Opportunities and challenges for technology transfer intermediaries to move beyond firm level to innovation system level interventions

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Chapter 1 Introduction

The purpose of this publication is to explore ways in which Technology Stations can engage at two different levels in the innovation system. The first and most obvious intervention point is at the level of firms. Interventions aimed at firms should draw from the rich and diverse literature and experiences related to good management of technology and innovation, as well as technology transfer. Individuals with an engineering, technical or business management background can easily determine the technology needs of individual firms provided the right incentives. The second and more difficult to define level of intervention is aimed at the broader innovation system surrounding the firm. While some of the other public and private actors that should be supporting the firm are obvious, an innovation system is more dynamic than a group of institutions marketing their services better to a group of firms. Interventions aimed at improving innovation systems goes beyond this static public sector configuration and the emphasis is more on **the dynamics, process and transformation of knowledge and learning into desired outputs within an adaptive and complex economic system.**

Most research into innovation systems draws on evolutionary and complexity theories (Ramalingham, Jones, Reba & Young, 2008; Foster & Hölzl, 2004; Nelson & Winter, 2002), where economic growth and technological change are seen as endogenous to the system (Romer & Link, 2008; Nelson, 1995a; Nelson, 1995b).

In this short paper we will look at ways in which technology transfer intermediaries such as the Technology Stations can move beyond the firm level interventions into how they can support the broader and more dynamic innovation system. We will also look at the opportunities, challenges posed by this distinction, and will reflect on the changes that would be required in the programme to incentivise a broader role for these intermediaries.

Chapter 2 Background to and evolution of the TIA Technology Stations Programme

The concept of making the expertise and infrastructure of universities available to industry, business and society is referred to as the so-called “third academic mission” and has been practiced for decades all over the world. In particular, the engineering and management faculties have succeeded in engaging in substantial cooperative activities. The support for small enterprises represents a particular focus in this domain with a generally high political priority and respective financial support from all spheres of government.

In line with this thinking, the Department of Science and Technology (DST) developed the Technology Stations Programme with the objective of strengthening technological innovation activities and related skills upgrading to increase the relative competitiveness of existing technology-based SMEs in targeted sectors in the national, regional and global markets.

The aim and practical challenge for the DST and the Tshumisano Trust as the implementing agency which has been incorporated into the Technology and Innovation Agency beginning 2010 is to strengthen and expand the mutually beneficial link between universities of technology and SMEs by establishing and maintaining a sustainable system of competent providers of technology transfer

and related needs-oriented services at universities of technology. For further information on these centres please go to http://www.tia.org.za/Engineering or contact TIA on the same site

In this system, the technology stations will play a key role as intermediaries, addressing the product and process technology needs of SME manufacturers and service industry through the development and demonstration of production technologies as well as product development services as embodied in the specific competence and capacities of the universities. Targeted skills development interventions will be a substantial complementary component for transferring and disseminating technologies that are new to the client or market. Through this method, TSP-assisted SMEs will finally improve their productivity and growth, while enhancing their capacity to engage in ongoing product and process innovation. This concept is based on the German Steinbeiss system (see the Technology Stations Programme source book (Tessmar, 2005)).

In one of the earliest reference sources of the Tshumisano Programme, Tessmar (2005), describes the programme as providing a two-way learning process in which

- INDUSTRY: SMEs will improve their operations through technology assimilation and upgrade their innovation capabilities.
- ACADEMIA: Technical universities will adjust and expand their teaching and skills development activities by introducing more work-integrated phases and through close cooperation with SETAs and professional bodies. Technical universities will enrich their R&D activities by improving their real-world understanding of industry as well as their production-oriented equipment.

From these two statements the following two objectives were formulated:

1. Bring industry closer to the university

2. Focus the university on the needs of industry.

RALIS as a method was successful in achieving the two originally stated objectives, but problems were experienced in the implementation of several proposals due to other objectives. This will be discussed in Section 5 of this document.

Chapter 3 Important concepts that are often misunderstood by intermediaries

Before differentiating between the different levels of intervention into innovation system it is necessary to briefly revisit some of the phrases or concepts that are frequently confused. From the experience of the authors of working with Technology Stations and other technology intermediaries the following phrases are often confused:

- Innovation (often confused with invention)
- technology (often confused with hardware and equipment)
- innovation systems (often confused with systems internal to the firm or the technology intermediary)

Furthermore, many Technology Stations and other small business support agencies do not make a distinction between systemic or system-level interventions (at the level of the industry) and interventions aimed at improving micro or firm-level performance. The intention of this publication is to try and clarify this conceptual confusion.

A more detailed description of these different concepts is provided in some of our other recent reports (Cunningham & Wältring, 2010). A very brief summary is provided below for the convenience of the reader.

Innovation: According to Fagerberg *et al.* (2005:4-5), invention is the first occurrence of an idea for a new product or process, while innovation is the first attempt to carry it out in practice. Thus invention and innovation could be closely linked, although in most cases it is separated in time, place and organisation. To be able to turn an invention into an innovation, a firm typically needs to combine several different types of knowledge, capabilities, skills and resources. Furthermore, it is important to highlight that while product and process innovation is better known, competitive advantage often emanates from organisational, business model and network innovations.

Firms usually innovate because they believe there is a commercial benefit to the effort and costs involved, and this process typically starts by reviewing and re-combining existing knowledge (Schumpeter, 1964/1911).

While it may seem that innovation mainly happens inside firms, the innovative behaviour of firms is shaped in a systemic way by the external environment and resources in which they operate. This is the departing point for the RALIS approach (described under a different heading).

Innovation is the key ingredient of economic and social development (OECD, 1992). Innovations are the basis of productivity increases which lead to the generation of a surplus that can be invested, which in turn leads to further productivity increases and accordingly the strengthening of a sector's competitiveness. This is the reason why the question of how to stimulate innovation receives such great attention. Productivity sets a region's standard of living (wages, returns to capital, returns to natural resource endowments).

Technology: the narrow definition of technology refers to technical artefacts. However, complementary factors, without which the employment of technical artefacts makes no sense, are

above all *qualification, skills, and know-how* (of the people who work with artefacts) and *organisation* (i.e. the process of tying artefacts into social contexts and operational sequences).

In several of the technology stations (and other business supporting agencies), "technology" is mainly treated either as an object (process or product), or as hardware and perhaps as knowledge. In many cases, the organisational dimensions of technology are not addressed or mentioned, while knowledge mainly refers to codifiable knowledge. It is imperative that all four components mentioned in the broad definition is should be taken into account by these centres when dealing on firm level.

Technology Management: The management of technology and innovation plays a strategic role in a business, and involves the management of research and development, the linking of science, engineering and management disciplines to plan, develop and implement technological capabilities to shape and accomplish the strategic and operational objectives of an organisation. Although information and communication technology has become increasingly important in organisations, technology management goes far beyond this. Important questions that technology management seeks to address are:

- Who carries out technological exploration?
- How is it carried out?
- How will it affect the organisation and its environment?

The **management of technology and innovation concentrates on the internal value chain of the firm** and its competitive environment. It is important to recognise that the management of technology in firms and other organisations can also be improved by general management, engineering and scientific qualifications.

Organisations that manage their technology and innovation activities are critical to the improved performance of economic systems and increased wealth. Thus the ability of organisations to consciously manage their innovation and technology-related activities is important also in the context of innovation systems. In order to understand the drivers of performance of a specific innovation system, it is necessary to understand the major factors that influence the competitive and innovative behaviour of the organisations within the system, as well as the broader policy environment.

Innovation systems:

Some entrepreneurs may argue that they have an innovation system within their enterprise. However, it is necessary to make a distinction between an innovation system within an organisation and a broader innovation system. Freeman (1987:1) defined an innovation system as "*the network of institutions in the public and private sectors whose activities and interactions initiate, import and diffuse new technologies.*" Lundvall (1992:10) argued that the '*structure of production*' and the '*institutional set-up*' are the two most important dimensions that jointly define an innovation system.

The literature on **innovation systems concentrates more on the aggregate system and the interaction between different actors, while technology management concentrates on the strategic micro behaviour within organisations**. There is a relationship between these two topics, because

innovation systems depend on the ability of firms and other organisations to be innovative, and firms will only be incentivised to be competitive through the management of the technology if the larger innovation system supports innovative behaviour. Thus a two-way relationship exists between technology and innovation management and the broader innovation system around the firm. Figure 4.1 attempts to distinguish between the technology management approach and the innovation systems approach.

Chapter 4 Distinguishing between technology management and innovation systems

Often people find it difficult to distinguish between the concepts of innovation systems and the business management subject of (strategic) technology and innovation management (see Burgelman, Christensen & Wheelwright (2009)). What is the difference between these two approaches, and why is it important to differentiate between them if both are necessary?

Figure 4.1 below attempts to compare these two approaches.

Figure 4.1: Distinguishing between the technology management and the innovation systems approaches

The technology management and innovation approach

- Draws on business management literature (objective is to optimise the use of technology in its difference forms in order to reduce costs, manage resources or increase competitiveness)
- Takes a strategic perspective of the technology management of the firm
- The focus is on developing and managing technology, innovative capabilities, research and development, engineering and science within the firm
- Establishes relationships with carefully selected external knowledge providers (including equipment suppliers, scientific or technical knowledge sources, knowledge-intensive business service providers and customers)
- Focuses on reducing the costs of knowledge exchange with external knowledge providers
- The main emphasis is on the internal value chain of the firm and how it is affected by the external competitive and technological environment

Often these topics are confused because they have certain terms or ideas in common. It is important to understand the difference and relationship between these two approaches

The innovation systems approach

- Draws on subjects of evolutionary economics, complex adaptive systems and technological upgrading of industries – evolution is a central idea
- Focuses on systemic configurations at national, regional and sectoral levels
- Interventions are aimed at meta, macro, meso and to a limited extent micro level (macro and meso most dominant)
- Patterns of interaction, knowledge and information flows in the system between actors are important
- Sometimes there is too little focus on firm-level incentives or pressures to innovate (abstract and policy driven)
- The unique patterns of behaviour and interaction are emphasized

Source: Authors

Although Figure 4.1 emphasises the differences between the two approaches, they are often conflated or treated as one and the same approach by development practitioners and management consultants in the field. **It is necessary to assist firms to manage their technology better, but this alone is not sufficient to improve the performance of the broader innovation system and economy of the country**. For instance, helping firms to engage with open knowledge platforms (such as the knowledge or science commons) may increase their levels of knowledge and reduce the costs of acquiring external knowledge. However, improved usage of knowledge by one or a few firms does not translate into an improved innovation system automatically. It is only once this changed behaviour spills over to other competitors or affects the behaviour of other actors in the system that the broader system is affected. For this change to become visible other competitors have to receive signals that there is a new or different way of doing things, or that better results can be achieved through the use of specific knowledge. **It is therefore hard to predict which change in behaviour at the firm level may trigger a change of performance of the broader system**.

However, we believe that when attempting to stimulate the innovativeness and increased usage of technology in a specific sector, practitioners will have to give attention to both technology management (within firms and with the close collaborators) and existing innovation systems. It is important that these two separate but related fields of study are not confused (or conflated), as it may lead to unintended consequences or unsustainable interventions. By being aware of the difference in approaches, interventions to stimulate the improved performance of the system can be designed in a more systemic way. The systemic nature of innovation systems means that a small intervention at a particular point in the system may have large effects elsewhere in the system.

As eluded before the technology stations often only concentrate on the firm level interventions (sometimes not even looking at all 4 components of technology) however it should be noted that this is often due to the incentive structure that is in place for these transfer intermediaries by government departments and it's implementing agencies on what they have to report on. It requires deeper thought to put proper deliverables in place on innovation level.

Chapter 5 Current role of technology stations in innovation systems

Most of the technology stations have mastered interventions aimed at the firm level. While some follow a more of a technology-push approach to promote new technology and ideas to firms, other have mastered a demand-pull approach, where their efforts are aimed at responding to requests, demand or specific problems faced by firms. Some of the stations have even managed to balance a push and a pull approach. For instance, one of the five focus areas of MCTS is about Sand technology. While the demand for sand-testing is still limited (but growing rapidly) the station is promoting better sand technologies to foundries, along with testing and advisory services. While a part of the solution is off-the-shelf, the MCTS had to also innovate around other areas of the offering. These activities can best be described as helping foundries improve their economic performance through better technology and technology management. Thus it is a firm level intervention that is aimed at certain foundries in the metal casting sector.

At the same time MCTS cooperates with several other organisations supporting the foundry sector, such as the industry body SAIF (South African Institute of Foundrymen), Mintek and the NFTN (National Foundry Technology Network). Most of these interventions however are still aimed at

improving the use and management of technology in foundries. The main question is how can this technology station move from firm level interventions to a more innovation system approach?

Several initiatives along these lines have been implemented by technology stations in the past:

- emphasize the regional innovation system by concentrating on cluster effects, positive spill-overs between firms, and joint initiatives
- better articulate the inventions and innovations at leading firms to strengthen signals in the sector
- improve the knowledge flows between firms, industry associations and public sector support organisations
- respond to the skills and education needs of industry through improvements in the education system, career paths or curricula
- investing in new technology that is too expensive for industry to allow for shared use and learning

However, we believe that much more can be done in a more systematic way.

The table below shows how the different kinds of industry knowledge base could be used to determine the best approach to diffuse new technology.

Type of industry	**Main sectors**	**Main features**			
		Source of process technology	**Balance between process and product innovation**	**Relative size of innovating firms**	**Appropriability or diffusion of technology**
Supplier-dominated	Agriculture, housing, private services, traditional industries	Suppliers	Process	Small	Diffusion of new technologies and learning takes place by learning-by-doing
Scale-intensive	Bulk goods (steel, glass), assembly lines	In-house R&D, equipment suppliers	Process	Large	Appropriability is obtained through secrecy and patents
Specialised suppliers	Machinery, instruments	In-house R&D, customers	Product	Small	Appropriability comes mainly from the localised and interactive nature of knowledge
Science-based	Electronics, chemicals, software, engineering	In-house, suppliers	Mixed	Large	Science is a source of innovation, and appropriability means are of various types ranging from patents to

					lead times and learning curves

Source: Adapted from Pavitt (1984) and Malerba (2005)

In general Technology Stations have not concentrated much on the following topics:

- Developing cluster effects around them in industry (positive spillovers)
- Addressing market failure in a structured way for instance by increasing public goods, increasing positive externalities, addressing scale issues (some have done this without understanding the economics behind their plans)
- Assisting to develop new markets locally and internationally
- Focusing less on engineering and technical issues and focusing more on business and market development.

Of course, based on our own experience, there where instances where these issues were addressed, but then this often more about the personal experiences of the station manager than due to a systemic intervention. In many cases, Technology Stations are still preferring supply push approaches to industry, rather than a demand based approach.

Chapter 6 Conclusions

This paper explained the difference between interventions aimed at improving technology performance at a firm level and the interventions aimed at strengthening the innovation system. While these two different kinds of interventions require different skills, strategies and management systems it is possible for a single technology transfer intermediary to do both. However, this is only possible if the management systems and the performance management of the technology stations programme will recognise these efforts to strengthen the systems level and not only the firm level. It would also require a different approach to measuring the performance of technology stations, for instance by focusing on both firm level indicators and system-level interventions. It may also have consequences in how technology stations are staffed. While the firm level interventions require technical and engineering skills, the system level interventions often require more facilitation, communication and project management skills.

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