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Unpacking the Nature of Demand and Supply Relationships in the Mining Capital Goods and Services Cluster: The Case of PGMs

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Introduction

South African policy makers and industrial planners are centrally concerned with identifying strategies and programmes that maximise and broaden the economic linkages that naturally arise from the need to extract, process and refine the country's mineral resources (DST, 2002; DTI, 2002). At an industry level these linkages encompass 'downstream' (beneficiation) activities, 'backward' linkages (the supply sector), and 'lateral' linkages (arising from the modification and application of generic technologies to other industry sectors). While the need to increase the level of value added/beneficiation to primary resources prior to export has received a considerable amount of attention in recent years (see Jourdan, 1992; Baxter, 1994; RSA, 1998; Chamber of Mines, 2000; MMSDsa, 2002, Metcalfe, 2003), there is a relative paucity of studies that explore the backward linkages arising from the mining sector.

Backward linkages refer to the linkages arising between an industry and its suppliers and essentially make up the supply chain of a mine. Such linkages have emerged as a consequence of vertical, horizontal, and technological demand-supply interactions between mining producers, specialised manufacturers, input providers, agents and distributors, and service suppliers over a long period of time (Robinson, 2003). Given the long history of mining activities in South Africa, the extent of backward linkage development has been significant and has played an integral role in the emergence and evolution of other sectors in the economy in addition to mining. The clustering of firms involved in metal products, machinery and equipment, electrical equipment, and construction activities, the majority of which are geographically concentrated in Ekurhuleni, Gauteng, is the most tangible manifestation of this effect (Machaka and Roberts, 2004; COMMARK, 2004a; Walker, 2004a).

From a policy perspective, strengthening and enhancing existing (and rejuvenating "lost") linkages between the mines and the supplier industry and leveraging the know-how and expertise embodied in the products and services exchanged to stimulate new linkages, is considered important for three reasons. First, a sophisticated and internationally-competitive supplier industry provides competitive strength to the underlying industries which purchase its inputs. Inputs enable producers to undertake productivity enhancements as well as commission new plants/mines. However, this only becomes possible with the advent of new technology in capital goods and service inputs. Demand from the mines thus plays an important role in driving the R&D process and creating a "virtuous cycle of innovation" at all levels of the cluster (Lundvall, 1992; Chamber of Mines, 2000). Second, given the volume, scale and range of products required by mining companies during the construction and operation of primary activities, the supplier network has emerged to become a significant generator of output, employment, skills and foreign exchange in its own right. This has increased in recent years as firms have expanded through diversification (particularly into the African market), adopted new mechanised mining methods, and successfully modified and adapted generic technologies and products (e.g. pumps, ventilation systems, fans, valves, conveyor systems, haulage vehicles) for use in other industries (construction, food processing, waste water treatment, agriculture, general manufacturing) where the commercial rewards are much greater (*Mining Weekly*, 2001b; COMMARK, 2004b; 2004c; Walker, 2004). Lastly, as manufacturing sectors exhibit greater learning effects than do primary sectors it is argued that South Africa will only catch up with other countries if it is able to export technology-based manufactures (Humphreys, 2000; Lall, 2001). As these tend to be embedded in non-resource-based and high-tech sectors, the country thus needs to build on what it has – i.e. "leverage[e] off our resources and resource technologies" (DST, 2002). South Africa can draw on the experiences of countries such as Finland, Sweden, United States, Canada and Australia that have successfully leveraged off the know-how embodied in the capital goods and services supporting resource-based industries to facilitate the transition away from low-valued primary-based activities to high-tech, knowledge-based export-oriented growth (see Dungan, 1997; NRCAN, 1998; Altimirano, 1999; Blomström and Kokko, 2002; McKay *et al*., 2002; Wright and Czelusta, 2003; Walker, 2004b).

Current investigations around the supplier network in South Africa have focused around formulating a general picture of the dynamics of the inputs cluster at the macro-level (reviewing the type of firms, scale of activities, spatial dynamics, and nature of operations) and micro-level (value chain analysis of particular product groups) (see COMMARK, 2004a; 2004b; 2004c; DST, 2004; Walker, 2004a). In order for the government to effectively plan targeted interventions and programmes aimed at boosting the growth of local metals, manufacturing, engineering, and construction firms (which comprise the supply chain), a much more detailed analysis of the nature of backward linkage development in the mining sector is needed. In particular, a greater understanding of the factors that initially gave rise to vertical, horizontal and technological linkages within the supply chain, current and future trends, types of supplier firms, and what bottlenecks/constraints are hindering the formation of backward linkages is needed. The role of the procurement process, R&D, and human capital issues have to also be considered.

This paper unpacks some of these issues and reviews the nature of the demand-supply process in the platinum group metals (PGM) industry. The discussion draws on a quantitative and qualitative analysis of the industry undertaken in 2005[1]. PGMs was selected for investigation as it is currently the highest earner in the domestic mineral industry and the commodity group experiencing the most expansion. Thus, opportunities for backward linkage development are significant. In addition, due to the geological and metallurgical complexities of the ore-bodies, the increasing depth of operations, and the constant need to reduce costs and improve operational efficiencies at the producer level, the sector is also characterised by a high degree of technological innovation and product development. Vertical, horizontal and technological linkage development into high-tech and sophisticated firms is therefore a distinct characteristic of the PGM sector.

The paper commences with a brief consideration of the role of the PGM industry facilitating the process of clustering and backward linkage development in South Africa and the various factors that contributed to its evolution. The structure of the platinum supply chain is then unpacked, key quantitative features noted, and the main types/groups of firms highlighted. The significance of backward linkages to the supplier industry is then illustrated using various examples of contracts signed. The paper then shifts to exploring some of the key trends and drivers currently influencing the formation of demand-supply linkages in the PGM industry. The role of the procurement process, R&D, and knowledge and human resource base are referred to. The responses of the various types of firms to these developments are noted and the constraints affecting future expansion highlighted. The paper concludes with some comments on the implications for policy.

[1] The study, entitled "*The Platinum Industry Cluster*", was funded by the DST and involved a consortium led by the CSID (University of Witwatersrand), Mintek and CSIR Mining Technology. A total of 55 firms were interviewed and included mining companies, consultancy firms, OEMs, and component suppliers, R&D organisations and industry associations. This was supplemented with extensive desktop research which drew on a range of sources such as trade journals, magazines, and academic articles.

PGMs as a Facilitator of Clustering and Linkage Development in South Africa

According to the literature, a "cluster" can be defined as a concentration of expertise among closely linked industries and companies in which extensive investment in specialised factors of production catalyses a positive growth trajectory. The agglomeration of producers, customers and competitors, whether based in geographical proximity or linked by complementary expertise, promotes efficiency, increases specialisation and gives rise to economies of scale and scope within and across firms. Successful clusters have a strong and vibrant entrepreneurial base of networked and interdependent firms which accelerate the pace of innovation, attract investment, stimulate job creation and generate wealth (Porter, 1990; Den Hertog and Leyten, 1999; Roelandt *et al*., 2000; Raines, 2001; Cortright, 2002; Rosenveld, 2002).

At the core of the cluster concept is the notion of "linkages". In economic terms, linkages refer to situations where a particular activity requires the use or involvement of other activities in order to be viable. It alludes to the mutual connections and interactions between individual industries in a particular activity (Hirschman, 1958; Lundvall, 1992; Robinson, 2003). In most cases, linkages arise through the economic exchange of resources between two parties, usually labour, services, information or a tangible product in return for capital.

According to Menell (2000, 1), "…mining constitutes what is surely the most successful 'cluster' in [South Africa's] economy". The various backward, downstream, and lateral linkages arising from the minerals industry have played a key role in driving growth and development for more than a century. While gold has historically been the dominant mineral mined in the country, since the 1980s an important source of foreign exchange earnings linked to minerals has come from PGMs, comprising platinum, palladium, rhodium, gold, ruthenium, iridium and osmium (Cowey, 1994). In addition to being a major source of employment, accounting for 127 672 jobs in 2003 and 30 755 new positions in 2004, the PGM industry is currently the commodity sector experiencing the most growth and expansion in South Africa (*Business Report*, 2004; DME, 2004; GCIS, 2004). Over the past thirty years, PGM production has increased steadily, peaking in 2004 at 4 865 000 ounces (an increase of 27.6%). The level of capital expenditure has also increased growing at a compound annual growth rate of 43.8% between 1999 and 2003. Expenditure peaked in 2003 at R11.82 billion – six times that spent in 1999. While investment has since tapered off, the PGM industry remains a significant source of demand for local goods and services. In some supplier firms, demand accounts for between 50 and 80 per cent of mining-related business activities and this is projected to increase over the next five to ten years.

There are two key factors that have contributed to the replacement of PGMs as the dominant contributor to industrialisation and economic growth in South Africa: factor conditions; and demand conditions. Each of these will be explored in turn.

Factor Conditions

Factor conditions refer both to the basic comparative advantages that initially catalysed the growth of the PGM industry (i.e. mineral endowments) as well as the core of local capabilities and expertise which enabled the technical challenges associated with extracting, processing, smelting and refining the orebodies to be overcome.

South Africa possesses more than 80 per cent of the world's platinum reserves, and is the world's largest producer of PGMs. These vast resources occur together with the world's largest reserves of chromium and vanadium ore in the Bushveld Complex, a geological formation that extends in an arc through the North West, Limpopo and Mpumalanga provinces. The PGM orebodies are concentrated in three narrow but extensive strata known as the Merensky Reef, the Platreef, and the UG2 chromitite layer. The mineralogy of these orebodies is quite distinct and this has necessitated a considerable amount of collaborative R&D and long-term innovation to develop the processes and techniques required to exploit them (Cowey, 1994; Jones, no date; DME, 2004).

The current success of the PGM industry can be also be attributed, in part, to the extensive foundation of accumulated knowledge and expertise in the extraction and processing of various other minerals in South Africa that existed prior to the exploitation of the Bushveld Complex. Due to the high chrome content of the UG2 ores and fact that no available ‘off the shelf’ technologies existed with which to process them, a considerable amount of local R&D and innovation was required before a suitable process was discovered. By leveraging this existing culture of entrepreneurship, innovation and manufacture of specialised products and services (developed around other mining activities – gold, diamonds, coal), appropriate technologies and processes were been developed, most notably Mintek’s process for the treatment of UG2 ores in the 1980s, which provided the impetus for the commencement of mining activities along the Bushveld Complex.

Demand Conditions

Drawing on the international experience of clustering and backward linkage development, it is evident that a significant and stable level of demand, coupled with a demanding local customer base, can provide the foundation upon which a competitive supplier base can be established (Porter, 1990). The existence of a source of domestic demand for goods services over a long period of time has played a critical role in the evolution of the PGM industry. Demand has been shaped by developments at both the international and national level.

At the international level, the demand for PGMs is influenced by global end-user market patterns and commodity pricing trends. Russia and South Africa are the two leading producers of PGMs in the world. However, while palladium is the principal product mined in Russia, in South Africa it is platinum. This is a unique comparative advantage for South Africa given that the two largest markets for platinum are jewellery and autocatalysts. Global demand for South Africa’s platinum resource thus has been significantly boosted by the expanding Chinese jewellery industry and increasing regulations regarding emissions control in the European automobile sector (DME, 2004). In 2004, demand for platinum within these two sectors amounted to 2.2 million ounces and 3.4 million ounces respectively.

The impact of these market demand patterns on local producer activities has, however, been strongly influenced by commodity cycle and exchange rate trends. When prices have been favourable, new greenfield and expansion (brownfield) projects have been planned, with concomitant spillover effects into the supplier industry. Conversely, when prices have been high projects have been put on hold or curtailed resulting in uncertainty and instability in the supply chain. Since 1997 the price of platinum has outweighed that of gold, peaking at US$937 per ounce in early 2004. While favourable pricing has spurred the expansion of the industry, it has also been influenced by local currency fluctuations. The significant weakening of the Rand in 2001 and 2002, culminated in a massive wave of brownfield investment programmes throughout the industry. Recent levelling and increased stability of the Rand, however, has seen the platinum price rise more than the Rand has strengthened, which has dampened the impact of the platinum boom. Many of the planned expansion programmes have been temporarily suspended and producers have adopted a more cautious approach in their capital investment plans.

At the national level, demand has been shaped by three factors. In the first instance, macroeconomic changes, specifically the increased liberalisation of the South African economy since the 1990s, the divestment of ground holdings activities by large mining conglomerates, and various legislative changes (the enactment of the *Mineral and Petroleum Resources Development Act* and the *Broad-based Socio-economic Empowerment Charter* and associated *Scorecard*), have facilitated the entrance of new foreign players (Southern Platinum (Canada), Aquarius Platinum (Australia), Cluff Mining plc, Pan Palladium) and various junior mining companies into the industry. This has significantly increased the local demand base. Secondly, at the producer level, factors such as the need to improve productivity and increase operational efficiency, adopt mechanised mining methods, improve health, safety and environmental practices, and increase BEE procurement, have exerted positive spillover effects into the supplier industry. Lastly, technical challenges associated with the geological and metallurgical nature of the orebodies – extraction technology is more complex, particularly at depth (e.g. narrow seam orebodies, high virgin rock temperature, presence of dips and potholes), processing variations in mineralogy require alternative processing procedures and techniques, environmental and safety issues (efficient tailing stream disposal, controlling SO_2 emissions, more ergonomically designed equipment to help reduce worker fatigue), and strong competition amongst producers have fuelled the demand for locally-available goods and service industries.

Three types of linkages have emerged between the PGM producers and mining capital goods and services cluster as a consequence of these various demand and factor conditions: vertical; horizontal; and technological linkages.

Vertical Linkages

The most obvious linkages in the platinum cluster are vertical ones – where demand, and the specificity of local demand, from the platinum producers impacts on the supplier network through the various levels of the supply chain. The greater the perceived and realised value offered by a particular firm in the supply chain to increasing the operating efficiency and productivity of the end-user (usually the mining company or EPCM firm), the greater the flow of resources. This transfer of capital between the end-user and the vendor in turn stimulates further exchanges, as the vendor expands, either through innovation or because of increased business with the end-user, its dependence on other service and supplier firms in other sectors also increases. This results in new contracts and exchange of resources arising between the initial vendors and new suppliers, broadening the supply base.

Horizontal Linkages

There are equally important ‘horizontal’ linkages which exist across firms and institutions involved in the platinum cluster, where the development of capabilities and knowledge in one firm enables other firms to attempt developments not otherwise considered possible. Such linkages may therefore embody spillover effects (or externalities), as the effects extend beyond the firm making the immediate decision or investment and are therefore ‘external’ to it. Given the high risks and costs involved in developing and testing a new product in the mining industry, there is often a high degree of collaboration and interaction between firms. Horizontal linkages are therefore quite common in the platinum industry.

Technological Linkages

Linkages also arise within the individual stages of the platinum production chain. These linkages are generally technological in nature and relate to the efficient operation and sustained productivity of a specific piece of equipment or process in the chain. Each plant/operation involved in the production of PGMs (i.e. mines, concentrator plants, smelters and refineries) are all individual systems composed of numerous high-tech components, yet are all closely linked and integrated with preceding and successive stages. The breakdown or failure of any one component in the chain can influence the overall economic viability of the production process. Similarly, the introduction of a new piece of technology or improved component in one stage can result in considerable economic impacts/repercussions through the chain, particularly in terms of increased costs savings, efficiency and production. R&D plays an important role in the strengthening and expansion of such linkages.

The discussion now shifts to unpacking the nature of demand-supply relationships in the PGM industry by first reviewing the various participants comprising the supply chain, then documenting the significance of demand, and then exploring the trends and factors influencing the supply chain and development of linkages.

The PGM Supply Chain

At the top of the PGM supply chain are the producer companies providing the key source of demand for goods and services. There are six producers of PGMs active in South Africa: Anglo American Platinum (Angloplats), Impala Platinum (Implats), Lonmin Platinum (Lonmin), Northam Platinum, Southern Platinum and Aquarius Platinum. Collectively, these mining companies operate twelve mines, four smelters and three refineries. The three top PGM producers in 2004 were Angloplats (41.9%), Implats (35.3%) and Lonmin (15.9%), accounting for 93.1% of South Africa's total production. Supporting these producers is the supplier network (Figure 1).

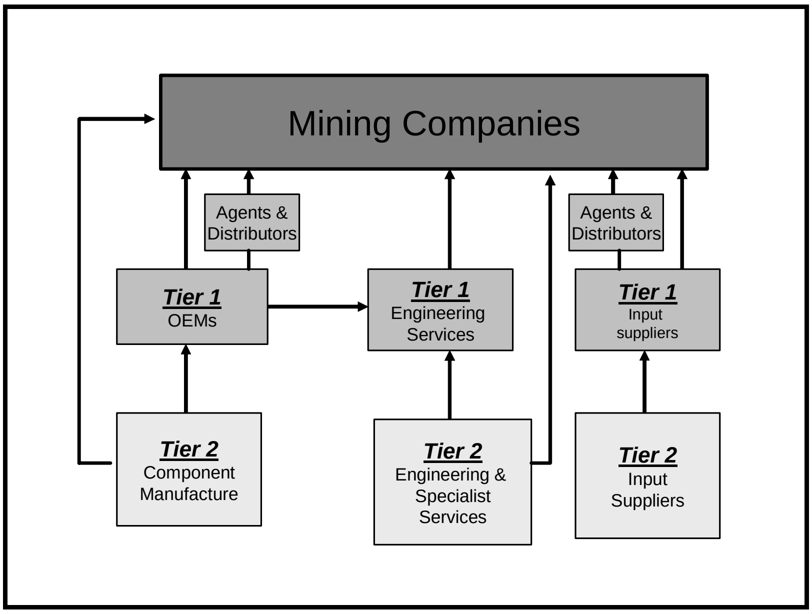

Figure 1: The structure of the PGM supply chain

The PGM Supply Chain: Key Features

From the quantitative analysis[2], it is evident that the supplier network supporting the platinum industry consists of a diverse range of firms. The majority (76%) can be classified as small- to medium-sized enterprises, employing between 1 and 150 employees. There are only a few that can be classified as large-scale firms, employing more than 1 000 people, and together account for the largest number of direct employment spin-offs in the cluster. Based on available data for 393 supplier firms, a total of 94 252 direct employment opportunities have been fostered in the cluster. If additional employment in branch offices, subsidiaries, and additional manufacturers and suppliers (many firms outsource such activities to other firms in the supply chain) is taken into consideration, the impact is much greater. There is a high degree of foreign representation (approximately 33%) in the cluster, which can be attributed to the fact that many international equipment suppliers see South Africa as an important locus for new minerals-related innovation and product development and therefore have well-established branch offices and assembly-oriented operations in the country. Most of these firms are OEMs and standard component suppliers. "Local" (i.e. home-grown) South African firms comprise approximately 67% of firms reviewed. Most of these firms provide specialist consultancy services, are niche component suppliers, or are engaged in the sale, manufacture, service, repair, export, import and distribution of component supplies. The majority of the firms reviewed are between 10 and 20 years old.

[2] This discussion draws on both the firm survey of 55 firms involved in the cluster as well as to a database of 678 mining and mineral processing capital goods and service suppliers operating in South Africa (see Walker, 2004a).

In terms of spatial dynamics, the location of supplier firms is not influenced by the siting of primary facilities. While mines, concentrators and smelters are based primarily in the North West and Limpopo provinces (due to access to orebodies and concentrates), refineries and suppliers tend to be concentrated in Gauteng. Within Gauteng firms agglomerate according to the nature of business. With few exceptions, most OEMs, assembly-based firms and component suppliers are situated in Ekurhuleni (including Modderfontein and Kempton Park) and Central Johannesburg. Engineering and project management consultancy firms, as well as mining company head offices, are based in Rosebank, Sandton, Rivonia, Bedfordview, Randburg and Braamfontein. There are a few firms based in the West Rand, Pretoria and Midrand area. Aside from a few subsidiaries, branch offices and warehousing facilities, few suppliers have relocated operations outside of Gauteng. This can be largely attributed to locational factors such as proximity to an international airport and transport routes, quality of living, and that most companies are involved in more than one commodity sector/industry necessitating the siting of a central office in Gauteng. Despite the spatial differences in the location of the mining companies' operations and the supplier network, long-standing relationships (principally procurement and R&D-based) bind the various firms together.

There are two groups or Tiers of supplier companies depending on whether they provide inputs directly or indirectly (i.e. via an intermediary or aftermarket sales) to the mines and what type of products or services they provide. The key features, characteristics and relationships of the firms to the PGM producers are reviewed below.

Tier 1 direct suppliers include the following types of companies:

Engineering Consultancy Firms

Consulting firms providing engineering, procurement, construction and management (EPCM) services are important players in the market. EPCM firms are often expected to advise end-users (usually mining companies) on product requirements, specifications and availability, and thereby influence their purchasing decisions. They play a particularly important role in the platinum cluster. They usually provide lump-sum turnkey (LSTK) functions, which entails carrying the full cost of the project and handing over the project once everything is operational. The financial strength and ability to facilitate project finance are increasingly becoming the key determinants for these firms' international competitiveness.

The plants and mines designed and built by engineering consultancy firms consist of numerous large-scale high-tech components many of which are not available 'off-the-shelf'. The supply of such products requires considerable in-house expertise or collaboration with other input suppliers with specialised knowledge to meet the required specifications. The core proprietary technology of such components and plants is generally held by the project-management company contracted by the mine to oversee the project. The important factor is the overall design concept and the designer's ability to integrate the different components. The project engineering companies can therefore be considered technical integrators. Much of the cost is taken up by items such as civil construction, steelwork, piping, and cabling, which is generally outsourced to local firms. South African engineering consultancy firms operate both locally and internationally and undertake projects ranging from R50 million to R3 billion. The local and international competitiveness of South African EPCM firms is largely due to the long and close engagement between such firms and mining companies.

South Africa has a very strong base of local EPCM firms which have benefited from the expansion and growth of the PGM industry. While foreign representation tends to be low, most local EPCM firms have strong ties to international research organisations, companies and specialists. Employees are usually graduates with strong practical and technical skills and capabilities in design and engineering. Most of the senior staff have been involved in the mining industry for a long period of time and have an extensive knowledge of the South African and global minerals industry. As most EPCM firms started as either a consequence of an industry push or as a natural spin-off arising from a perceived need, the rate of new start-ups in this category of firm is low.

The nature and role of the EPCM firm has changed considerably within the past few years. There has been a gradual strengthening of some of the previously smaller EPCM firms and concomitant shrinking market share of others. In addition, increasingly the nature of business has shifted from encompassing both a service and manufacturing faction to just a service one with turnkey functions. Factors such as fluctuating commodity prices, the strengthening of the Rand, environmental challenges, and increasing pressure to diversify activities and products and enter new markets have been influential in facilitating this change.

Original Equipment Manufacturers (OEM)

During the development phase of a project mining companies purchase large pieces of capital equipment (e.g. fans, mills, crushers, drilling rigs, and furnaces) directly from an OEM. These products are also sold through agents. OEMs may also sell their equipment to an engineering firm who integrates the products into a complete system, usually for LSTK-type projects (e.g. conveyor systems). OEMs are highly specialised and generally offer expertise/inputs in only one or two product areas.

There is a strong and diversified base of OEMs operating in the country. Most OEMs involved in the mining and mineral processing stages of the PGM production chain are branch offices or subsidiaries of foreign multinational firms with a long history of involvement in the global minerals industry. Due to the small local market for large pieces of capital equipment, most bulk materials handling, underground drilling and hauling, and mineral processing equipment used in the PGM industry are foreign brands. Such firms have benefited significantly from the expanding PGM industry. Most home-grown OEMs providing inputs to the extracting and processing stages are specialised in niche areas such as hauling, drilling and crushing and have emerged and expanded through close interaction with the mining industry over a long period of time, manufacture equipment under foreign licence, or act as distributors and agents for assembled products. While the majority of OEMs involved in the smelting stage are home-grown, most clients currently come from the ferrous industry due to the fact that there are only four PGM smelters operating in the country and demand is limited to brownfields developments. A distinctive feature of the OEMs operating in South Africa is that most are export-oriented in nature and supply a diverse range of industries and commodity groups in addition to PGMs.

Employees in OEMs are either graduates with strong practical and technical skills and capabilities in engineering and design or involved in artisan-type activities. As with EPCMs, many of the senior skilled employees have a long history of involvement in the mining industry, either as employees/technicians on mines or as researchers in R&D institutions or Science Councils. While labour turnover is low, there is a significant degree of poaching of skilled staff in recent years (particularly BEE candidates). Although the rate of new start-ups is low (given the high degree of foreign representation and specialised nature of the products supplied), there has been a considerable amount of consolidation and formation of partnerships in the sector, particularly amongst the smaller home-grown OEMs.

The degree of value added to the products manufactured by OEMs has increased in the past few years and has contributed to increasing the operational efficiencies of the clients concerned. However, as the core technology underpinning such products is high-tech in nature and tends to be held by the parent company based overseas, the actual value added to South Africa in terms of broadening the local technological base has been low. Increasingly, the nature of business within OEMs has shifted from encompassing purely a manufacturing function to including a greater service dimension. After-sale services and asset management are increasingly being included in the total package offered to clients.

Input Suppliers

These are companies that sell products, usually consumables, directly to mining companies. Typical products include explosives, reagents, chemicals, fuel and fluxes. Such inputs are generally highly-specialised and expensive and sold on long-term contracts with the mines.

Agents and Distributors

These companies are important players in the supply chain, either through their capacity as an importer/exporter or in supporting OEM products through the provision of services and spares. These firms are intermediaries and play a greater role in particular product sectors such as pumps, bearings, vehicle parts, etc. There is a significant degree of foreign representation in this sector with numerous branch offices and distributorships scattered throughout the country.

Tier 2 indirect suppliers include:

Engineering & Specialist Service Suppliers

These are specialised engineering companies sub-contracted by an EPCM or LSTK company to undertake selected aspects of the design, management or installation of a project. Such firms usually have expertise in one or two areas, such as electrical engineering, ventilation, or environmental/tailings management. Such functions, however, would also be used directly by mining companies during the ongoing operation of the mine or plant.

Component Manufacturers

These firms provide the standard components used in a particular piece of equipment or process. Component suppliers comprise a wide spectrum of firms and are numerous in number and roughly fall into three categories. First, manufacturers of standard components such as conveyor belt idlers, electric motors, and electric cabling. While there are numerous firms providing such products in South Africa, most of these are distributors and agents for foreign companies. Secondly, manufacturers of specialised niche components, such as hoisting hooks and pinch valves. A considerable amount of innovation and entrepreneurship characterises the activities of such small- to medium-sized companies. While the finished item adds significant value to a particular production process, demand for the product is usually limited to a select range of customers. Thirdly, foundries and steel fabricators are an important part of the supply chain, providing structural materials, unfinished components and wear parts to different levels of the chain.

The largest concentration of home-grown suppliers in the PGM supply cluster is represented by the component manufacturing sector. Many of the firms involved in this sector have benefited from the platinum boom. Due to the diversified nature of their activities – many component suppliers provide inputs to more than one client across a range of resource-based firms – most small firms have been able to withstand the effects of currency and commodity pricing fluctuations in the market. Most firms are small to medium in size. In specialised niche suppliers, given the high-tech and incremental nature of product adaptation and development, the rate of new start-ups is currently quite low. The market for standardised components is significantly larger than that for specialised niche products, however, the penetration of pirated parts is a threat to the continued existence and expansion of such firms.

It is important to note that the number of firms in the cluster increases exponentially as one moves further down the supply chain.

Type of Products

The supply chain supporting the platinum-mining industry is vast. Broadly, the equipment used by the mining industry can be divided into the following sectors and sub-sectors: mining (surface and underground vehicles and haulage equipment, drilling equipment, ground support, underground mining equipment, explosives ventilation and cooling equipment, pumps, wear parts, and drilling consumables); mineral processing (machinery to sort, screen and wash mineral products, crushing and milling equipment, mill consumables, spray and dispersing and leaching equipment, pad and pad liners and rubber products, flotation cells, filters and thickeners, chemical reagents, control equipment); smelting (furnaces, refractories, electrodes, converters, ladles, ingot moulds, consumables); refining (industrial, laboratory, furnaces, ovens, incinerators and dryers); and general cross-cutting equipment (conveyor systems, pumps, valves, tanks, hydraulic and pneumatic systems, electrical equipment, and health and safety equipment).

Most of the equipment supplied by the mining and mineral-processing goods and service cluster, especially the component suppliers, falls within the following Standard Industrial Classification (SIC) codes: 356-359[3] (machinery and equipment), 361-366[4] (electrical machinery), 382 (non-electrical machinery), and 385 (transport equipment, excluding motor cars).

The Significance of Demand

Demand for inputs in the PGM production chain tends to be concentrated in four areas – mining (both surface and underground); mineral processing (including crushing, milling and flotation); smelting; and refining (base metal and precious metal)[5]. As each processing step is designed to increase the grade of the economic components of the ore while reducing the bulk of the products, technology issues get more complex and the process becomes more skill-intensive with each subsequent level of processing undertaken.

In order to appreciate the significance of backward linkage development from the PGM industry it is necessary to highlight some examples of contracts signed at various stages of the production chain.

The Mining Phase

Establishing a deep level PGM mining operation could cost anywhere between R1 and R3 billion. The main areas of expenditure include: shaft sinking (R300 000-R450 000 per metre), initial underground development (R100 000-R150 000 per metre), civil and steel infrastructure work for the buildings and concentrators, purchase of fleet of underground equipment (drill rigs, LHDs, trucks), and ventilation and pumping systems (see Box 1 and 2). Once operational, the main capital cost areas in the mine include labour (approximately 37% of costs), mining equipment (17%), engineering and bulk supplies (16.5%), mining consumables (28%), and other (1.5%). The mining stage accounts for 72% of total operating costs across the production chain.

[3] Machinery and equipment includes engines & turbines (except aircraft, vehicles & motor cycle engines); pumps, compressors, taps & valves; bearings, gears, gearing & driving elements; ovens, furnaces; lifting & handling equipment; general purpose machinery; agricultural & forestry machinery; machine tools; machinery for metallurgy; machinery for mining, quarrying & construction; machinery for food, beverage & tobacco processing; machinery for textile, apparel & leather production; weapons & ammunition; other special purpose machinery; household appliances; and office, accounting & computing machinery.

[4] Electrical machinery includes the manufacture of: electric motors, generators & transformers; electricity distribution & control apparatus; insulated wire & cable; accumulators, primary cells & primary batteries; electric lamps & lighting equipment; and other electrical equipment

[5] The exploration stage was excluded from the analysis as an entirely different set of skills is required. It also has the smallest representation in the cluster. The further beneficiation of PGMs beyond the refined metal stage was also excluded as the majority of the PGMs produced in South Africa are exported and beneficiated off-shore. The local concentration of input suppliers and consulting firms are likely to be significantly less in these final stages than in the previous four stages.

BOX 1:

Impala Platinum, Construction at Winnarshoek

Contracts for the initial construction and preparation at Winaarshoek included:

- Boxcut mining and support for Driekop decline – MCC Contracts (approximately R6 million)
- EPCM contract – DRA (R22,75 million)
- Earthworks contract – UWP Consultants (R950 000)
- On-site earthworks – VVB Construction (R14 million)
- Access road construction – Basil Read (R24 million)
- Roadworks EPCM contract – SRK/Ninham Shand joint venture (R2 million)
- Decline sinking was projected to start in the first quarter of 2002, and commissioning was set for the third quarter of 2003.
- Start-up capital was approximately R1,75 billion.

Source: Mining Weekly, 2001a.

Impala Platinum, New shaft infrastructure – No 16 Shaft

Impala Platinum is investing in new shaft infrastructure at its North West Province mining operations. This includes the development of No 16 Shaft situated on the south-east corner of the Impala mining lease down-dip of No 1 Shaft. Features of the project:

- Capital expenditure on new shaft infrastructure – R6,6 billion
- EPCM contract awarded to RSV in 2004
- Sinking of No 16 main and ventilation shafts contract awarded to BEE firm Shaft Sinkers – R560 million
- Upon completion, the headgear will consist of:
    - 1 360 t of reinforcing steel
    - 9 420 m^3 of concrete
    - 800 t of structural steel inside the headgear

Source: Engineering News, 2005.

BOX 2:

Boart Longyear's contract with Brandrill Torrex

Boart Longyear was contracted by Brandrill Torrex in 2002 to supply the full suite of machines required for Crocodile River Mine's, Maroelabult Section Project, in the North West Province. The contract, valued at US$6.5m, included:

- 4 single boom Aardmaster LPD rigs;
- 4 UV42 single boom Roofbolters;
- 9 Aardmajor LHDs;
- 3 UV42 utility vehicle cassette carriers;
- 2 UV42 fixed explosive carriers;
- and a fully inclusive maintenance contract that will run for a minimum five years.

Source: Boart Longyear Press Release, 2002

Vehicle maintenance and assembly costs

Mobile hauling and drilling equipment is generally assembled underground at a cost of R100 000 per vehicle. Vehicles are expensive to operate (each catalytic converter costs R15 000 to replace) and all run on diesel.

Mineral Processing

Mineral processing typically accounts for 10% of costs involved in the platinum production chain. Development costs for concentrator plants are approximately R400 million. The civil construction is the largest costs, followed by mills, steelwork and flotation cell. Once operational, labour, utilities (power and electricity), capital equipment and reagents are the largest areas of expenditure. An example of the value of contracts associated with the establishment of a concentrator plant is provided in Box 3.

BOX 3:

<u>Impala Platinum's Marula PGM Concentrator:</u>

- Capital expenditure for construction and commissioning – R1,53 billion
- EPCM contractor – DRA. Portion of contract valued at R900 million.
- Features of the construction phase:
  - Duration: 18 months
  - On-site construction workers: 1 500 – 1 600 people (35-40% local)
  - Bulk earthworks: 1.5 million m^3 of earth moved
  - Concrete poured: 17,470 m^3
  - Structural steel: 2,950 t
  - Platework used: 1,078 t
  - Piping installed: 33 km
  - Cabling used: 340 km
  - Access road constructed: 6.2 km
  - Drives installed: 700
  - Fencing used: 25 km
  - Number of EPCM man-hours: 280 000
- The project was broken down into some large contract packages, as well as numerous smaller contracts. Major contracts included:
  - Civil works: Group 5 – R60 million
  - Earthworks: VVB – R40 million
  - Structural steel, platework and mechanical equipment erection section: Dorbyl Structural Engineering (larger portion of contract) and Concor Engineering – R60 million
  - Conveyors: Roymec – R32.5 million
  - Piping: Fabricated Piping Systems – R25 million
  - Electrical instrumentation: Kentz – R30 million
  - Main access road construction: Basil Read
- DRA responsible for installing potable water plant, sewage plant, power reticulation and the construction of the tailings dam
- Mine sorted out contract for access road (Basil Read), main water supply, electricity (Eskom), and local labour (Teba) before DRA took over EPCM contract.

Source: Mining Review Africa

Smelting and Refining

Smelters are among the most expensive plants to establish in the PGM production chain. Each of the four smelters in operation in South Africa cost between R1 and R1.5 billion to build. Infrastructure and construction account for around 50 per cent of the total establishment costs. The furnace itself might only account for 15 per cent of the overall costs. In terms of operational costs, both smelters and refineries account for 9 per cent of total operational costs. Salient features underpinning the construction of Anglo Platinum's Polokwane Smelter in 2003 are highlighted in Box 4.

BOX 4:

Anglo Platinum, Construction of the Polokwane Smelter

- Capital cost – R1,31 billion. Main areas of expenditure were:
    - Infrastructure – 24%
    - Construction – 24%
    - Reimburseables – 18%
    - Furnace – 15%
    - Dry concentration handling – 6%
    - Matte handling – 3%
    - Off gas handling – 3%
    - Slag handling – 2%
    - Electrical infrastructure – 2%
    - Wet concentrate storage – 2%
    - Services – 1%
- In addition, during the construction period:
    - Earth moved – 1.90 million m^3
    - Concrete used – 60,000 m^3
    - Structural steel and platework used – 5,700 t
    - Piping – 32 000 m
    - Cabling used – 380 000 m
    - Cable racking used – 9 700 m
    - Number of electric motors installed – 314
    - Number of light fittings used – 3 200
- The supply and installation of electrode columns and low-voltage bus systems – R20 million

Source: Anglo Platinum, 2003.

From the various examples highlighted above it is evident that firms that succeed in becoming preferred suppliers to the mines, either directly or indirectly, stand to reap significant economic and commercial rewards. The degree to which a firm is able to capitalise on these opportunities is, however, strongly dependent on the decision-making and procurement process at the mine and subsequent levels in the supply chain.

The Procurement Process

The procurement process occurs at each level in the supply chain and receives its initial impetus from the mining company.

Dynamics at the Producer Level

The producer companies largely 'govern' the value chains that arise in the manufacture and supply of a particular capital good or service input. The exceptions are where the suppliers are particularly influential due to the nature of their capabilities. In light of the need to transform the industry and ensure equitable representation in all facets of the production chain, enforce regulation in the area of health, safety and the environment, remain cost-competitive and improve efficiencies in the production process, a considerable amount of re-evaluation and re-assessment has occurred at the producer level with regard to the way the procurement process is managed and the type of goods and services used.

In particular, there has been a change in where procurement decision-making takes place. While some producers have centralised procurement, gaining economies of scale, other have decentralised activities to the level of the individual operation. Associated with this has been a change in the nature of contracts and the responsible firm/department for selecting suppliers. The nature of the contract determines how the mines procure from its suppliers and also the interactions needed to fulfil the orders. In a greenfield project, engineering firms play an important role in the procurement process. If it is an EPCM contract, engineering firms usually play an administrative and integrator role and draw suppliers off a pre-approved supply list. In a LSTK project, such firms either purchase equipment independently or via prior consultation with the mining companies. For brownfield projects, the role played by engineering firms is minimal as OEMs and component suppliers generally sell directly to the mines. To a certain degree, the increasing emphasis on cost reduction and maximising efficiencies by the mining companies has resulted in a shift in responsibility and power in the procurement process to EPCM firms. Increased outsourcing is seen as both a cost-saving and risk reducing strategy with benefits to both parties. At the same time, in many instances long-term contracts (5 to 10 years) have been re-evaluated and firms are now on a monthly, or short-term contact (6-12 months), which is subject to review before reinstatement. Maintenance and contract mining contracts are usually on a much longer term basis and generally performance-based.

Another significant development that has occurred at the producer level, is a consolidation and reduction of vendor lists. Mining companies are increasingly shifting more and more to outsourcing non-core activities and sourcing from suppliers capable of providing a 'total solutions' package. The degree of outsourcing, however, differs for each mining company. Smaller mining companies with limited internal capacity typically outsource more work to contract suppliers. For all producers, however, most of the outsourced contracts are currently focused on asset management which has increased the role of the OEM in the procurement process. While vendor lists are constantly being reassessed and reduced this has been countered by a move to increase the level of BEE/HDSA procurement. In terms of the criteria used to select suppliers, there is an increasing emphasis on the 'total cost of ownership', which involves not only the initial capital costs but also maintenance and operating costs of the equipment. For commodity, or easily interchangeable products, price is the main factor influencing the procurement process at the producer level. However, for certain products that are technology based, price plays a lesser role.

Dynamics at the Supplier Level

The increasing emphasis on outsourcing and reducing vendor lists at the producer level has had important ramifications at the supplier level, particularly in terms of increasing the efficiency of equipment and services offered and the formation of additional linkages in the supply chain. The impacts and response of the various firms are worth noting.

The shift to centralising the procurement process to the divisional level or at head office of mining companies has meant that the level of flexibility in sourcing alternative products and services has decreased. Buying officers prefer to deal with a smaller more manageable and organised list of suppliers. Furthermore, the flexibility to change suppliers is limited to the management level as there is often a reluctance to change from known equipment to an unknown and new source and run the risk of having to keep a greater range of spare parts. The reduction of vendor lists has placed large firms at an advantage and has meant that smaller firms have to enter into collective arrangements during the tendering and supply process in order to compete for contracts and provide the range of goods and services required. However, inefficient communication in the supply chain has meant that many of the smaller firms are unaware of new projects and opportunities for partnerships.

The shift to outsourcing and the increasing emphasis on the provision of 'total solutions' at the producer level has forced many suppliers to diversify their scope of business in order to offer as broad a product line and range of capabilities as possible to secure tenders. The fortune of the various suppliers active in the inputs cluster has been mixed as a consequence. Some local EPCM and specialist consulting firms have expanded activities and raised their competitiveness as a consequence of the increased outsourcing of responsibility and project management by the mines and the expanding platinum industry. For others, the level of involvement has decreased. Many of the large international OEMs active in South Africa country have benefited significantly from the rising demand from the PGM producers. Their ability to provide a broad range of products and expertise has meant that they tend to get preference during the tendering phase, often to the detriment of the expansion of local smaller OEMs lacking such advantages. While the level of competition between OEM firms has increased significantly in light if this, it has also been matched by an increase in local collaboration and co-operation, particularly amongst smaller firms, to provide clients with a total package. Although OEMs have traditionally focused on selling equipment, such firms are increasingly including asset management and after service maintenance contracts as part of their contracts, which is strengthening their position and role in the procurement process. Asset maintenance contracts are usually formalised at the outset of a project and are usually renewable. While this gives surety of business to some firms over the short- to medium-term, it also means that some suppliers are excluded from the process and are forced to seek alternative (non-platinum related) markets for business.

Although mining companies claim that the purchasing decision is made with both technical and commercial input, there is a perception amongst suppliers that commercial issues have become more important in the selection process. In the past, non-price measures were prioritised over price measures, but increasingly the trend amongst mines is to shop around for the lowest price. Component and OEM suppliers regard the EPCMs' procurement processes as being too rigorous. While the decision to use a particular supplier is influenced and determined by design and quality requirements, product availability, support services, financing stipulations, and overall price, the need to limit the overall capital cost of a project can lead to an engineering company specifying certain cheaper, but shorter-life items. Many of these cheaper products are foreign imports, which undermines the competitive position of niche component suppliers and delays opportunities for involvement in the industry.

Component suppliers maintain that smaller firms have been most affected by the changing nature of the procurement process and assert that it is very difficult for new firms to enter the market. In particular they argue that the procurement process has become more commercialised and specialised in nature – whereas firms would previously deal directly with end users in the mining companies, commercial contracts are now being redirected via a functional procurement department with specialist buyers. The drawback is that contracts are subjected to greater scrutiny by specialist buyers than before. Buyers use their bargaining power to force greater competition in the market by engaging suppliers in competitive tendering processes e.g. getting at least three quotations per product offering. Entry is also being challenged by the presence of firms providing pirated parts at a much cheaper rate as well as foreign imports of similar products. The market for component supplier is also changing with the increasing emphasis by mining companies to source from BEE-compliant companies as part of fulfilling the *Mining Charter* requirements. This is placing strain on many of the local family-owned suppliers as they seek to maintain both their family heritage and involvement in the industry and fulfil the broader transformation requirements of the industry.

In terms of how firms at the top of the supply chain view the competitiveness of the component suppliers, OEMs and EPCM firms argue that while the steel and foundry industries play an important role in broadening downstream fabrication opportunities in the country and are very good at making short run orders, they are only reasonably competitive at present due to high input costs and limited production runs. In addition, problems are often encountered regarding the quality of the product produced, time taken to deliver the products, and compliance to contract specifications.

Overall, firms at all levels of the supply chain maintain that relationships are a key factor in securing work. Many OEM and component suppliers feel that EPCM firms and mines tend to favour sources that they have used previously and often impose conditions which cannot always be met by small firms. The consolidation of the minerals industry under the control of a few large multinational mining companies has weakened the position of the small, individual, local supplier. This has resulted in a weakening of manufacturer-client relationships, which are critical in the development of incremental product improvements. There is also a general feeling that poor and fragmented communication along the value chain has hampered the growth and global competitiveness of both the broader minerals industry and the inputs cluster.

Firms argue, furthermore, that there are a number of other indirect factors that have affected their ability to secure contracts and capitalise on demand opportunities. At the OEM level these include the high cost of doing business, pricing pressures, the threat of pirated parts, the high cost of local manufacturing, the threat of monopolies, and the small size of the local market for bulk products. For standardised and niche component suppliers factors such as a fluctuating currency, increased costs of raw material inputs (e.g. steel), variability in demand, inadequate certification, working capital constraints, little transparency in the procurement process, and increased threat of pirated parts are adversely affecting the degree of backward linkage further down the supply chain.

While the procurement process remains the key factor currently influencing the dynamics of the cluster, the ability to sustain and broaden existing activities as well as develop future capabilities and expertise in the manufacture and design of internationally-competitive products and processes requires expanding basic factor conditions. In this case, understanding the level of R&D and available skills base characterising the cluster is critical in order to project where future opportunities lie and what bottlenecks need to be alleviated in order to facilitate future linkage development.

Evaluating the Current R&D Base

Despite the long history of innovation and adaptation in the PGM industry, there is concern that South Africa is rapidly losing its competitive advantage in niche areas. Within the past 10-15 years the minerals industry has seen a shift in emphasis from long-term research and development and pure innovation to short- to medium-term product development and design. Historically, a considerable portion of long-term 'blue sky' R&D was undertaken within research laboratories of the main mining houses and the Chamber of Mines Research Organisation (COMRO). This changed fundamentally from the early 1990s when the minerals industry embarked on a massive wave of restructuring in response to broader national changes and a dramatic decline in the gold price. Virtually all the mining conglomerates embarked on a process of consolidation, listed operations overseas, and divested all non-core activities, including in-house research laboratories (Chabane, *et al*., 2004). Although many of the engineers and scientists retrenched during this process subsequently formed new consultancies and manufacturing operations directly supporting the mines, a considerable portion of expertise was lost through emigration and retirement.

Given the risk, capital-intensity and long time lags involved in the research, development and final commercialisation of a product or process, most long-term R&D is now undertaken by state-funded research organisations such as CSIR Mining Technology and Mintek. However, such organisations have also undergone significant restructuring in recent years, with greater emphasis being afforded to product development and commercialisation than 'blue-sky' research. Science Councils are no longer perceived by suppliers to be the primary 'one stop shop' for solving critical R&D problems and providing skilled employees in the country, rather, they are regarded as being just another research laboratory or consultancy. The importance and relevance of the Science Council in preserving the 'blue sky' R&D dynamic in the country is therefore changing and requires reassessment at both the Government and private-sector level.

These developments have been matched by a gradual decline in the level of in-house R&D undertaken by the private sector. Producer companies perceive their primary business to be the extraction, processing and refining of PGM resources for local consumption and export. Similarly, engineering services companies see their role in the cluster as one of designing, building, installing and integrating the various capabilities and products needed to bring a new project or expansion to fruition. Neither regards long-term R&D as their core business *per se*, but all are involved to varying degrees in the design and development of product upgrades and process improvements. Such companies reserve involvement in 'ground-breaking' innovations to joint ventures and partnerships with other companies, research organisations and universities (both locally and abroad).

In OEM firms and specialist service companies, a portion of the annual turnover (0.5-5%) is usually reserved for R&D efforts. This R&D, however, is generally short- to medium-term in nature and reserved for specific products and areas. While some mining companies prefer not to get directly involved in OEM-related R&D, in other cases there is a general willingness to collaborate with OEMs in refining and modifying equipment and processes. Collaboration is viewed as means by which to reduce costs and minimise risks and beneficial to both parties. Due to the high degree of foreign involvement in OEM-type activities in South Africa, however, most of the R&D undertaken by such firms is generally held by the parent company overseas. In OEM firms that are South African by origin, if the required technology or expertise needed to fulfil a particular order is available locally firms will tap into it. If not, the current business philosophy in most companies is to acquire or purchase technology from overseas and locally adapt it or just to act as agents and distributors for specialist foreign manufacturers. Capital is not invested directly in long-term R&D as it is difficult to justify such expenditure when trying to meet the bottom line.

In niche oriented component suppliers, while R&D is perceived to be critical for maintaining current operations and future competitiveness (especially with the increasing threat of imports and pirated parts), very little R&D is undertaken due to the small margins of such firms. R&D is limited to product adaptations and incremental improvements. Many firms in this sector maintain that even if R&D is undertaken and improved technologies or products result, there is no guarantee that the product will be used by an EPCM or mining company. Mining companies are generally reluctant to switch equipment and are risk averse to using untried or unfamiliar products. The preference of the industry for short-term, product improvement-related R&D, rather than long-term applied research has important policy implications, not only in terms of preserving the current dynamism of the cluster but also the development of future capabilities, know-how and technological linkages.

While the government has introduced a number of incentives to assist firms in improving their innovative activities, R&D and exports, consultation with supplier reveals that many firms are unaware of the existence of such schemes. Many also lack the resources and spare capacity to identify and pursue such assistance packages. Moreover, those that have drawn on them (generally the larger firms) find the application procedure and eligibility requirements restrictive and time-consuming. There is also a general perception amongst participating firms that government programmes and incentives are geared towards supporting R&D for products or ‘widgets’. Most service engineering firms and suppliers involved in software or IT-based technologies therefore cannot take full advantage of these incentives given the intangible nature of their final products.

A notable finding from the assessment of R&D in the PGM industry is that where there are clearly defined goals and incentives, institutional activities and collaboration between firms and mining companies are co-ordinated, R&D expenditures and technological outputs are the highest. In addition, innovation and product development has been greatest when there has been a distinct ‘technology push’ or motivated by a definite industry need. In this regard, increasing regulations and monitoring of health and safety and environmental issues, the shift to mechanisation and the need to drive down costs at the producer level have stimulated numerous technological developments and advancements throughout the supply cluster.

Engineering and Skills Base

The South African mining industry has historically been recognised (both locally and internationally) as a being a world leader in various aspects of the extraction and processing of mineral resources. This has led to a core of expertise and technical know-how in areas such as deep level mining. Over the past 10-15 years, however, the engineering and skills base has undergone significant transformation, restructuring and contraction which has implications for the sustained growth and vibrancy of the supply cluster. There have been a number of factors and reasons for this.

Firstly, the contraction of the local mining industry in the early 1990s resulted in significant job losses throughout the industry through retrenchment, emigration, and the early retirement of skilled personnel. Insufficient and inadequate succession planning in the industry in subsequent years has been unable to fill this void.

Secondly, there has been a change in mindset regarding the career opportunities to be found in mining. Mining has acquired an image of being dirty, eco-unfriendly and dangerous. The increased popularity and attraction of sectors such as ICT has seen many graduates pursuing careers in such areas over that of mining and mineral processing. Consequently, over the past 10 years there has been a gradual decline in the number of graduate engineers, technicians and artisans entering the workforce. This presents a huge challenge to ensuring the future growth and sustainability of the PGM industry.

Thirdly, there has been a change in where skills are sourced by participants in the cluster. Twenty years ago most technicians working for the major mining houses, such as Anglo American and Gold Fields, received a considerable degree of training in-house. Parastatals such as the railways, Iscor, and the army also provided a valuable pool of skilled technicians and artisans which industry tapped into. However, much of this apprentice-type training has since been lost through the restructuring of the industry. The contribution of the Science Councils to generating a skilled workforce has also gradually declined. Although Mintek does have a bursar and training programme for technikon and university (under- and post-graduate) students, particularly for historically disadvantaged South Africans (HDSAs), there is a widespread opinion amongst specialised suppliers that the kind of metallurgists and mineral processing engineers produced are not of the standard and number needed to sustain the local hydro- and pyro-metallurgical industry in the medium- to long-term.

Three types of skills are in particular demand within the supplier industry. Firstly, engineers with expertise in all major fields as well as specialised engineering design skills and an ability to approach a problem in a 3-D manner are also needed. Secondly, there is a shortage of technicians with skills in automation and mechanisation. Suppliers have seen a dramatic growth in the number of machines in use in the mining industry over the past five years. The profile of technical skills in demand has thus changed in light of the shift to increased automation and mechanisation, the widespread use of CAD and software/IT, and emphasis on short lead times and maintenance. Thirdly, artisans, particularly draughtsmen experienced in CAD, fitters, millwrights, turners, boilermakers, toolmakers, welders, CNC operators, patternmakers, cutters, and IT technicians are needed. The average age of an artisan in South Africa is 45 years old.

In terms of finding solutions to the long-term skills challenge, a distinction needs to be made between those that relate to education and those to training. With regard to education, there is general consensus among suppliers that while there is some alignment between programmes offered at tertiary institutions and industry needs in some areas, in other areas it is weakening. Areas of collaboration and knowledge development at the tertiary level are highest in the fields of metallurgy and mineral processing. In other disciplines, such as mining and mechanical engineering, the supplier industry feels that closer collaboration between the universities, universities of technology (former technikons) and manufacturing and design firms is needed to ensure that the skills acquired by students meet those required by the industry. Firms are concerned that not enough people have on-mine experience and the appropriate training needed to commence work immediately. Firms at all levels are undertaking in-house training programmes in an attempt to compensate for this. Firms maintain that the training programme offered by the mines to graduates is important and needs to be re-evaluated regularly to ensure alignment. They also maintain that the possibility of reintroducing the apprentice programme should be re-evaluated. The Government supports these initiatives and has introduced the Skills Development Act (1998), South African Qualifications Framework, and the Mining Qualifications Authority (1995), and established SETAs in an effort address these problems at the national level (Walker, 2004a).

Discussion and Conclusion

The South African PGM sector is currently the highest-earning sector in the domestic minerals industry and a key force behind the development of vertical, horizontal and technological linkages throughout the economy, particularly in sectors such as manufacturing, metals and engineering, and construction. From the perspective of Government, understanding how these linkages formed, what provides their current dynamic, and whether they will be sustainable into the future is a critical concern.

The supply chain supporting the PGM mines, concentrator plants, smelters and refineries is a diverse and broad network of different sized companies, most of which are concentrated in Gauteng. The cluster is dominated by a strong collection of Tier 1 project engineering companies and Tier 2 specialist consultancies that are internationally competitive and active in numerous markets. There are significantly fewer local Tier 1 OEM manufacturers competing on the world markets as the South African market is generally too small to sustain them. Thus, there is a strong reliance on foreign companies for large-scale, high-tech capital equipment. There are a few South African OEM companies involved in pyrometallurgy, haulage equipment, and drilling equipment. South Africa has a broad and diverse range of Tier 1 and Tier 2 input and component suppliers. Many of these companies have demonstrated an ability to generate incremental demand-driven innovations for niche environments and markets. It is this type/group of companies that government should focus its future attention and support on in fostering a vibrant inputs cluster with linkages and spin-offs in mining and non-mining activities.

From the review of the PGM industry and associated suppliers it is evident that while some firms have benefited from the increased demand for goods and services at the producer level, others have not. Factors affecting competitiveness and sustainability of supplier activities include: access to engineering and technical skills, access to skilled artisans, access to government incentives and finance for R&D for ‘home-grown’ firms, awareness of projects and business opportunities, lack of adequate business training and management, certification, high cost of imports, lack of resources to identify assistance programmes, lack of understanding of BEE, preferential relationships in the procurement process, and threat of inferior imports.

Resolution of these bottlenecks requires collective action at the government, industry sector, and management levels. Possible interventions include, firstly, re-evaluating the procurement process. In particular, the Mining Charter must be linked to local value-added through the supply chain and supplier relationships between international and local OEMs and component suppliers must be strengthened. Secondly, the local skills base needs to be boosted, particularly in artisan, technical and engineering-type activities. One measure than could be adopted is to establish learnerships. At the same time, immigration laws need to be relaxed, existing skills must be retained, and programmes must be put in place that enable the transfer of skills from one generation to another. Thirdly, in order to boost BEE involvement in the supply chain a greater understanding of the targets and criteria outlined in the *Charter* needs to be transmitted to small- and medium-sized firms. In addition, facilitation mechanisms for non-listed firms to comply with BEE requirements must be put in place (e.g. via partnership arrangements, IDC development finance, black business supplier development programmes). Fourthly, one of the greatest limitations hindering the development of backward linkages in the PGM industry is the lack of industry sector co-operation and efficient knowledge and information management. Joint collaboration of specialised supplier groups would go some way to ensuring greater ‘local’ participation in the procurement process. This, however, requires the identification of lead projects in input sectors and proactive government support. In order to increase awareness of local and international opportunities for capital goods and services, an industry information portal should be established and export support packages should be made available to assist firms in leveraging new opportunities. Lastly, in terms of increasing the level of long-term, applied R&D in the PGM sector, a review of existing incentives and assistance programmes needs to be undertaken.

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