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Understanding interactive capabilities for skills development in sectoral systems of innovation

A tentative framework

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INTRODUCTION

Firms in South Africa are challenged to upgrade their technology and to innovate, so that they can become more productive and competitive in a global and national economy while creating more jobs for sustainable and inclusive growth. This means that the nature of the skills and thus education and training required is changing rapidly, challenging post-school education and training (PSET) organisations to be more flexible, adaptable and responsive.

Skills development is thus high on the South African policy agenda. The White Paper for Post-School Education and Training (2013) sets out 'a vision' for a more integrated and responsive PSET system – in order to contribute to improving alignment between dynamic skills demand and supply. A key strategic priority articulated is to create a centralised national institutional mechanism for skills planning. It is recognised that effective skills planning can be used to inform supply-side planning in PSET organisations, particularly the development of new qualifications and programmes, funding priorities, sectoral or regional plans and so on. The SETAs, colleges and universities will be expected to play a strategic role, engaging and consulting with stakeholders, to link education and work more effectively. However, a problem remains:

> *How do we ensure that in the South African context, post-school education and training organisations have the will, matching expertise and capabilities to meet industry demand?*

PSET organisations with distinct historical trajectories respond in diverse ways to government policy and market imperatives. Similarly, different types of firms – whether multinational corporations, large firms, or SMMEs, and whether in primary, secondary or tertiary sectors – respond in different ways to global and local shifts, new technologies and new knowledge. In short, firms or universities or colleges will not automatically adopt new skills policy interventions and regulations, or respond to attempts at steering. Hence, we need an understanding of the ways in which PSET organisations interact with firms and labour market organisations to shape their core activities, in order to identify appropriate change mechanisms and strategies. Such a nuanced understanding would complement forecasting models and research on and analysis of critical and scarce skills demand. There is no simple blueprint or tried and tested approach that is guaranteed to yield results in the South African context.

What we propose in this paper is a framework for analysing existing interaction and interactive capabilities in key sectoral systems of innovation (SSIs) in South Africa, as a basis on which to proceed. We have adopted a network and interactive capabilities approach to skills planning, a conceptual framework that has not yet been used systematically or widely in South Africa. To complement current efforts to develop frameworks for skills planning and datasets, we argue that a more nuanced understanding of skills demand and supply, uncovering dynamics and complexity, is needed. We highlight the need to research the interaction between PSET organisations and labour market organisations in SSIs, including firms, farmers and intermediary organisations such as SETAs, professional associations and industry bodies. Key questions addressed include: *How do we address skills gaps in South Africa to ensure that there is a match between what the education and training system produces, and the needs of the public and private sector? How can industry and education departments work together to produce relevant graduates?*

A FRAMEWORK FOR UNDERSTANDING INTERACTIVE CAPABILITIES FOR SKILLS DEVELOPMENT IN SECTORAL SYSTEMS OF INNOVATION

The project adopts an innovation systems approach to studying skills development in South Africa, an approach that has been used to study university-industry interaction and firm learning in relation to research and innovation, to determine what new insights the approach can provide:

> *Basically, the theory underlying innovation system analysis is about learning processes involving skillful but imperfect rational agents and organisations. It assumes that organisations and agents have a capability to enhance their competence through searching and learning and that they do so in interaction with other agents and that this is reflected in innovation processes and outcomes in the form of innovations and new competencies.* (Lundvall 2010: 331)

We propose a framework that emphasises dynamic interaction, interactive capabilities and network alignment, drawing on innovation systems approaches, specifically the work of Malerba (2005) and Von Tunzelmann (2010). The approach is dynamic and evolutionary, emphasising change over time, but also how historical trajectories and institutions shape what is possible. **Interactive capabilities** are defined as the capacity for learning and accumulation of new knowledge on the part of the organisation, and the integration of behavioural, social and economic factors into a specific set of outcomes (Von Tunzelmann & Wang, 2003; 2007 in Lammarino et al. 2009). A good example of interactive capabilities at a university of technology is a work-integrated learning office that has institutional status and sufficient resources to coordinate activities across departments and faculties, build long-term partnerships with firms and mentor and support students in a way that is functionally integrated into the organisation's teaching and learning activities and ensures that students are able to receive quality workplace learning to graduate.

Why focus on building networks and interactive capabilities?

The framework proposed was informed by our work from within an innovation systems approach, in relation to the role of universities in the national system of innovation and development. We have developed a body of work on the interaction between universities and firms in developing countries to promote innovation and economic development, and have extended this work to analyse university interaction with a range of external social partners, including government, communities and civil society organisations (Kruss et al. 2012). The focus of this work was on understanding the institutional policies, structures and mechanisms that promote or constrain distinct forms of interaction, with their associated benefits for firms in a sector, and for universities. The research focused primarily on the role of universities in relation to knowledge generation, research and innovation. However, innovation and skills development are inherently interlocked and interdependent, hence the role of universities in knowledge diffusion, in teaching, is closely intertwined. So, although it was not a primary focus, our innovation studies work has highlighted dynamics relevant to the production of skilled graduates for high-skilled professions and occupations.

We decided to explore the new kinds of questions we would be led to raise, and the new kinds of insights that would be possible, if we applied an innovation systems approach more systematically to focus directly on skills development, across the PSET systems.

For an innovation systems approach, at the heart of explanations of growth and development is a focus on the alignment between knowledge, skills and capabilities for learning in firms, and those in the PSET sub-systems – that is, on capabilities for knowledge, technology and innovation. It is a dynamic and evolutionary approach, tracing change over time but also how previous historical trajectories and conditions shape what is possible, summed up in the notion of 'path dependence'. It offers a systemic approach, mapping the main actors in key systems and sub-systems and the linkages among them, and focuses on researching their capabilities. It emphasises interaction, mapping flows of knowledge and resources between actors for learning and innovation. With a focus on learning, capabilities and interaction, it enables us to identify weaknesses that may lie within organisations, related to their capabilities, or externally within the system itself, including misalignment between networks, missing organisations and critical blockages.

The potential value of the innovation systems approach is evident: it would provide a dynamic analysis of firms and their skills needs in relation to dynamic processes of technological upgrading, and of the interactive capabilities of PSET systems, which would enable us to move beyond static conceptions of supply- and demand-side matching.

However, focusing the unit of analysis and operationalising concepts for the design of the methodology and instruments requires a number of steps.

First, innovation systems research typically places firms at the centre of analysis, and the literature is far stronger in terms of analysing firms. We have mined the literature for concepts that can be used to illuminate our work on universities, and drawn on concepts from the higher education literature, to facilitate more in-depth analysis of PSET systems within the national system of innovation.

Second, our existing work has to be extended to investigate post-school organisations other than universities, such as FET colleges, with their distinct knowledge focus, strategic purposes and forms of organisation.

Third, and most significant, while most of the innovation systems research in South Africa has focused on the PSET system's capabilities in relation to research and innovation, for this project, the focus is in relation to labour market needs and skills development. There is growing precedent for this in the international literature. Lall's work stresses the significance of skills development across all levels of the workforce, which highlights the significance of PSET organisations at all skills levels. More recently, Lundvall and Lorenz (2012: 13) has emphasised the significance of vocational education and training for firm learning in developing economies, proposing that rather than the typical sole focus on academic qualifications, attention should be also paid to 'developing practical skills and experience based learning […] to the training of skilled workers, technicians and engineers'. In this regard, the starting point is to determine the skills and capabilities that are important for firms, and to consider how firms build those capabilities to enhance productivity and facilitate technological upgrading, and hence, economic growth.

Fourth, for the present research study, the concepts need to focus on and theorise interactive capabilities of PSET systems more sharply. Our focus is on the alignment and misalignment within the South African national system of innovation in relation to skills development. We thus propose that from within the vast innovation systems literature, the most appropriate conceptual distinctions for our purposes can be drawn from Von Tunzelmann's work (2010; Von Tunzelmann & Wang 2007). Von Tunzelmann has developed a framework that emphasises interaction, competencies, interactive capabilities and network alignment.

In the rest of this document, we define a set of working definitions of key concepts, and will elaborate on and refine them as we proceed, in light of the empirical trends.[1]

1 It will be essential for all researchers to read a set of articles to be able to work with the concepts that we summarise here.

A network and interactive capabilities framework

Considering that sectors differ significantly in terms of knowledge bases, skills needs and institutional conditions, we focus on **Sectoral Systems of Innovation** (SSIs). Rather than simply emphasising a sector as an industrial concentration, here, a sector is defined as 'a set of activities which are unified by some related product groups for a given or emerging demand and which share some basic knowledge' (Malerba 2005: 65).

Figure 1 provides a **generic** representation of the actors and potential flows and interactive learning in an SSI in the South African context. It illustrates how the system could be mapped, as a basis for studying skills development networks, and the interactive capabilities of the main actors. We integrate Malerba's (2005) SSI framework and Von Tunzelmann's (2010) interactive capability and network alignment framework, and identify four main building blocks for analysing the interactive capabilities of PSET organisations, and the extent of alignment in skills demand and supply:

- Common knowledge bases and similar technologies;
- Actors and networks;
- Institutions; and
- Interactive capabilities.

The fourth building block is an addition to Malerba's (2005) SSI framework. 'Interactive capabilities' for dealing with routine activities directs empirical attention to the network alignment between the components of the system (Von Tunzelmann 2010; Von Tunzelmann & Wang 2007). For our purposes, the focus on interactive capabilities brings a critical focus on the (organisational) competencies of actors in the system and the institutional environment.

What is highlighted is the need to map the existing structure, agents, mechanisms/strategies and dynamics of skills development in specific sectors. The unit of analysis is the interaction between the main actors in the PSET organisations, firms and labour market intermediaries within an SSI, from which challenges and bottlenecks to inform policy interventions can be identified.

The approach requires data describing the key actors (firms, universities, colleges, government agencies) and the relationships between these actors, with a focus on the generation and movement of skills (Lorentzen et al. 2011).

Figure 1 provides a framework for mapping the SSI, as a basis for studying networks and interactions, and the interactive capabilities of the main actors.

The four building blocks

Knowledge bases and technologies

A sectoral system of innovation (SSI) approach emphasises the role of knowledge and learning in the process of innovation. It is assumed that firms in a sector search similar knowledge bases to inform their productive activities, face similar technologies (and challenges related to national and global technological development), undertake similar productive activities and are influenced by the same institutional environments (Malerba 2005). They would thus show similar patterns of learning and organisation. Firms in a sector are, however, likely to be heterogeneous, to some extent, in terms of their previous learning experiences, competencies, organisational routines and culture, and opportunity conditions.

The knowledge base of the firm and accessibility of appropriate technologies may act as constraints to innovation and learning. Similarly, the knowledge base in the sector around which firms search may pose constraints to or opportunities for technological upgrading and innovation. Interaction and dynamic interdependencies in the SSI can be a source of learning, organisational change and innovation, hence the emphasis on networks.

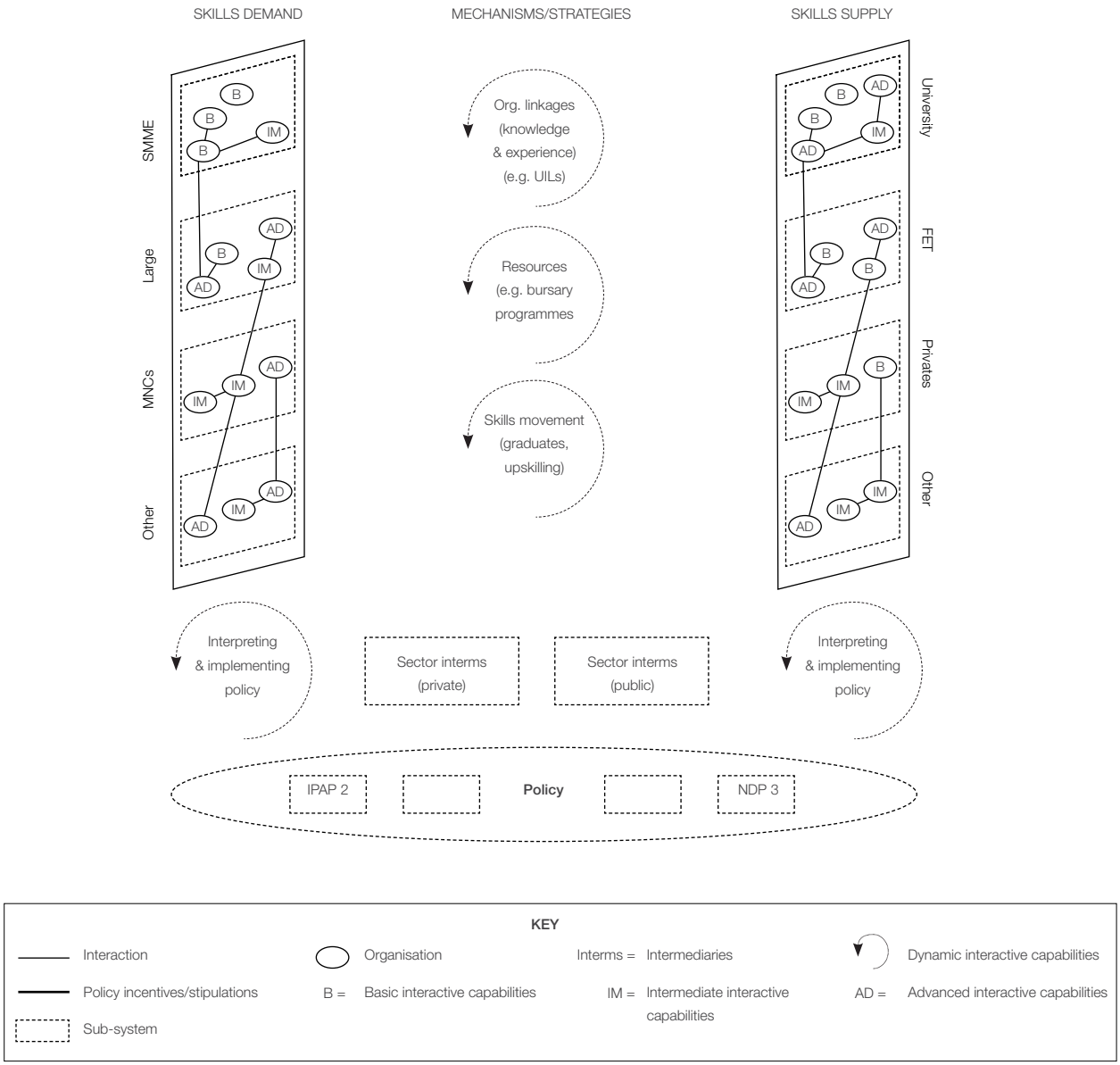
Actors and networks

Innovation is an interactive or 'networked' activity shaped by the institutions in which the actors are embedded. The networks of actors include interaction between *firm* (e.g. producers, input suppliers) and *non-firm* organisations (e.g. universities, government agencies) – also including sub-units (e.g. R&D department) or groups of organisations (e.g. industry associations) – and *individuals* (e.g. scientists,

entrepreneurs) connected through *market and non-market relations*. Hence, the analysis of a SSI investigates the wide variety of actors involved in the generation and exchange of knowledge that is relevant to innovation and its commercialisation (Malerba 2005). The structure and nature of interaction and networks differ from sectoral system to sectoral system. Rather than placing the types of actors, usually the firm, at the centre of the analysis, the SSI 'places dynamics, process and transformation at the centre' (Malerba 2005: 64). Sectoral boundaries are thus not a given and are not static but dynamic.

We will use structural network analysis (SNA) for mapping the actors and interaction within the SSI in relation to skills development and as a way of analysing the structure of the networks. With the use of SNA we would be able to identify distinct forms of organisation, (actual) network intermediaries, and missing organisations and linkages. SNA is, however, limited in that it provides static 'pictures' of networks. We will thus require additional data to illuminate the dynamics and benefits/disadvantages of the interactions and skills development strategies of organisations in the SSI.

Figure 1: Capability building processes at the sectoral level



Institutions

The institutional environment plays a key role in shaping the structure and nature of interaction among actors and networks of actors in the SSI. Institutions broadly refer to rules or guides for behaviour. Different types and levels of 'guides for behaviour' are recognised in the SSI approach: formal (e.g. institutional policy, national policy) and informal (e.g. organisational culture); binding (specific regulations) and created by interaction (e.g. contracts); and national (e.g. patent system) and sectoral (e.g. sectoral labour markets). Here, we also identify institutional 'sub-systems' (e.g. university sector, FET college sector), each with their own 'guides for behaviour'.

Hence, the main assumption of the SSI approach is that innovation and learning – with skills development lying at the heart of these processes – takes place in networks shaped by their institutional environments with actors transforming and being transformed by institutions.

Competencies, interactive capabilities and dynamic interactive capabilities

What is most useful about Von Tunzelmann's approach for our purposes is that it highlights the importance of specific sets of capabilities required for effective strategic interaction, and provides concepts to differentiate and distinguish between these.

Competencies stem from inputs to produce goods and services, that is – the preset attributes of individuals and firms, typically produced by organisations such as PSET organisations (Von Tunzelmann & Wang 2003).

In our framework, competencies take two forms:

- Tacit knowledge embodied in the human resources of the organisation and organisational routines; and
- Codified knowledge present in organisational structures, technologies, formal policies or other physical resources.

An actor's organisational processes or routines are shaped by its competencies, and both its competencies and routines as well the strategic alternatives available to it are path-dependent (Teece et al. 1997). Competencies also include cognitive aspects, such as beliefs and attitudes, which influence learning. For instance, the recruitment of university graduates or artisans may be a necessary internal competence for firms that want to adopt new technologies (Audrtech & Vivarealli 1994 in Lammarino et al. 2009). However, merely employing graduates or qualified artisans does not guarantee learning or the successful adoption of new technologies.

This requires **interactive capabilities** – defined here as the capacity for learning and accumulation of new knowledge on the part of the organisation, and the integration of behavioural, social and economic factors into a specific set of outcomes (Von Tunzelmann & Wang 2003; 2007 in Lammarino et al. 2009). Interactive capabilities are the result of adaptive learning processes that in their collective dimension can be highly localised, giving rise to system capabilities. This means that within a specific region or locale, a concentration of highly qualified human resources is not a capability per se, but a resource (competencies possessed) that, through learning, may become technological capabilities for firms or academic capabilities for PSET organisations or the system as a whole. All variables related to human resources or cooperative linkages with external actors are to be considered as determinants of an organisation's capabilities.

In the context of dynamic change – in terms of dynamic competition and institutional change – actors in an SSI require an additional set of capabilities, that is, the capability to respond to *non-routine* changes in circumstance effectively and efficiently. Changes in circumstance also often result in changes in the organisations' capabilities. In the literature, this set of capabilities is often referred to as 'dynamic capabilities' in emphasising the key role of strategic management in appropriately adapting, integrating and reconfiguring internal and external organisational skills, resources, and functional competencies to match the requirements of a changing environment (Teece et al. 1997: 515).

Drawing on Von Tunzelmann (2010; Von Tunzelmann & Wang 2007), we refer to such capabilities as **dynamic interactive capabilities** in order to distinguish the interactive capabilities necessary for routine activities and interactive capabilities requiring greater flexibility in responding to non-routine changes in circumstance.

The four dynamic capabilities identified by Pavlou and El Sawy (2011) are useful for the purposes of our research: sensing, learning, integrating and coordinating (see Figures 2 and 3).

As depicted in Figure 1, the ability of an organisation – a firm or PSET organisation – to respond to changes in the business and institutional environments effectively and efficiently depends on the appropriate use of the organisation's competencies through its organisational processes or routines. Management thus needs to identify (or sense) changes in the environment that present opportunities, threats or constraints to the organisation, and identify the organisation's competencies and capabilities to respond, through its organisational routines. An appropriate response requires the exploitation of the organisation's competencies and capabilities, and often involves the acquisition of new knowledge and competencies that transform and are transformed by the firm or PSET organisation (through learning). The new knowledge and competencies then need to be integrated into existing organisational structures and processes. Most importantly, the success of this process hinges on the effective coordination capability of management and leadership.

This is where Malerba and Von Tunzelmann's frameworks fall short. Neither provides the analytical tools needed for analysing the role of the skills of key individuals for searching for relevant knowledge and coordinating learning. The concept of '**social skill**' identified by Fligstein (2001; Fligstein & McAdam 2012) is apt for this purpose. The strategic management literature commonly refers to the crucial role of managerial or leadership skills without clear definitions. Essentially, social skill refers to 'the ability to induce cooperation' among actors in an organisation or any other field (Fligstein & McAdam 2012: 46). With the notion of social skill, we understand that those in managerial and leadership positions (e.g. unit managers, principal investigators of projects) have to possess effective skills for sensing changes in the external environment and be aware of the organisation's competencies. They should be able to sense which external changes are relevant and appropriate for the organisation to take on board, and devise effective strategies for coordinating and integrating new knowledge into the organisation. These strategies may include the identification of appropriate actors with which to collaborate in order to best address those changes and improve the performance of the organisation. This process of coordination and integration involves identifying matches and mismatches in competencies and capabilities, and finding effective ways of getting individuals and groups of individuals within the organisation on board for changes. Skilled strategic actors possess a repertoire of social skill (e.g. agenda-setting, presenting themselves as a neutral actor) which they use as appropriate.

In our framework, the importance of feedback between actors in interaction, and the co-evolution between actors and the wider institutional contexts in which they are embedded, are highlighted. Also highlighted is the relative compatibility of the capabilities of actors in the sub-system (e.g. firms or industry) or related sub-systems (e.g. university sector) representing the 'pool' or 'networks' from which actors can source essential knowledge and other resources – hence, the critical role of alignment in capabilities and goals between networks of actors in the sub-systems that make up an innovation system. It is important to note that units within organisations can differ in terms of their interactive capabilities.

Our research focus is on **the networks and alignment between the actors in PSET sub-systems, and firms in distinct sectors**. In the next section, we elaborate on each of the main actors and networks of the SSI essential for skills development: firms/farmers, PSET organisations and sectoral intermediaries (public and private).

Actors and networks critical for skills development

Firms/farmers

Skills demand in an SSI is not simply 'an aggregate set of similar buyers'. Rather, demand in the system consists of a heterogeneous group of firms – or farmers, as economic agents may take diverse forms, particularly in developing countries – each 'characterised by knowledge, learning processes, competencies and goals, and affected by social factors and institutions' (Malerba 2005: 67).

Determining skills demand requires an understanding of employability, which depends on an understanding of firm learning and technological upgrading (Gamble 2003). An important elaboration on technological upgrading or technological capability-building in 'developing countries' is found in the work of Lall on firm learning and technological capabilities. **Technological capabilities** can be defined as the **specialised resources** – skills, knowledge and experience, as well the institutional structures and linkages – that are needed to generate and manage technological change in a firm or sector (Bell & Pavitt 1995: 78; Costa et al. 2001). We refer to these 'specialised resources' as competencies and interactive capabilities.

Initially, developing countries obtain industrial technologies mainly from more advanced countries, although increasingly, they develop their own capacities. Therefore, the process of building capabilities starts with importing and using technology developed elsewhere (Sato & Fujita 2009). The main technological challenge is to master, adapt and improve on the imported knowledge and equipment in relation to local contexts. Lall (1992: 166) points out that gaining mastery of new technology requires skills and efforts by the receiving firm, and the extent of mastery achieved is uncertain. Once technology has been identified, its efficient use requires firms to undergo another costly, risky and lengthy process of developing new skills and new knowledge to master its tacit elements (Lall 2001). This learning process is characterised by externalities and coordination problems, which might limit the process. Even though firms in a country may not innovate in the sense of creating new products at the technology frontier, they do need to invest in technological effort, requiring processes of firm learning and technological development (Fransman & King 1984; Lall 1992; Bell & Pavit 1995). Technological capability-building calls for purposive and incremental efforts to collect new information, try things out, create new skills and operational routines and strike new relationships (Lall 2002: 262). In South Africa, we have lead firms that do innovate at the technology frontier, but most innovative firms are mastering machinery and technologies acquired elsewhere.

The learning process is path-dependent and cumulative – firms tend to move along particular trajectories in which past learning contributes to particular directions of technical change and in which experience derived from the past reinforces existing stocks of knowledge and expertise (Bell & Pavitt 1993: 168). The stock of the past capabilities and routines provides a base on which firms develop the capabilities to cope with new technology change. Thus firms are distinguished according to the levels of technological capabilities – that is, basic, intermediate and advanced – they possess in key areas. Possessing different stocks of accumulated knowledge and expertise, structures and linkages, firms at different technological capability levels face different challenges and constraints. Some technologies are more difficult and costlier to master than others because the learning process is longer and more uncertain and involves more advanced skills, greater technological efforts, and more externalities and coordination problems.

The literature points to different kinds of strategic mechanisms for learning and accumulating technological capabilities, such as staff training, staff hiring, systems of performance feedback, interaction with external agents, agglomeration, networking and research and development activities (Costa et al. 2001). The skills base, the stock of people produced by the national PSET system with the right kinds of qualifications, is recognised as a critical factor in firm learning and technological capability-building.

Hence, our research on firms is focused on understanding how they acquire the qualified human resources required at all occupational levels, through interaction with national PSET sub-systems.

A significant contribution made by Lall for our purposes is the emphasis on the development of technological capabilities at all levels of the firm. Technological upgrading does not involve only R&D or high-level skills, but depends also on informal activities and learning at all levels of a firm (Lall 1992 in Lall 2001):

> *Capability building involves efforts at all levels – shop floor, process, and product engineering, quality management, maintenance, procurement, inventory control, outbound logistics, and relations with other firms and institutions.*

The prevailing policy wisdom is that in the context of a globalising knowledge economy, growth and development requires a country to develop a greater stock of high-level skills. Lall's contribution points to the need for capability building and skills development at all levels – basic, intermediate and high-level skills. A similar argument has been made in the South African context, in terms of a challenge to the 'high skills thesis', and the need for a multi-level skills strategy (Kraak et al. 2006). Recent institutional mechanisms promoting technological development in national priority sectors reflect a shift to such a multi-level skills strategy (e.g. IPAP2). Emphasis is now on high-skills and high-technology sectors as well as artisans and basic and intermediate skills for rural development and broader employment opportunities.

In sum, Lall's approach to technology capability building provides key insights for our research, by pointing to the importance of specific embodied resources (i.e. tacit knowledge embodied in human resources and organisational routines) and disembodied resources (i.e. codified knowledge – appropriate structures, technology and other assets) for routine operational activities and developing competitive advantage. These resources can be acquired and developed:

- internally through workplace learning, formal training, feedback and R&D; and
- through linkages with external actors with the use of various strategies and mechanisms (e.g. knowledge transfer, training, hiring and financial investment).

These (generic) resources and capability-building processes are illustrated in Figure 2. We make one significant addition – a set of dynamic interactive capabilities. Although Lall highlights the effect of conditions and circumstances related to the business environment, he does not distinguish between sets of capabilities required for effective and efficient response to routine and non-routine changes in the environment.

Education and training organisations

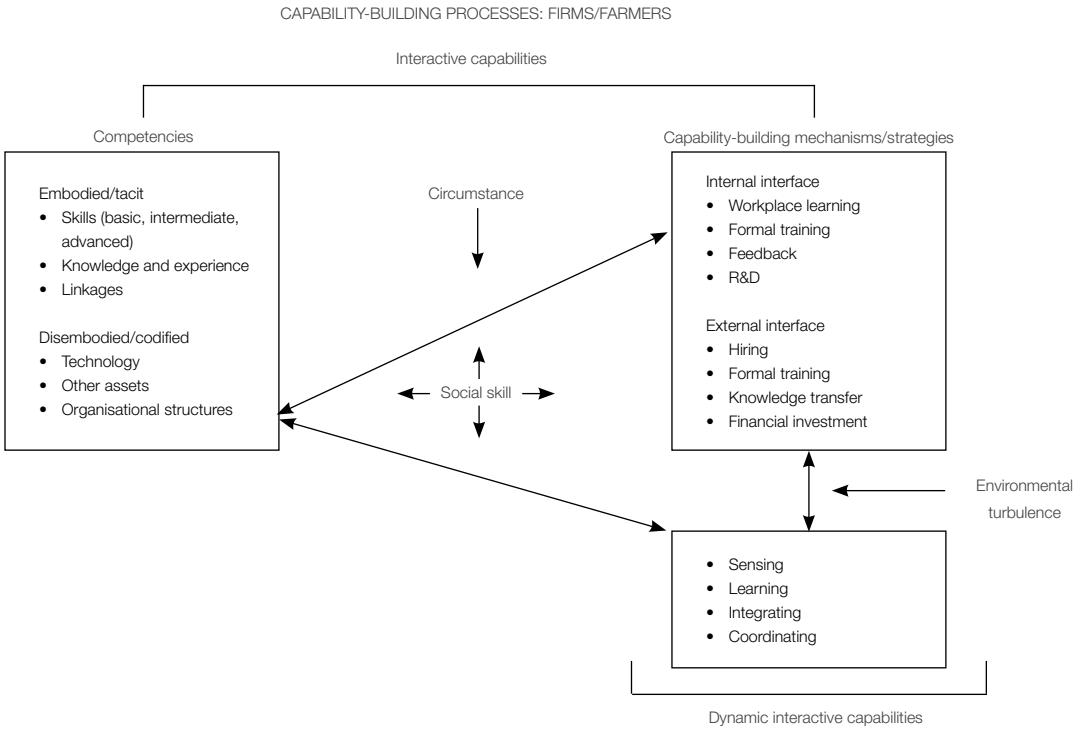
Similar to demand, 'supply' in a sectoral system of innovation (SSI) is not provided by a homogeneous group of PSET organisations.

We have argued that PSET organisations' activities are crucial to firms' technological capability-building, which is necessary for innovation and economic development at a sectoral and national level. In order for PSET organisations to contribute to technological capability-building within a sector, they have to produce skilled people that are employable and research that is useful to firms. Since our main interest is on skills development, we focus on the former.

The concept of technological capabilities may be extended from firms to PSET organisations. Similar to firms, PSET organisations require 'specialised resources' for producing employable graduates and diplomates, and effectively managing change within the organisation, and in the educational environment and wider institutional context.

An analysis of how PSET organisations learn and the strategies they use to meet skills demand in sectoral systems of innovation is generally lacking in the literature. Liefner and Schiller (2008) introduced the term 'academic capabilities' in relation to universities, based on Lall's framework of technological capabilities, an approach that we can draw on and extend to other PSET organisations. As with firms, the competencies of PSET organisations can be distinguished between internal embodied and disembodied resources, which PSET organisations need to exploit in meeting the needs of industry and society more broadly. They do so through the use of internal and external mechanisms and strategies (i.e. internal and external interface structures). The strategies they use depend on their

Figure 2: Capability-building processes at the organisational level – a generic framework for firms/farmers



stock of knowledge and other resources (or internal competencies) and the current routines or organisational processes they have in place – that is, their interactive capabilities. The strategies they use also depend on the opportunities available to them (environmental conditions and circumstance).

PSET organisations thus can also be distinguished by their level of capability, according to their competencies and interactive capabilities.

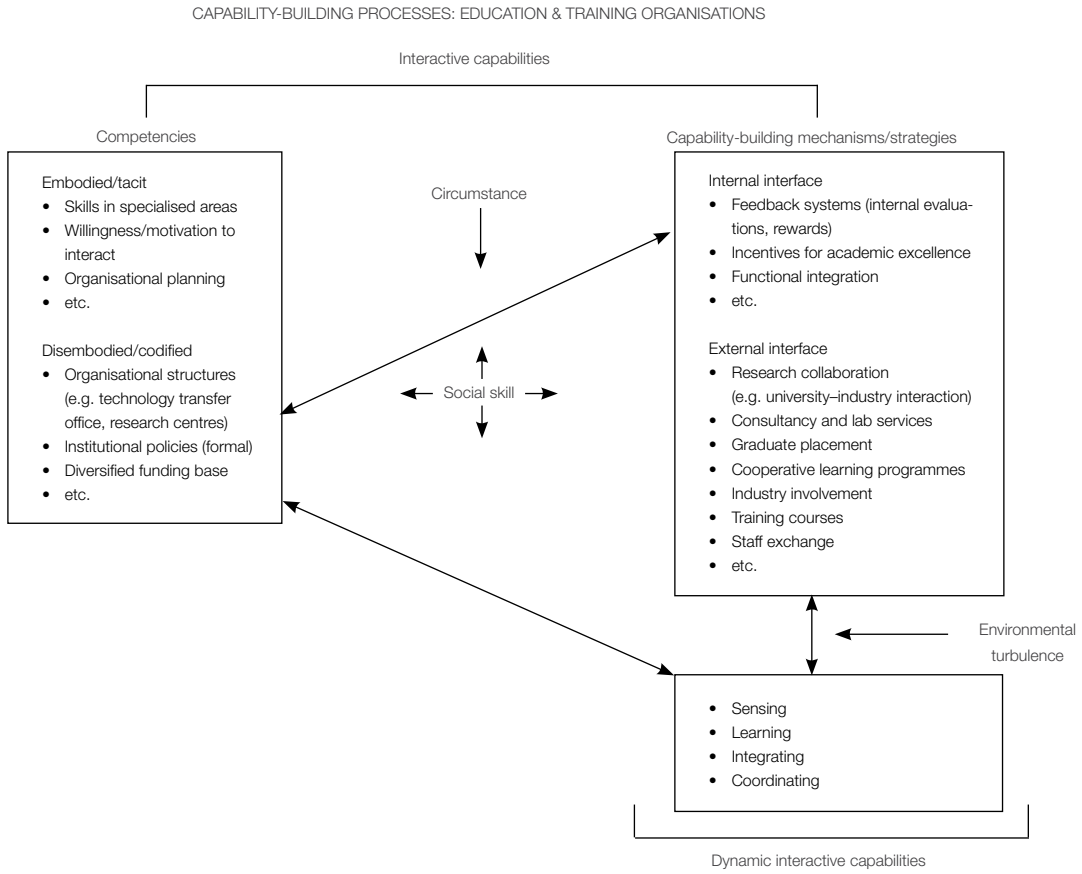
Liefner and Schiller classify universities according to three levels of capability – basic, intermediate and advanced capabilities – in relation to four functional competencies (teaching, research, outreach and functional integration) and three organisational competencies (budgeting, management and institutional building). The different levels of academic capability in relation to the competency areas that result are outlined in Table 1 for illustration.

These distinctions are useful for our purposes for differentiating between universities according to level of capability, at the same time allowing for the assessment of the capability of the university sector as a whole for meeting the skills needs in an SSI. We aim to develop such distinctions for other PSET organisations in relation to skills development in specific sectoral systems of innovation, based on the findings of the research.

However, based on our conceptual assumptions, not all academic capabilities can be measured or analysed directly. An analysis of the competence base and how PSET organisations translate their competencies into these ‘academic’ capabilities through their interactive and dynamic interactive capabilities is required.

The ‘functional integration’ capability is an important concept for our research on the dynamic interactive capabilities of PSET organisations, as it emphasises the need for networking and learning between departments and units, and integration of knowledge across functions (e.g. integrating knowledge obtained via R&D university–industry linkages into teaching). We can use the concept of functional integration as ‘an indicator’ for analysing dynamic interactive capabilities. Functional integration is, however, only one internal interface strategy that PSET organisations use as part of their organisational learning or capability-building

Figure 3: Capability-building processes at the organisational level – a generic framework for PSET organisations



processes. Other possible strategies and mechanisms that PSET organisations may use as part of their learning and capability-building processes are illustrated in Figure 3.

PSET organisations may develop new or sharpen existing competencies and/or develop better ways of carrying out their routine activities through interaction with other organisations (e.g. firms, other PSET organisations) and in managing change in the education environment. For example, through research collaboration with firms, universities may develop the skills of their post graduates but staff may also learn new and current techniques to teach their students. They would, however, need to be open to learning these new techniques and integrating them into the curriculum, which also needs to be supported and promoted by the institutional culture and formal policy of the university. An analysis of the competencies of the organisation is thus important.

Hence, our research will focus on the **capabilities and circumstances that may enhance or constrain a PSET organisation's ability to interact with firms in a sector.**

We will need to take into account the specific features of diverse types of PSET organisations. Vocational education and training (VET) organisations that operate primarily at the intermediate and basic skills levels play a very different role in the national system of innovation: knowledge diffusion, as opposed to universities' roles in knowledge generation and diffusion[2] (Toner 2005; 2011; Toner et al. 2004). VET organisations have a more explicitly economic role, and a more direct link to meet the training needs of local firms. Their roles relate to diffusing practical and technical skills, and

2 Toner (2005; 2011) has produced a useful body of work focusing on the role of organisations at the intermediate skills levels (Toner et al. 2004).

Table 1: Framework assessing academic capabilities according to level of capability and competence area

Teaching	Research	Outreach	Functional integration	Organisational		
				Budgeting	Management	Institution-building
Low						
Limited mix of programmes (e.g. undergraduate education only), outdated curricular teaching from textbooks mainly, lack of quality and quantity of courses	Adaptive assimilation of existing research results, internal grants, lack of equipment, no specific reputation	Occasional ad hoc linkages, consulting and laboratory services, direct hiring of professors, personal contacts	Fragmentation of academic tasks, no cross-fertilisation between different activities	Line-itemised public budgets, incremental changes, no own income besides tuition	Bureaucratic, dominated by government policy, teaching focus, no specialised units besides traditional faculties	Inefficient or non-existent evaluations, industrial outreach activities are not allowed
Intermediate						
Some mix of programmes, up-to-date curricular research-oriented teaching, lack of quality	Appropriate application of excellent international research, competitive research grants, national reputation	Regular linkages, contract research, training courses, graduate placement programmes, official contacts on behalf of university	Occasional synergies between academic tasks, exploitation of academic capabilities through outreach activities	Public block grants, performance-based funding, some own income sources	Partial academic autonomy, limited leadership of university administration, traditional academic focus, specialised research centres	Internal and external evaluations, incentives only for academic excellence, regulations for outreach activities still insufficient
Advanced						
Mix of programmes (e.g. undergraduate, diploma, PhD), research-oriented teaching, demand-oriented curricula (from industry, community, etc.)	Reputation for innovative research, competitive research grants	Strategic linkages, alliances, collaboration, responsiveness to labour market and societal needs	Cross-fertilsation, synergetic augmentation of academic tasks, teaching and research oriented towards labour market and societal needs	Diversified funding, performance and competitive funding	Admin autonomy, strong leadership, 'enterprising'	Performance appraisal, clear regulations and promotion of outreach

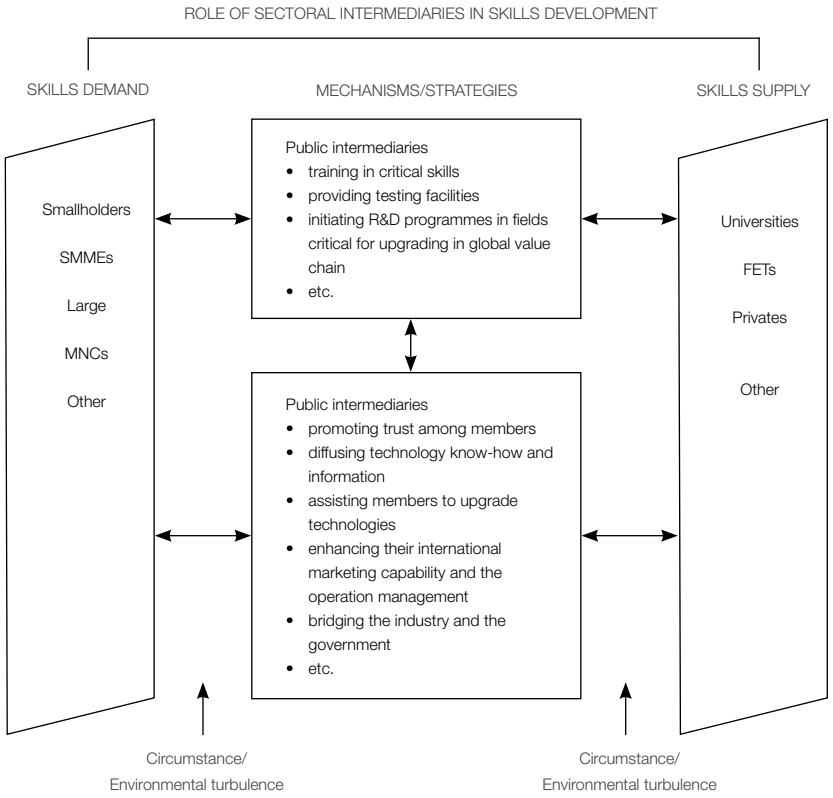
knowledge of production processes, to 'design, install, commission, adapt, operate and maintain new and existing technologies' (Toner n.d.: 10). Such analysis can inform the elaboration of a table akin to Table 1 in relation to VET organisations.

The framework highlights the need to explore how tacit and codified competencies, and internal and external interface mechanisms, are manifest in FET colleges (public and private) and SETA skills development programmes such as learnerships – *what are the main forms of their competencies, interactive capabilities and dynamic interactive capabilities?*

Sectoral intermediary actors

In 'developing countries' where SSIs may be fragmented and weak, characterised by system failures, a key role is played by a set of 'intermediary actors'. They may facilitate alignment between firms and other actors or address systemic problems or create conditions that promote networks and coordination to address failures in the SSI, for example. They play a role bridging user needs and the supply side, particularly in relation to knowledge flows through skills, human resources and R&D (Intarakumnerd & Chaoroenporn 2013). Sectoral intermediary organisations may also be identified as part of the skills demand networks in an SSI. For example, an industry association may provide highly specialised training for graduates in order to meet specific skills needs of firms in the sector. They may also play a crucial role in coordinating skills development in a sector and in providing training in sector-specific skills in order to fill skills gaps. Hence, sectoral intermediary organisations are suitably placed to provide insight into knowledge and technological change in the sector and related skills needs, as well as challenges/constraints/threats/facilitators to skills development and any bottlenecks, in order to provide recommendations for more targeted institutional mechanisms.

Figure 4: Role of sectoral intermediary organisations – a generic framework



We distinguish between the roles of public and private sectoral intermediaries as they differ in terms of their main functions (see Intarakumnerd & Chaoroenporn 2013). Figure 4 illustrates the key dimensions we aim to investigate in relation to sectoral intermediaries, with possible features of each for illustrative purposes.

Public sectoral intermediary organisations include organisations that support technological upgrading of firms in a sector, by providing 'public goods' such as training or R&D that are costly for a single firm, and by connecting key actors. Public sectoral intermediary organisations may include:

- Government-funded sectoral authorities (e.g. National Agricultural Marketing Council);
- Government-funded sectoral programmes/ master plan (e.g. Automotive Industry Development Programme); and
- SETAs may play a key intermediary role in a sector (in addition to anchoring vocational education and training sub-systems).

Private sectoral intermediary organisations support and inform these activities, and include:

- Industrial and trade associations;
- Professional associations;
- Research and technology organisations; and
- Private foundations.

Private and public sectoral intermediaries can be very effective in linking firms and post-school organisations, or providing missing skills training for the sector. The coordination and alignment between public and private sector intermediaries is equally critical to their effective functioning in an SSI. For example, if a public intermediary does not have sufficient funds for its skills programmes, or if roles are not clearly defined, there may be competition with private intermediary actors, weakening the SSI. The network and interactive capabilities framework proposed here highlights the need to explore the role of sectoral intermediaries in building alignment within an SSI.

CONCLUSION

This paper shows how a network and interactive capabilities approach can provide the analytical tools for a more systemic and nuanced understanding of skills demand and supply, one that uncovers complexity and dynamics. The approach allows for an analysis of existing capabilities, dynamic interactions and networks of the organisations contributing to skills development in a sectoral system of innovation. The central concern is how to identify incentives, mechanisms and interventions that will encourage PSET organisations and industry to work together more effectively, to mutual benefit and to address national skills priorities. For instance, an FET college may have well-qualified engineering lecturers, but there is no way to communicate with local firms, or no support to change curriculum in response to changing technology in firms in a key sector in its immediate location. The intervention required relates to finding dynamic internal and external interface mechanisms. However, another college may lack the qualified lecturers, which means that we need different interventions in this instance, to improve lecturers' qualifications and pedagogic expertise.

The framework allows us to identify a number of potential spaces for intervention to promote such learning and change, each of which will require specific mechanisms and strategies. These strategies may include the identification of appropriate actors with which to collaborate in order to best address changes and improve performance.

We could intervene to enhance firms' interactive capabilities. This could take the form of industry audits of scarce and critical needs, for instance. Of greater value are interventions to promote productivity and technological upgrading in the sector. Sectoral bodies could coordinate needs across firms and play a bridging role to communicate demand.

On the PSET side, a different set of interventions is required to enhance interactive capabilities. PSET organisations play multiple roles alongside producing graduates for the labour market, and may resist attempts to narrow their roles in terms of economic responsiveness. Any interventions need to recognise the nature of PSET and that skills development is but one role. Another challenge is to strengthen institutional structures and organisational integration. For example, universities of technology have the mechanism of industry advisory boards. The challenge is how to introduce similar mechanisms in universities or FET colleges, but equally, to ensure that these mechanisms are inserted into the core educational business of the organisation, to work effectively.

As indicated in Figure 1, firms and PSET organisations may use a range of mechanisms and strategies to link supply and demand. For example, there may be flows of resources, whereby firms provide scholarships and bursary programmes to meet their future skills requirements. Varying degrees of direct involvement are possible, which could include knowledge flows as well. For instance, the firm provides a list of topics for thesis research, or the firm hosts artisans for workplace training.

Sectoral intermediaries play a key role in unblocking bottlenecks, addressing gaps and facilitating interaction. For instance, an industry association may have organised private training based in key firms, given the different priorities of PSET organisations or the low levels of quality of PSET programmes offered in the public sector. The bridging and networking role of public and private

intermediaries provides multiple opportunities to promote better alignment and linkages.

The framework thus highlights the dynamic nature of skills demand and supply, and the critical role of alignment in capabilities and goals between networks of actors in a sectoral sub-system. Such an approach to linking industry and PSET organisations, we propose, can add more value over the longer term.

Analytical comparison and synthesis across and between SSIs will provide rich insights to draw out implications for skills planning. For firms and PSET organisations involved in a sector, such an evidence base can enhance understanding of effective interactions, alignment, organisational strategies, and blockages and gaps, in order to identify specific ways in which to enhance institutional capabilities. The ability of a firm or PSET organisation to respond effectively to changes in the business and institutional environments that impact skills development depends on the identification of changes that present opportunities, threats or constraints, and the firm or PSET organisation's internal capabilities to respond. An appropriate response often involves the acquisition of new knowledge and capabilities that transform and are transformed by the firm or PSET organisation through learning.

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