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Strengthening technological capability

This article is a summary of a research paper that Mesopartner was commissioned to write for Trade and Industry Policy Strategies (TIPS) on behalf of the Department of Trade and Industry in South Africa. It is about strengthening technological capability in developing countries like South Africa to prepare for the changing nature of work, production and trade.

The ability of a society to discover new knowledge, or to adapt, refine and synthesise what is sensed to be relevant is referred to as the technological capability of a society. This capability is a central topic in the promotion of innovation systems. However, the promotion of innovation systems often focuses too much on formal science, technology, engineering and research, while learning by doing, everyday innovation and problem solving by businesses, teams, communities and networks of actors are often neglected. Mesopartner uses the framework of promoting innovation systems and the framework of strengthening technological change together as this allows improvements in both innovation and learning networks, learning by doing, knowledge flows and more structured research and development to be accommodated.

As in innovation systems, the technological capability of a country is not only determined by enabling framework conditions and sufficient competition at the level of enterprises. Our late business partner, Joerg Meyer-Stamer, always reminded us that these are necessary but not sufficient. A diverse range of actors, publicly funded organisations, key suppliers, and demanding local and international buyers, all contribute to making this technological capability possible.

Hillebrand *et al.* (1994) argue that technological capability is built on four pillars:

1. The skill of the enterprises to imitate and innovate at product, process and business model levels. This is largely dependent on pressure to compete as well as pressure to collaborate with each other.

2. The economic, political, administrative and legal framework conditions determine whether there are incentives to develop technological capability. In the past, it was often not recognised that these incentives were lacking in many developing countries.

3. Direct support by technology-oriented state organisations or specific types of knowledge-intensive service companies, depending on the existing level of development, the competition situation, and the characteristics of a technology branch in the given country. These organisations disseminate technical and expert knowledge between different actors, knowledge domains and industries, and play a critical role in the use and application of tacit and explicit knowledge.

4. Indirect support by the public and private educational systems. In addition to a sound basic education, it is important that technical training of a suitable quantity and quality is available at secondary school level and in the universities. The private sector often plays a role in short-term training aimed at particular technology applications. Overall the education sector must be able to identify and respond to changes in the application, development and use of technology in society (see also Article 11, *Responding to technological change by promoting learning and skills upgrading in the economy*).

The close interaction and dynamic between these four pillars create technological capability. The third and fourth pillars are about the meso level and its ability to encourage or shape the innovative efforts of enterprises.

Table 1: Examples of functions performed by technological and educational institutions

Examples of functions performed by technological institutions	Examples of functions performed by educational institutions
• Provide technical infrastructure, such as promoting quality standards, measurement, and testing. • Quality assurance, certification, compliance. • Technology consulting and management consulting. • Technology and knowledge dissemination, technology demonstration. • Technology and manufacturing extension. • Research and development consultancies, centres and contract research organisations. • Intellectual property protection. • Research and development financing, venture capital. • Technology assessment. • Technological and trade journals focused on technology dissemination, evaluation and technical journalism. • Access to scarce or specialised equipment on a pay-per-use basis. • Technological or production technology trade fairs and exhibitions. • Prototyping, simulation and design services.	• A comprehensive primary education. • Appropriate technology-related secondary schooling. • Exposing children and youth to emerging technologies, scientific thinking, abstraction and logic. • Vocational skills training. • Higher education, especially: • Scientific, technology, innovation and engineering-related qualifications • Management, problem-solving, strategic leadership, technology and information management qualifications • Ongoing education, workforce development and retraining. • Academic research. • Providing interns, researchers and instruments to industry. • Developing, formalising and organising industry, domain, and specialised knowledge, pools of expertise, researchers and knowledge. • Attracting public and private funding to enable searching, deliberation and exploration of new topics, and the development of new forms of knowledge.

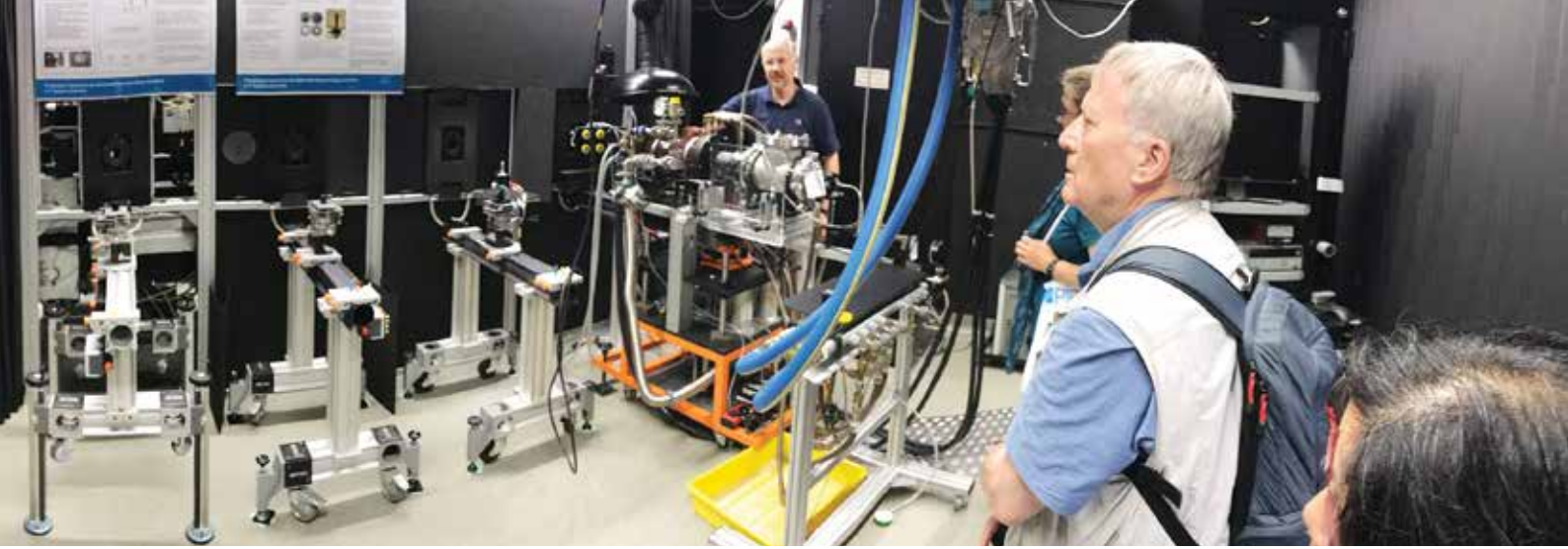
Of the technological institutions (the left column in the table), the easiest to find are the formal organisations that are established through public funding, or the organisations created or supported by industry as a means to enhance their competitiveness. Of particular interest for improving the technological capability of an industry or a region are those organisations that disseminate technological knowledge in the society and assist enterprises to solve problems, master new technologies, and make scarce or specialised knowledge and technology available to the society. They promote dissemination of ideas that will work within the context of the organisation seeking assistance. In general, they respond to temporary or persistent market failures by, for example, overcoming indivisibilities, reducing information asymmetry, reducing adverse selection, and overcoming barriers to entry. For instance, a technology extension service could offer access to scarce equipment and expertise, thus giving access to critical infrastructure that smaller enterprises could not afford by themselves.

While some services may be supply-push oriented (e.g. technical regulations, certification or technology demonstration), others may be more demand-oriented (e.g. technology and management consulting, technology extension services and contract research organisations). Many organisations may not even identify with the topic of technology dissemination, and may simply be fulfilling a regulatory requirement. The development or compliance assessment with standards is an example. Yet standards (or even patents) transmit valuable information about performance, processes, systems and performance requirements, and in this way play an important role in disseminating knowledge, technology and innovation in a country, region or industry.

What is often surprising is the importance of equipment suppliers and multinational buyers in disseminating new technology, knowledge and innovations. Equipment suppliers who provide technology demonstration, comparison or even trial use can be critical players in encouraging upgrading and reducing risks. Multinational clients can set private standards to performance criteria, or require specific process technologies, materials or other compliance that can play a significant role in upgrading their local supplier base.

The fourth group in the list above (right column in Table 1) is collectively referred to as the "education institutions". Again, formal organisations such as universities, colleges, schools or training centres are the easiest to identify and mainly disseminate formal knowledge to the economy in the form of education, courses and academic research. This group includes public as well as private organisations involved in education and schooling, as well as higher education and vocational training.

The ability of individuals and organisations to learn difficult and abstract concepts is largely dependent on this group. These organisations often also encourage informal knowledge dissemination through social networks and personal relations. Through research, development, analysis and publications, these institutions also signal and disseminate information that enables better decision-making in the society. These organisations must be accessible, flexible and responsive to the ever-shifting needs of the society. However, it would be a mistake to focus only on these organisations, as they are mainly involved in structured learning and the dissemination of codified knowledge, whereas technological institutions are involved in the dissemination of codified and tacit knowledge that is often more context specific.



In conclusion, while national technological capability can be described in highly aggregated terms and measured with high-level indicators, it consists of many overlapping and complementary technological capabilities that exist in certain regions, around certain industries or are shaped around certain markets or technology domains.

Yet technological capability is neither about the existence of a particular organisation or programme nor about the performance of a handful of enterprises. Rather, it is about a dynamic relationship between policies, programmes, organisations and incumbent as well as emerging enterprises. This capability must also be able to adapt, new organisations must be created, redundancy must be addressed and performance must be measured and managed.

Lastly, meso organisations cannot only respond to what is expressed as a need by the private sector or to insights gained from analysing statistical data. The meso level also needs to be assessed on how well it is preparing the society and enterprises for the future. In this regard, the ability of the educational institutions to lay a strong foundation and to enable individuals to further educate or diversify their qualifications is important, but the diversity, depth and responsiveness of the technological institutions are critical.

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A challenge that many developing countries face is that meso organisations have to work hard at creating capabilities that should already have existed five years ago, while trying to keep abreast of new international and domestic shifts that require new management capabilities, human resources, technologies and strategies. Not only the private sector can be overwhelmed or paralysed by competing technological choices, but public sector management can suffer the same symptoms. This means that in the framework provision should be made to differentiate between basic (or fundamental) offerings and future-oriented or more advanced offerings. This is not an additional kind of organisation, but it could be different functions provided by the same organisations.

While some organisations may be more important for improving the productivity and competitiveness of incumbent firms, others may be more relevant for lowering entry barriers to new start-ups and investors. Even if new start-ups lack market access or technological experience, in a dynamic environment their different knowledge and unique technological capability may put them at less of a disadvantage than the incumbents.

Some meso organisations may be hard to classify because they offer diverse services to different beneficiaries. For instance, universities often play an essential role in lowering the costs of gaining access to new knowledge, codified knowledge and research. At the same time, a university may offer industry access to scarce equipment on a pay-per-use basis, while a university laboratory may offer certification or analytical services to another research group. Or a research programme based at a university may be a sophisticated client of a private enterprise that specialises in advanced equipment, while the same enterprise may be dependent on post-graduate students from the university. Some of these relationships and interdependencies are impossible to map without deep insight into how knowledge, technological ideas and people flow between organisations in the public and private sectors. Yet it is possible for the same organisation to show up in different typologies, in different markets served, or in multiple roles.

Next year we will have to try and figure out how to map these organisations without making it overly complicated and difficult to use, maintain and adapt.

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