SMART INDUSTRIES

THE IMPORTANCE OF TECHNOLOGY AND R&D FOR INDUSTRY PERFORMANCE

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1. Introduction

RECENT NATIONAL AND PROVINCIAL GOVERNMENT policies have focused on the need to promote high-technology and 'knowledge-intensive' industries. The National Research and Development Strategy (NRDS), the Advanced Manufacturing Technology Strategy (AMTS) and the Integrated Manufacturing Strategy (IMS) all highlight areas such as biotechnology and information and communication technology (ICT) as crucial for future industrial development. Gauteng's Growth and Development Strategy targets the creation and fostering of 'smart' industries as part of the Province moving beyond the 'old' industries which have performed relatively poorly.

Understanding what is meant by smart industries, as well as the underlying reasons for the poor performance of the sectors which make up the industrial base, is evidently important. We draw on surveys of manufacturing performance and detailed sector studies to address the questions of the importance and meaning of technological capabilities for industry performance, and the appropriate role for government. We find that the application of up-to-date technologies is important

Technological capability development across all sectors of the economy is vital for industrial development. The sector studies discussed in this paper indicate that the traditional 'heavy' industries have not only developed leading technological capabilities in their fields but also created opportunities for lateral migration into 'smart industries' and other markets. The paper shows that for developing economies, technological advancement has less to do with pushing back technological frontiers than with the assimilation and adaptation of technologies..

across industries and that there are important industrial and technological capabilities in many industries not necessarily identified at first sight as 'advanced'. In other words, all industries are potentially 'smart'. The paper highlights the importance of technological capabilities and R&D as part of a broader set of competitiveness factors for overall growth and employment generation.

After briefly reviewing literature on the importance of technology and R&D for industrial growth, the findings from the manufacturing firm surveys and sector studies are assessed in section 2. Section 3 then assesses the current policy frameworks on technology and R&D, and discusses the role of government in this regard. Section 4 concludes and proposes areas for action that will support broad-based sustainable growth and employment generation.

1.1 The importance of technology and R&D

The accumulation of useful knowledge and the extension of its application are the essence of modern economic growth (Teece, 2000). Growth accounting studies typically find a very large proportion of growth is due to the 'Solow residual' which includes technological progress (Best, 2001). There is now widespread agreement that technology should be regarded as an important variable in growth models, but it is poorly understood.

Technological capabilities are a central element of firms' overall capabilities. Indeed, a major body of the literature argues that how enterprises manage the process of mastering, adapting and improving upon existing technologies is the single most important determinant of industrial development (Lall, 2003). This in turn is an outcome of firms' decisions and wider strategic orientation. Improved technological capabilities and the development of production in dynamic products have been important components of rapid industrialisation (Lall and Teubal, 1998; Lall, 2000 and 2001).

There is an important distinction between developing new technologies and the adoption and adaptation of existing technologies. For developing countries, which are 'followers' in terms of industrialisation, the challenges of development have more to do with the latter. The experiences of the high growth, Newly Industrialising Countries, reinforce this fact. Key to the success of industry in countries such as South Korea and Taiwan was a policy framework and environment which encouraged high rates of investment, in both physical and human capital. This investment involved adopting advanced technologies into manufacturing processes, as these technologies are embodied in machinery and equipment. The ongoing process of learning and developing production capabilities was part of the development of industries such as automobile manufacture, which is captured in the concept of dynamic comparative advantage. This refers to identifying areas of potential strengths, contingent on the appropriate set of capabilities being developed, which often require some form of state support. These comparative advantages, however, when established, place the country on a higher development trajectory as there are ongoing advances in these sectors in which the country and its firms now participate (see Lall, 1994; Lall and Teubal, 1998; Amsden 2001).

Four dimensions can be identified to the processes of technology and industrial development (Lall 1994):

- Technological upgrading within industries;
- Entry into more complex activities;
- Increasing local content involving local innovations and design; and
- The mastering of more complex technological tasks within industries.

As will be seen, these are not foreign concepts for the South Africa industries such as the foundries, plastic products and machinery and equipment industries that are examined in section 2. And, while South Africa's technological development is that of a follower country – to do primarily with adoption and adaptation of international production technologies (Machaka and Roberts, 2003) - there are, however, areas in which South Africa has developed leading capabilities due to the support provided because of strategic concerns of the apartheid regime. These include petrochemicals linked to support for Sasol, and defence related applications (Roberts 2001a).

The process of building technological capabilities does not take place in isolation, but through linkages with input suppliers, competitors, with unrelated industries, tertiary education institutions and technology centres (Lall 2003). International relationships are key in the process.

There are widespread and intrinsic features related to technological capabilities, which mean it takes time and effort to learn to use technologies, and that private firms will under-invest in the related activities to build technological capabilities (Lall and Teubal, 1998; Lall, 1994). Market failures are pervasive, and learning and technical change involve ongoing incremental and path dependent processes (Phele et al., 2005). Firms deal with the demands of technological changes by developing organisational and managerial routines. The process of building capabilities runs across all aspects of an organisation, from factory floor, process, product engineering, quality management, maintenance and procurement to relations

with other firms and institutions (Lall, 2003). This corresponds with a wide range of studies examining detailed processes of technological change and economic development at the institutional level (Dosi et al., 1994).

The importance of skills for competitiveness is generally accepted, but it is essential to explain the link between skills and the capabilities of firms and/or sectors. The effective use of technologies requires skills (Lall, 2001). The fast rate of improvement in technical progress dictates that, as production activities change, so do the skills needed to operate them (Lall, 2001). As such, an important part of more rapid growth is the ability of firms and their workers to learn how to upgrade their production capabilities and access new markets (Tewari and Goebel, 2002). One of the most important aspects of international economic linkages at the firm level is the mechanisms by which firms can learn from developments elsewhere. It is important to remember that this is not a new thing, and nor is it specific to what may be seen to be 'new' industries such as biotechnology. Industrial production has been international in terms of flows of techniques and processes from the earliest times, and there is continued development across all industries. But the learning process is not costless and it takes time, which means that intervention and support (rather than free trade) are required to realise the biggest gains from globalisation.

2. Sector performance and the significance of technology

Manufacturing firm survey data and detailed sector studies involving extensive in-depth firm interviews are drawn on to assess the main issues of technology and industrial development in the context of industrial development in Ekurhuleni. Manufacturing firm surveys were undertaken in 2003 and 2004. Detailed studies have also been made of the following sectors: foundries; plastic products; mining machinery & equipment; and tooling. These studies draw on existing and related work as well as the primary research in Ekurhuleni. The sectors studied are generally involved in the manufacture of intermediate products, that is, products that are used as components, inputs, or capital goods for the production of finished items.

Through an evaluation of this research we will seek to address the following main questions:

- Are there particular sectors where technology matters and others where it does not, or does it matter in all sectors?
- What are the sources of technologies that are applied?
- What stimulates upgrading?
- How important is trade?
- How important are international linkages?
- How closely is it related to investment by firms, skills and training?

A key issue related to capital equipment, and mining machinery in particular, is the extent to which there is the opportunity for lateral migration of technological capabilities. This refers to a situation where leading capabilities, developed in response to demand, are utilised in production in other sectors. The migration of generic technologies (e.g. process control, pumping, materials handling, construction equipment, etc.) therefore provides the opportunity for the widespread application of technology and processes across unrelated industries. The realisation thereof allows for profitable opportunities to be spread from the acquisition of new markets that would not be possible if the technology was restricted to the original industry.

In addition, the capital equipment sectors are also highly technical in nature and even more important, deemed growth potential industries in light of the anticipated massive investment by government in the next 5 years on infrastructure, along with the major investment programmes planned in mining in South Africa and the region.

Furthermore, these selected industries that have shown growth potential are situated in Ekurhuleni, the largest industrial concentration not only in South Africa but Sub-Saharan Africa. When exploring an economic strategy for the province, it is pertinent that they be included. This does not negate the industries identified by Gauteng Provincial Government as 'smart' and strategic (ICT, telecoms, research & development and biomedical), but it does imply a broader understanding of 'smart'.

Such an understanding acknowledges that the application of improved technological capabilities is important across industry. It also indicates a forward-looking imperative which takes account of the huge demand opportunities which arise from the infrastructure investment programme. These opportunities will only translate into major growth in production in input sectors if these sectors can upgrade their production capabilities through adoption and adaptation of improved technologies.

2.1 Ekurhuleni survey findings

The survey, carried out with 317 firms operating in Ekurhuleni in 2004, assessed factors underpinning industrial performance such as the main markets served, growth of demand, investment and technology, local linkages and firm-level competitiveness, amongst others.[1] The survey followed a similar one undertaken in 2003 which yielded similar results. The

[1] *The survey results are reported in detail in CSID (2005a).*

data allow inspection of linkages between the importance of technology and firm performance both in terms of turnover and employment. The relevance of investment, skills and training were also examined.

Overall there is a relatively large and dynamic group of firms within Ekurhuleni that are recording high rates of growth of output and are increasing employment.

A key challenge is to maintain the growth of these firms and to upgrade other firms and attract new entrants.

A very important observation is that the firms that were growing in terms of turnover are also growing employment and making investments in upgrading their machinery and equipment. Investment is thus not at the expense of employment but is part of a longer-term sustainable growth path.

Firms do conduct in-house R&D of some form and the majority of firms have made improvements in technology (mainly incremental improvements to process technology).

Firms also source new production techniques from suppliers. This supports the importance of building stronger local linkages, both upstream and downstream.

The importance of technology was also associated with better firm performance, and with higher levels of training and investment, as would be expected. While firm's investment is associated with their growth, there is also an association between the importance of technology for firms' competitiveness and the purchase of imported machinery and equipment. Firms that rated technology highly for their competitiveness are 21 percent more likely to have increased investment in imported machinery & equipment. This reflects the fact that technologies are embodied in machinery and equipment. Importing machinery is one step in drawing on international technological progress. The key question is whether this then translates to a more dynamic local industrial development path.

Investment in machinery and equipment increased significantly between 2003 and 2004. The average investment level per employee climbed from R36 490 in 2003 to R63 075 in 2004. Investment in domestic and imported machinery & equipment grew by 64 percent and 53 percent respectively for the same period, with domestic machinery and equipment accounting for larger portion (53 percent) of all new investment. Higher levels of investment in new machinery were strongly associated with employment growth. Firms that invested in 2004 were 38 percent more likely to have grown employment and firms that increased investment between 2003 and 2004 were 25 percent more likely to have recorded positive employment growth figures. This indicates that investment in machinery has been complementary to employment growth as part of an overall dynamic firm orientation, rather than machinery being a simple substitute for labour.

The most important factors indicated for increasing investment were expected sales growth or domestic demand, followed by raising efficiency levels and the need to improve quality through employing more up-to-date technology.

Given the tendency for firms to under-invest in technology-related activities (whether narrowly defined R&D or broadly defined product development), appropriate institutions have an important role to play. The survey highlighted that relationships between industry and tertiary institutions, science councils and other research organisations are chronically weak. For continuous efforts by industries to improve their technological ability these relationships must be strengthened in order to enhance capabilities with respect to materials, process, and environmental technology.

2.2 Foundries[2]

The foundry industry is crucial to overall development of local manufacturing capabilities as it provides intermediate inputs to a wide range of other sectors, including machinery & equipment and the auto sector. The sector has also developed the required production capabilities to serve the mining industry.

There are effectively two tiers in the local foundry industry, characterised by their very different technological capabilities. The first tier comprises firms that have responded to competitive pressures by improving their technological capabilities and innovative capacity. These firms have focused on their core business activities by outsourcing non-core functions, have modernised their equipment, and have acquired and absorbed new technology. The process of modernisation has taken place in the context of a legacy of outdated and increasingly unsuitable casting equipment and machinery, and has accelerated the trend – notwithstanding domestic market limitations – towards higher-volume production. These firms are growing, both output and employment.

[2] *Based on work done by Phele et al. (2005)*

Surprisingly, the technological capabilities of firms in the first tier do not appear to be a function of the casting process or of the market to which they supply. There are technologically dynamic firms across the range of casting processes and the vast majority of firms supply to a range of different markets, notwithstanding the trend towards increased specialisation.

Die-casting firms supplying the automotive market, however, have clearly benefited from positive externalities generated by the MIDP and are developing their capabilities on the back of the programme's success.

In a separate survey of foundry firms in Ekurhuleni, firms rated modernised and more efficient technology very highly as an important factor for competitiveness. However, machinery & equipment of most firms captured during the survey is still quite old. Just over 50 percent of firms made major investments in casting machinery and/or equipment since 2000. These investments have a strong positive influence on performance; firms that have made investments have reported annual growth in turnover greater than 10 percent in 2003.

A majority of the firms surveyed indicated that they have introduced technologically improved casting products to the market and/or made improvements to the casting process since 2000. More than 50 percent of these improvements were incremental while just above a quarter were radical. The changes were highly influenced by the local markets.

A significant number of the firms indicated domestic in-house development and suppliers as the main sources of new technologies and/or improvements. Foundry interactions with consumers and competitors were also important sources of innovative efforts. The small firms that responded to the survey also indicated their desire to interact with other foundries in terms of information sharing. Firms are also undertaking R&D, which is closely related to technological improvements.

Foundries indicated the following factors as main impediments to innovative efforts in the casting technology: financial constraints; economic risks; lack of qualified personnel; and lack of familiarity with new casting technology.

As the producers of key intermediate products, being cast components for machinery, motor vehicles and other products, the technological capabilities of foundries are crucial to the performance of industries further down the value chain. Foundry capabilities become critically important, particularly given the increased demand for machinery & equipment implied by the major investments being made in electricity generation and transmission. The trend towards specialisation and usage of in-house expertise by local foundry firms is indicative of their specific knowledge base. However, it is crucial that advances in technology internationally, such as related to the properties of alloys and computer aided manufacturing in casting, be adopted in South Africa.

2.3 Plastic products[3]

Most plastics products form intermediate inputs for other domestic industries. The manufacturing of plastic products involves both relatively standardised production technologies embodied in machinery and more complex processes to make engineering plastics. These are plastic products which are replacing metals (such as the development of a plastic chain to drive a food products conveyor).

Besides the skills of the workers, the technology of production in the plastics sector mainly entails the machinery, moulds and computer software employed. Production processes are mostly micro and computer controlled but the industry is said to lag in the use of information technologies (Wesgro, 2000). Most machinery and equipment is imported – the size of the South African market means that demand is small relative to scale economies in manufacturing machinery. This means that, as the South African economy becomes increasingly integrated into the international economy and firms are expected to meet international standards, investment in regular upgrading of machinery and equipment is very important

As a material in which there are constant developments related to chemical properties such as rigidity, colour and flammability, the capacity of firms to adapt and adopt technologies as part of ongoing product development and innovation is crucial to the downstream plastic sector. Product development depends to a great extent on links with external sources for information and advice. Technological trends and priority areas of development are mainly identified through international visits to trade shows, were the latest technology developments are show-cased. In addition, strategic technical alliances with foreign, primarily European, plastic converters were identified as being critical to firms' technological and innovative capacity.

In terms of its trade performance, when polymers are excluded the plastic products sector has continuously recorded significant trade deficits. Exports have accounted for around 8 percent of output for most of the

[3] *Based on work done by Dobreva et al. (2004) and Mohamed (2005).*

last decade while imports are equivalent to around 13 percent of plastics consumption.

In-depth interviews with plastic firms highlighted their ability to compete on short production runs with products customised to particular requirements. The flexibility in the production runs by way of adjusting their production to accommodate customer demands has given those firms that respond to such short-run requests a competitive advantage. Some examples of product development are:

Pool cleaners: The original design for automatic swimming pool cleaners has spawned an ongoing process of improvement, designed to yield a more effective product, with greater durability. The tooling costs in South Africa meant importation of tooling; this has been reversed recently with the tooling being transferred back to South Africa due to the firms' involvement in product development, and their production capabilities.

Geyser brackets: The search for new products by a medical equipment manufacturing firm which already specialised in producing highly specified products led them to examine replacing metal geyser brackets with plastic ones. Problems with the design for wall mounting led to this small firm using a US university's research capacity to test and refine the product.

Fruit crates corners: South African fruit exports remain in the cold chain (in storage and transport) for considerable lengths of time during which standard corrugated cardboard boxes become wet and soggy. Extruded corrugated polypropylene sheet (plastic) was developed to replace cardboard, and one firm has specifically focused on developing the corner pieces for the boxes to ensure strength and stacking. This is product development by a small firm in Ekurhuleni.

The investment in machinery and equipment, and the upgrading of technological capabilities that accompany it, was associated with turnover and employment growth. Even in cases where investment increased capital intensity, it was still part of overall improvement in the firm's competitiveness. The most important reasons given by plastic firms in the 2004 manufacturing survey for investing in machinery and equipment was raising efficiency levels through up-to-date technology, followed by increases in local demand, and improving product quality.

The relatively old machinery and equipment and low levels of investment in new machinery often affects the quality of moulds. Tooling[4] is an important component of technology and capital equipment. Good tooling means greater efficiency and product quality, and the design of moulds can greatly reduce the amount of material required for a specific product. The nature of plastic products means new moulds and dies are required for new products or variations on existing ones (Dobreva et al 2005). The ability to design and deliver moulds therefore become crucial to product development.

A plastic manufacturing firm's performance depends on the abilities of their relatively low-skilled machine operators to ensure the consistent quality of the product and efficient changeovers between different production runs. Another feature of the better performing firms was a low turnover of personnel, which facilitated the accumulation of on-the-job skills. At least two distinct classes of workers where skills scarcities are reported are trained engineers and artisans. Therefore, addressing the skills constraints is important not just to improve competitiveness of the sector but to enable it to keep abreast with new development in technologies.

In addition, there are unexploited markets that have tremendous growth potential and that require technical know-how that is already present. The potential markets are:

Automotive

This is the most important source of demand for high specification engineering plastics. These include products such as trims, bumpers and wiring harnesses. Demand for these specifications has also grown driven by the need for assemblers to increase local content under the MIDP. The standards of the auto-industry are an important driving force behind improving firms' technical abilities.

Building products

In addition to the large items such as pipes and flooring, there is a multitude of other plastics used in construction, including moulded fittings and

[4] *Will be further discuss as a separate sector in 2.5*

kitchen and bathroom ware. The ability of products to withstand stresses without deterioration is key. Thus apart from the market opportunities that exist, there is vast opportunity for technical improvements and product development.

Composites

Composites refer to plastic products (generally moulded) reinforced with other material such as fibreglass. There has been a very rapid development of these activities world-wide as, with the correct technical specifications and production, light, durable and very strong shaped products can be produced. Some of the better known applications include yachts, aerospace, building materials and pressure vessels, all of which fall within target industries in South Africa. The greatest potential is in thermoformed plastic composites where South Africa is currently judged to be three to four years behind international developments.

2.4 Mining machinery and equipment[5]

Machinery and equipment is at the heart of industrialisation, particularly from the perspective of technological capabilities, as this sector manufactures the capital stock in which production technologies are embodied. This has been the key reason that many countries have placed development of the sector at the heart of their industrial policies. South Africa has a developed machinery and equipment industry in certain areas, most notably in mining machinery. In these areas there is a base of world class activities; the challenge is to sustain the base and extend it across other segments of the sector.

South Africa's strengths in mining machinery have come on the back of local mining activity. South Africa is the world's largest producer of platinum and among the world's largest producers of many other minerals. The country has developed innovative capabilities in mining, especially where it is required to meet specific needs such as ultra-deep level mining, in which South Africa is the world leader.

We illustrate these capabilities by focusing on two examples below, being pumps & valves and conveyor systems.

There are also developments related to the use of mineral products. For example, Mintek is involved in a research project that is creating materials from platinum that can withstand higher temperatures than nickel-based alloys used in turbine blades. The new materials will remain solid in temperatures of up to 1 350 Celsius higher than 1 150 Celsius that nickel-based alloys can withstand. This will enable aircraft turbines and power generators to run more efficiently at much higher temperatures. The project is carried out in consultation with a number of international science institutions.

R&D is critical to fostering linkages between participants in the platinum cluster and ensuring the sustainability of the industry in the long term. Within the past 10 to 15 years the platinum industry has seen a shift in emphasis from R&D and pure innovation to product development and design. There have been a number of factors at the national level which have been responsible for this change. Investment in R&D is perceived to be critical for maintaining current operations and future competitiveness (especially with the increasing threat of imports and pirated parts).

Production-related linkages usually arise within the individual stages of the platinum production chain and relate to the introduction of new technologies and the adaptation and improvement of existing pieces of equipment. Small improvements in the production process can result in significant economic gains and efficiencies further down the chain as well as assist in the diversification of product lines of supplier firms.

Pumps and valves

Pumps and valves form an important part of the capital equipment industry. The firms that are able to supply specialised products usually face fewer competitors. Key to gaining this type of advantage is technological innovation. While large multinational firms are able to spread the cost of research and development across the group, smaller locally-based firms have demonstrated an ability to react quickly to take advantage of niche opportunities.

Working in conjunction with valves, actuators[6] have accounted for much of the recent advancements in the industry. Within valves themselves, there has been a constant supply of new designs around the actual opening and closing mechanism. While small valves continue to be dominated by ball mechanisms, larger or more specialised valves have incorporated a range of designs. These specialised valves are usually designed with a specific application in mind, based on unique operating conditions related to pressure, temperature, corrosive or abrasive environments. Size has also been found to be a distinguishing factor, as few firms have the capacity to manufacture very large valves.

Pumps are inherently more sophisticated products, and innovation usually involves investment in research and development. For markets such

[5] *Based on work done by (CSID 2005b)*

[6] *The control mechanisms for the valves.*

as petrochemical, innovation is more difficult as standardised specifications (i.e. American Petroleum Institute, or API) leave very little room for changes. In these cases firms compete on reliability and service rather than on unique design.

Within the mining industry, there is a push to increase pumping efficiency, reduce maintenance costs, and reduce interruptions to production. As a result, firms have introduced new materials into pumps, not only through specialised steels but also by introducing polymer based liners.

Pumps are complicated products, and innovation usually involves a high degree of investment in research and development. Quality and reliability form an important part of a valve manufacturer's reputation in the market, and in some cases are the basis for charging a premium price.

The existing cost structures within the South African manufacturing industry mean that locally based pump and valve manufacturers will continue to have a difficult time competing on simple commodity-type products. In particular the costs of the component parts, such as castings, impact negatively on firms competitiveness.

Firms who are able to differentiate their products through innovative design and manufacturing techniques will maintain a competitive position. The ability to maximise such niche areas is, however, constrained by insufficient skills, lack of working capital, threat of pirated parts, and lack of accreditation or certification.

Conveyors

Bulk materials handling involves the transportation of large quantities of unrefined ores and concentrates from the underground to the surface, or transporting input material from a stockpile to a processing plant. Bulk materials handling equipment includes conveyors, stackers and reclaimers, feeders, gates, diverters, pipes, weighing and monitoring equipment, and storage facilities.

Conveyor systems are one of the largest sub-product sectors in the minerals handling market and require various components. Conveyors are used by many industries, however, mining applications still account for the vast majority of the market.

On the back of local demand for conveyor systems from mining, South Africa has developed an exporting industry focused around the design, construction and manufacture of conveyor systems. There is ongoing innovation and product development in the manufacture of the components, as a small improvement in the durability of, for example, the rollers on which the belt runs, can mean a huge gain in the life of the system and the number of times it needs to be stopped for maintenance to be carried out.

There are opportunities for lateral migration into other markets, products and systems. It is particularly true for firms interested in entering the assembly line conveyor systems market. New technology has also created opportunities for the industry; for example, pipe conveyors are a new design and opens up a number of opportunities for the conveyors industry.

The volatility of the local currency (Rand) and the pricing of the main input material (steel) into components used in a conveyor system have adversely affected the performance of the industry and the development of production and technological capabilities.

2.5 Tooling[7]

The tooling industry is central to manufacturing. It is used in the application of technologies ranging from plastic injection moulding, high pressure die casting, and the pressing of metals, to the manufacture of coins, cell phones, and automobile components. The sector is also very closely linked to design capabilities. It requires high levels of precision engineering, design, machining, and assemblies to feed an increasingly sophisticated manufacturing industry. Without an international standard tooling industry, the country will not be able sufficiently support its manufacturing base and none of the economic goals will be achieved.

There is also a key driver related to the plastics industry. Light weight but high strength plastic components are increasingly replacing metal parts. The production of these plastic products is crucially dependent on the technological capabilities of the local tooling industry, as the properties of the products depend partly on the design of the moulds used.

Despite the critical role played by the tooling industry for the competitiveness of other downstream industries, as well as its own potential for export and employment creation, the South African industry is in a serious decline. The sector has lost a lot of its tool-making capacity and capabilities over the past 15 years.

This is attributed, amongst others, to the ageing of tool makers, low levels of investment and the lack of skills training. At this point, apart

[7] *Based on work done by Blueprint (2005) and Dobreva et al 2004*

from the established local players serving small niche markets, there is not an effective value chain in place for the South African tooling industry that links designers, producers and core markets.

As indicated, investment in the industry has been low. The average level of investment by tooling firms per year over the past five years has been R1m. These investment levels are regarded as very low by world standards. Given the current status of the industry, tool rooms need to invest at least R15m to bring them to speed with internationally competitive standards and thereafter invest 10 percent to 15 percent of annual turnover to maintain competitiveness.

Based on the levels of local market demand amongst all manufacturing industries, the South African tooling industry is valued at R1.4bn per year, of which R1.3bn is imported and only R441m is exported. The large trade deficit is an indication of the growth potential of the sector. There is potential for the production and processing of value-added tooling for which there is considerable demand in domestic and international markets.

2.6 Summary

We have highlighted the importance of firms' productive and technological capabilities as an important factor in manufacturing performance across a range of different sectors. Collectively these sector studies highlight the inherent capabilities and opportunities that exist within what may be regarded as traditional manufacturing activities. Moreover, the opportunities presented in these activities are amplified by the potential for lateral migration to apply the technological capabilities in other related fields.

The above sectors are also crucial to the overall development of local manufacturing capabilities as they provide intermediate inputs to a wide range of other sectors. The finding from the sector studies shows the importance of developing their production capabilities. This relates to their decisions on investing in machinery and the influence of the local markets and demand.

3. Policy framework on technology and R&D

Since 1994 the different national priorities of the ANC government led to a rethink of industrial and technology policies. Trade liberalisation led to far-reaching industrial restructuring (Phele et al 2005). Funding for the old research priorities was reduced, and a new technology mission was elucidated in the National Research and Development Strategy (DST, 2002). South Africa has made laudable progress through its establishment of explicit technology policies aimed at supporting its national system of innovation for the inclusive economic development and growth of its economy. Nevertheless, these technology policies and initiatives are mostly top-down programmes from South Africa's national government.

Historically, industrial and technology policies both focused on strategic concerns of the apartheid government such as defence and liquid fuels, and the needs of resource extraction and processing industries (Phele et al 2005). By comparison, recent industrial and technology policy frameworks aim to encourage downstream value-addition and employment creation. The Department of Science and Technology's recent AMTS and the Department of Trade and Industry's IMS complement each other. They emphasise the need to develop production capabilities, for firms and public institutions to work together effectively, and for technologies to be the foundation for growth of output and employment.

There are basically seven primary sources of innovation funds directly relevant to manufacturers: 1) the Innovation Fund 2) the Competitiveness Fund 3) the Support Programme for Industrial Innovation 4) the Sector Partnership Fund 5) the National Research Fund and 6) the Technology and Human Resource for Industry Programme 7) Khula Technology Transfer Fund.

An important technology initiative of direct relevance is the 2002 National Research and Development Strategy. The National R&D Strategy aims to support South Africa's R&D investment and more generally enhance the performance of its national system of innovation. For it to succeed, however, requires strong links being developed with skills development and industrial policy (Dobreva et al 2004).

Technology policies in general, and local technology policies in particular, need to support existing business organisations' knowledge and encourage the use of appropriate management, distribution, marketing, and design technologies. In this regard the AMTS is an important development.

There are at least three technological focus areas in the AMTS that are of particular relevance to manufacturing – Advanced Materials Technology, Advanced Production Technologies and Logistics. The AMTS identifies five goals and objectives:

- Developing a vision of South Africa's industrial sector circa 2014
- Identifying priority areas to support the Integrated Manufacturing Strategy and the National R&D strategy
- Stimulating technology upgrading in industry
- Facilitating development of innovation networks in industry and
- Facilitating the development of a conducive environment for innovation.

The goals of the AMTS are to be given effect in specific programmes such as a *National Tooling Initiative* launched by the Council for Scientific and Industrial Research's (CSIR's) National Product Development Centre. This is being driven initially by the auto industry but has now grown to be much broader and is currently at an advanced stage. In addition, the AMTS envisages a range of measures including the establishment of technology centres and innovation networks. Most of these initiatives are still at their infant stages and requires concerted efforts by all stakeholders to see them through.

Consistent public policies promoting endogenous development of the national S&T System is not enough. Both national and local systems of innovation may suffer more fundamental deficiencies than a lack of technological innovation in a narrow sense. Therefore technology and industrial policies need to be aligned and allowed to evolve together. While moving technology policy beyond a narrow conceptualisation within the S&T System, we must bear in mind its relation to the broader system of innovation and manage it accordingly.

Research institutions available for industries can be divided into four broad categories: 1) Public Sector Research Institutions, 2) Industrial Research Institutions, 3) Tertiary Research Institutions and 4) Collaborative/ Cooperative Research Institutions.

In the public sector, the majority of research capacity appears to be located within the CSIR. The commercial focus of the CSIR has also been identified as limiting its scope for R&D initiatives to support. Another public sector research institution that is available to industries is the South African Bureau of Standards (SABS). Tertiary institutions appear to possess crucial, but relatively underutilised, research capacity that could assist industries.

4. What defines a smart industry?

While targeting smart industries has been identified as an important part of industrial policies there is little clarity on what defines a smart industry. Is it the process involved, the end product or a combination of both? The review done here highlights an essential point that a smart industry is any industry where the application of technology is important for production, and where firm performance depends on the ongoing development of production capabilities. The vast expertise and know-how required to design, manufacture, adapt and innovate new or existing equipment to meet a specific need in traditional industries, such as mining and agriculture, has over time generated a large pool of high-tech skills which today underpin the international success of such industries.

There is also great potential for technologies, products and know-how to be applied in other areas. For example, process control equipment designed for a big smelter on a mine can, with adaptation and modifications, be used in the agricultural sector. Thus, what is required is a broader definition of what constitutes a 'smart' industry. In this regard it should not only acknowledge the finished product which adds value to a particular application but also the knowledge component in its development. The intangible process of knowledge development is what should make an industry smart – cutting edge, internationally competitive, dynamic, and adaptable.

The 2003 Trade and Industrial Strategy (TIS) of Gauteng has outlined five strategic areas or "thrusts", of which the very first is to divert manufacturing away from traditional heavy 'dirty' industries that are, according to the strategic document low in value addition, towards sophisticated 'clean and sexy' industries that generate high value added. The sector studies above, however, clearly show that these industries are still generating high levels of production and value added, and most importantly are highly technologically sophisticated and are continuously improving their production capabilities.

The fourth strategic aim of the TIS is employment creation. The industries regarded as smart by the province will do little to address the high unemployment rates present in the province. Even if very rapid growth of these new industries is attained, they will still account for a very small proportion of industrial employment. On the other hand, plastics, foundries and mining capital equipment predominantly employ unskilled to semi-skilled workers and will aid in addressing the unemployment problem. Investment in expanded capacity in these sectors will be job creating. The concentration of policy should therefore be around consideration for more generous incentive provision which should speed up investment, and not efforts diverting resources away from such industries.

We are not arguing that the sectors identified in the Provincial Strategy are not high-tech or without growth potential. However, we do question the narrow emphasis on the importance of improved technologies to a very limited set of activities and whether the identified sectors sufficiently meet the national objectives of reducing unemployment and broadening ndustrial technological capabilities, as asserted in the Accelerated and Shared Growth Initiative.

In light of the planned infrastructure investment programme of national government, the sectors examined as case studies here should be part of any growth strategy. These dynamic sectors are not only recording high rates of growth of output, upgrading their machinery and equipment but

are also increasing employment while broadening their technological capabilities. The competitiveness of the ICT, telecommunication and biotech industries is mainly dependent on relatively high-skilled people, whilst the foundries, plastic products and capital equipment sectors' competitiveness hinges on employing a range of skills combined with appropriate investment in capital stock.

The innovation hub owned by the Gauteng Provincial Government was established as part of the province's Trade and Industry Strategy (TIS) of 1997 which was later updated in 2003. It was developed as a high technology local and international network platform in association with the University of Pretoria and CSIR with specific focus on 'smart industries' as identified in the Strategy. In this regard it does meet the need we have identified here to examine the application of technologies across more traditional industries, such as through centres offering technological assistance, and testing and training facilities. What is needed are similar initiatives in the industrial heartlands of the Province.

5. Conclusions

Technological capability development across all sectors of the economy is vital for industrial development. The sector studies clearly indicate that the traditional 'heavy' industries have not only developed leading technological capabilities in their fields but also created opportunities for lateral migration into 'smart industries' and other markets. Local innovations are mainly related to local product development, which are stimulated by local demand characteristics. For developing economies, technological advancement has less to do with pushing back technological frontiers than with the assimilation and adaptation of technologies.

5.1 Potential action areas

Locating improved technological capabilities at the heart of accelerated and shared growth in order to maximise the potential returns from, inter alia, the infrastructure investment programme suggests a range of urgent interventions. We briefly explore some of the most important.

Skills development and training

There is wide recognition that there is an acute shortage of skills in general. Improved technological capabilities require skills development and training to take place. Therefore, it is important that in dealing with issues surrounding widening technological capabilities, the alignment of training programmes to industry ought to be considered. The Foundries Steering Committee on skills in Ekurhuleni is a very good example, where unit standards were developed by industry in consultation with the relevant training authorities. For industries such as plastics and mining capital equipment, that have immense growth potential, the following should be considered:

- A broad skills needs assessment
- With relevant stakeholders (training institutions, SETAs and industry) an assessment of current training programmes to assess whether they meet industry requirements, and to adjust them accordingly in consultation with industry
- An assessment of training institutions, where they are located and how best they can serve industry.

Benchmarking

Developing the industry requires a 'total package' related to upgrading production capabilities in which the approach of management to the organisation of production is important. Benchmarking enables firms to learn from each other and induces changes in management through a demonstration effect. Firms provide data on a range of performance criteria. The benchmarking enables them to assess their position relative to other firms, both locally and internationally. It then leads naturally to steps taken by firms to move towards the best in their group, as well to the sharing of experiences across firms and in local clusters. There were earlier indications from the Department of Trade and Industry of funding for such an exercise. Funding during the initial period should be seen as an important potential inducement for more firms to take part.

Institutions

There is an increasing understanding that in order to build the local industrial base it is necessary to get groups of companies to work together effectively with local testing and training facilities and tertiary education institutions. The technological centres and innovation networks that are envisaged under the AMTS can only be a reality if the constraints faced by these supporting institutions are addressed. The relationships between industries and tertiary institutions, science councils and other research organisations are chronically weak. This suggests a need for a more proactive approach by public institutions, with public funding, in addressing a problem of collective action. Ongoing technological development itself

requires the ability to test products to determine and improve specifications.

Thus, shared testing facilities with public funding assistance are important because available testing facilities, as illustrated in the sector studies, are generally in-house for large firms but not usually an option for smaller firms.

There appears to be a gap between the supply of available research capacity and demand for that research capacity by certain industries such as plastic products. Given the importance of such linkages the following action areas should be considered:

- An assessment of awareness of relevant research institutions and centres
- Identify reasons for the lack of awareness and utilisation of policy initiatives
- Further identify available industrial research capacity and its location/ connectivity to industries
- Identify impediments to research collaboration across institutions.

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The SADC Trade database is an online database consisting of the import and export data of 11 Southern African states. The database has been compiled from data provided by member states.

The initial dataset includes data for the following countries: Botswana, Lesotho, Malawi, Mauritius, Mozambique, Malawi, South Africa, Swaziland, Tanzania, Zimbabwe and Zambia. Data is published for 5 years. In most cases, this covers the period 2000-2004, but for three countries – Namibia, Botswana, and Lesotho – the period 1999-2003 is covered. These will be updated as soon as more recent data is made available. Measures for the data include values in local currency as well as in US dollars.

The data is made available via a powerful, yet easy-to-use web-based format that allows the user to configure the report by a number of different variables. The data can be downloaded in a number of formats ,including MS Excel.

Also available on the site are MS Excel-based analytical templates that assist in calculating basic trade analysis ratios such as shares and growth rates, based on both a partner and commodity view of trade.

Go to www.sadctrade.org/tradedata for more information and to register for access to the database.