Metrology and standards

While standards prescribe certain rules and specifications to be followed, public research institutes usually deliver metrological services to help organizations control the quality of their products with regard to certain “ideal measures” or control gauges, as well as to ensure their compatibility with established norms and practices that prevent human and natural hazards. The major goals of metrology and standards are to control the quality of goods and services to protect consumers, and to avoid excessive incompatibility of existing products and services, which may be harmful for innovation and economic growth. Universities and public research institutes play a crucial role in metrology and standardization, as they provide important technical expertise and services needed for these activities. Several conditions must be met in order to ensure that universities and public research institutions contribute to metrology and standards, and through them to innovation performance, including effective science-industry and science-government links, leading-edge facilities and equipment to ensure high quality measurement services and control, and open, transparent and consensus-based standardization processes.

What are metrology and standards?

The International Organization for Standardization and the International Electrotechnical Commission define standardization as producing documents “by consensus and approved by a recognized body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context” (ISO/IEC, 2004). In the innovation context, standards may be understood as sets of rules and norms related to innovative products to ensure consistency of growth, and compatibility of devices, services and processes available in the market.

While standards prescribe certain rules and specifications to be followed, metrological services are usually delivered by public research institutes to help firms and other organizations control the quality of their products with regard to certain “ideal measures” or control gauges, as well as to ensure their compatibility with established norms and practices to prevent human and natural hazards. In many instances, the precision of individual devices is critical for health, safety and the environment: take, for example, the navigation equipment of an airplane or a sea vessel, where the lives of thousands of passengers depend daily on fault-free hardware.

Therefore, the major goals of metrology and standards are to control the quality of goods and services (to protect consumers from faulty products) and to curb excessive competition (basically, to resolve market failure), which may eventually lead to increasing incompatibility in existing products and services, and continuous differentiation in the market between aligned consumer and industry groups, causing harm to overall economic growth and market governance.

Universities and public research institutes play a crucial role in metrology and standardization: these institutions provide important technical expertise and services needed for these activities. Such organizations as the US National Institute for Science and Technology, UK National Physical Laboratory, European Association of National Metrology Institutes, and the International Organization of Legal Metrology help businesses, governments and non-profit organizations to establish best measurement practices and standards, and ensure high quality products and services. In most cases, these organizations have leading-edge equipment and facilities that are only made possible by public support, as they require huge investment and technical expertise to run.

How do metrology and standards contribute to innovation performance?

Metrology and standards have some direct positive effects on innovation performance by ensuring that the quality of available goods and services meets established norms and precision requirements.

Metrology provides an important reference point for innovators to identify whether their new goods,

processes and services can offer better specifications than are already available in the market. In addition, metrology helps to promote such socially beneficial standards as clean air (through air pollution control), environmental monitoring, the health and safety of products and services, and so on.

Blind (2013) points out three major contributions that standards can make to innovation performance:

- Standardization may be an important channel for technology transfer and for facilitating intellectual property development.
- Intellectual property rights may be translated into standards, which will be useful for both IPR holders and standards implementers.
- Standards play a crucial role in public procurement processes and evidence-based policy making, which are now seen as important vehicles in promoting innovation.

In addition, standards also play a major role in industrial specialization by allowing sectors to formulate their identities and make strategic choices. Standardization permits the formation of industrial alliances, networks, and clusters of various groups of scientists, engineers, entrepreneurs and investors seeking to develop a particular technology, product or service. Although harmful in extreme cases, where such groupings may curb competition and form oligopolies, standards generally have the positive effect on streamlining and organizing the resources and capabilities of an innovation system into particular directions.

In the end, metrology and standards are a good form of codification of best innovation practices, which can be distributed among different groups of scientists, entrepreneurs and the wider public. In this sense, metrology and standards can serve as an important tool in streamlining entrepreneurial search and improving innovation governance. In the initial stages, they can be also used as an effective platform/reference point to identify the strengths and weaknesses of technology, and to guide innovators towards important tactical and strategic choices.

Main actors

National and international metrology organizations (e.g. NIST, NPL, EURAMET, OIML) play an important role in providing measurement services, training new engineers, and disseminating the best metrological practices to ensure quality and consistency in innovation, both in individual countries and across the globe.

- National standardization agencies: countries usually establish a wide network of standardization bodies affiliated with or subordinate to the head office coordinating these activities at the national level. Technical experts and research institutes are the core of national standardization organizations. For example, the Standardization Administration of China oversees the implementation of national standards strategy and serves as the major national body representing the country in ISO and IEC. Specialized industry standards are developed and propagated by relevant government agencies and trade associations. Local governments are responsible for local standards that are supposed to be harmonized with national and industry standards. At the bottom of the hierarchy are the enterprise standards. Similar systems exist in most countries around the world.
- At the supranational level, the European standards organizations CEN, CENELEC and ETSI have been established at the EU to develop and oversee the implementation of general, electrotechnical and telecommunication related standards. These organizations also largely depend on technical expertise and guidance from university researchers and scientists.

- International Organization for Standardization, International Electrotechnical Commission, and International Telecommunications Union oversee standardization processes at the global level, employ numbers ,of technical experts, and collaborate with universities and PRIs in various countries.

Conditions ensuring the contribution of metrology and standards to innovation performance

Several conditions must be met in order to ensure that universities and public research institutions contribute to metrology and standards and, through them, to innovation performance:

- Good science-industry and science-government links must be established so that technical expertise can meet the needs of the market and national priorities in the best possible manner.
- Leading-edge facilities and equipment must be utilised to ensure high quality measurement services, and adequate control of new products, processes and services to prevent social and natural hazards.
- Metrology engineers must be well trained.
- Standardization must be pursued in an open and contestable manner to reduce the impact of individual interest groups and eventual lock-ins to particular technologies.
- Opportunity costs must be reduced to increase the probability that researchers actively participate in standardization work, rather than spending their time writing scientific publications or promoting their research for proprietary applications.
- Standards must be developed in a proper timeframe so that they can make their largest contribution to innovation performance. Premature standards may lead to excessive competition, and lack of interoperability between various devices and services.

Measurement

The effects of metrology and standards on innovation performance are extremely difficult to measure, since they do not generate particular R&D output but rather help to organize the entire innovation process. Some basic statistics may be applied to identify the contribution of universities and PRIs to these activities, such as counting the number of researchers and organizations participating in standardization and metrological activities. For example, in 2008 the operation of China's standards system involved 264 technical committees and 386 subcommittees engaging some 30,000 technical experts. Twenty-five standardization research institutes at the national level and 158 local institutes were also ascribed the task of developing new standards (Suttmeier and Yao, 2008).

Metrology systems are usually assigned to particular technological areas, given the precision of tasks that they have to fulfill. Therefore, some statistics may be elaborated at the sectoral level in terms of the number of PRIs and special facilities devoted to metrological support. Some universities also train metrology engineers as part of their specialization – the number of students and graduates may serve as a good proxy to identify the scale and demand for such activities in the national innovation system.

The assessment of the direct economic effects of metrology and standards involves a variety of proxies, such as the number of collaboration agreements or contractual links between industry and universities devoted to the task of metrological support and standards development. A major challenge is to identify exactly what role metrology and standards play in general R&D collaboration between firms and universities/PRIs, since these tasks are usually incorporated in some broader collaborative schemes and are linked to more general innovation relations.

With regard to the effect of standards, it is also possible to count the number of products assigned to a particular standard or technical specification. However, this may be a dangerous route since

standards can also be used as an instrument of market competition, where interests and motivations may differ significantly.

What policies relate to metrology and standards?

Policy rationales

One of the policy rationales for promoting metrology and standardization is to resolve a market failure stemming from over-diversification of the market and the establishment of a large number of competitive small consumer and industrial alliances, which can curb effective innovation processes.

Metrology and standards can also be used as a tool to resolve network and capability failures, since they allow for better dissemination and codification of best innovation practices, as well as the establishment of best measurement practices.

Broader system failures are also applicable as a policy rationale for the use of metrology and standards, since they improve innovation governance and streamline resources to certain breakthrough points, as agreed upon by stakeholders in the innovation system.

To some extent, these services may even be used to resolve directionality failures, since they allow the establishment of specific rules and reference points that are controlled by specialized government agencies and industrial alliances, which may direct transformative change for the next 10-20 years, according to national and sectoral priorities.

Policy objectives

Policy objectives regarding metrology and standards include:

- establishing a general consensus in particular areas related to innovative and industrial activities
- involving the best researchers and experts who have intimate familiarity with specific topics, to ensure the quality and sustainability of new standards and measurement practices
- controlling the quality of new products and services
- providing leading-edge equipment and facilities to ensure high quality measurement practices
- improving training programmes for the effective reproduction of world-class metrology engineers
- curbing excessive competition between consumer and producer groups
- streamlining capabilities and resources into priority areas
- improving knowledge flows and learning through the dissemination of codified norms and practices
- controlling the direction of change
- facilitating intellectual property development
- improving public procurement processes.

Policy instruments

So that universities and PRIs effectively participate in metrology and standardization processes, governments must promote their open involvement in dialogues with industry and other interested parties.

Innovative firms should be required to ensure that they meet established standards by adopting best measurement practices and creating links with metrology facilities. Certification serves as an important step in promoting such behavior.

Special education and training programmes must be rigorously supported to ensure wide dissemination of standards and measurement practices among scientists and engineers. Cohorts of metrology specialists must be trained to ensure that the needs of the market and society are met to the fullest extent.

Standardization processes should be kept transparent and competitive to ensure that proper scientific argumentation and research skills are realized most productively. Incentives aimed at rewarding researchers for participation in standardization work (both financially and career-wise) are important tools in attracting more scientists to this activity, and providing greater motivation for them to spend time and resources on these tasks rather than on other work.

Blind (2013) also mentions a number of specific policy instruments needed to ensure the general contribution of different types of standards to innovation performance:

Types of standards	Role of Public Policy to Promote Innovation
Compatibility/Interoperability	• Initiate new standardization processes in case of lock in in old technologies in case of strong network externalities • Ensure compatible and interoperable solutions, e.g. by policy initiatives like the European Interoperability Framework • Promote network externalities by restricting IPR in standards
Minimum Quality/Safety	• Involve all stakeholders in open, transparent and consensus-based standardization processes • Initiate the development of performance instead of design standards • Reference standards asking for high quality in public procurement
Variety Reduction	• Initiate standardization processes including all relevant stakeholders, incl. public procurers, to develop – if possible technology-neutral – standards in order to promote critical mass in emerging technologies and industries in due time without selecting prematurely specific technologies • Reference standards in public procurement processes to promote the development of critical masses • Ensure that standards including IPR can be implemented by all interested companies in order to avoid market concentration
Information	• Promote the transfer of research results into standardization processes and standards supported by public support programmes • Promote the diffusion of the content of standards

Source: Blind (2013, p.27).

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