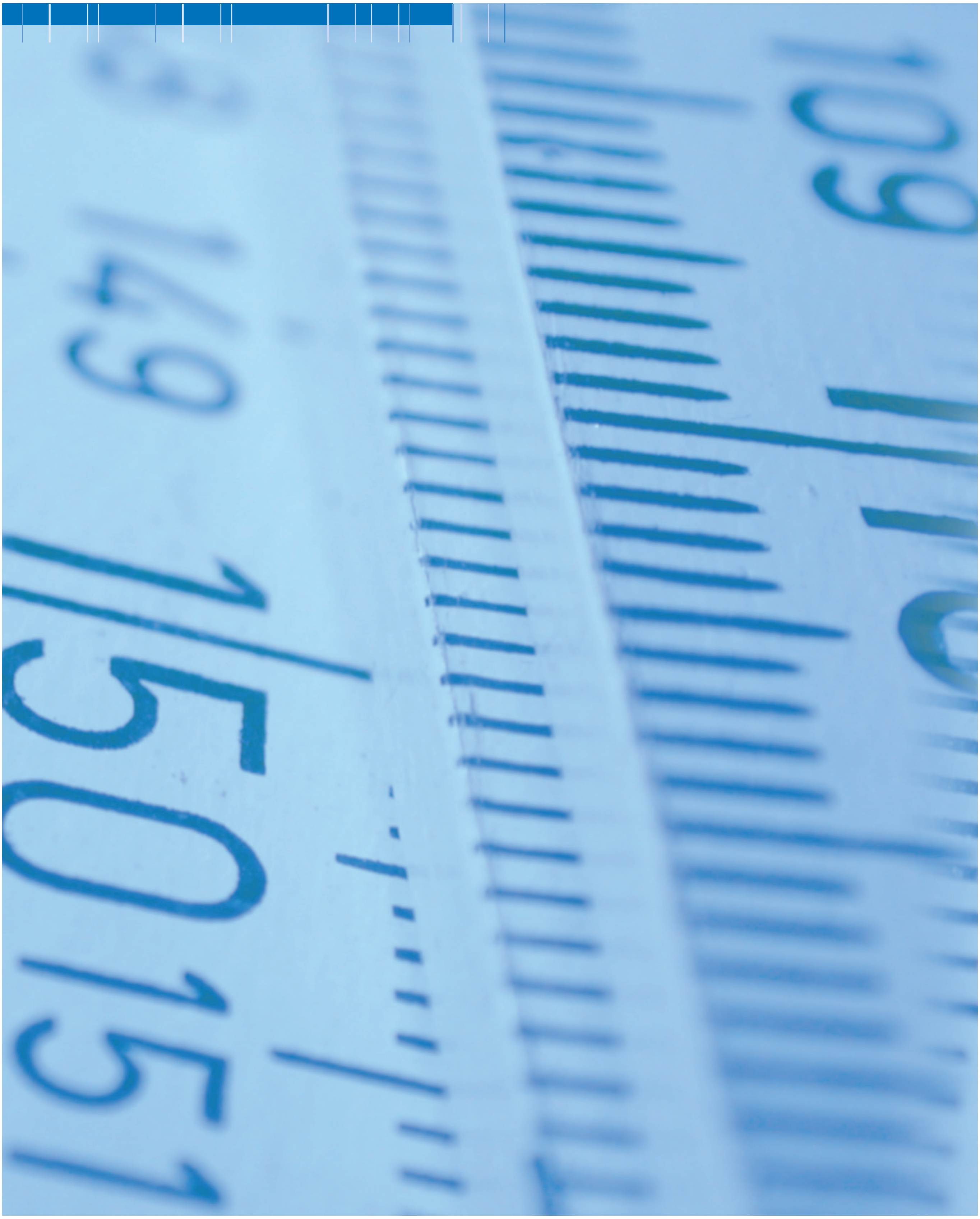

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