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INDUSTRIAL STRUCTURES AND SKILLS IN THE METALS BENIFICATION SECTOR OF SOUTH AFRICA

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Research Report

Industrial Structure and Skills in the Metals Beneficiation Sector of South Africa

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INTRODUCTION

South Africa is remarkably well-endowed with metals. It has more than 80% of the known world reserves in the platinum group metals (PGM) and manganese, more than 70% of chrome, and around 40% of gold and vanadium. In addition it holds considerable reserves in titanium and zirconium and produces considerable iron ore and nickel (DTI, 2005:13-14). Combined with the abundant supply of coal and cheap electricity, South Africa thus has a considerable comparative advantage in metals beneficiation.

This chapter presents an overview of the metal beneficiation sector of the South African economy. It starts off by demarcating the sector and indicating its significance to the South African economy. It then summarises the historical forces that shaped the growth and structure of the sector. This is followed by a discussion of the value chain that shows the extremely low levels of beneficiation that have been achieved thus far and the reasons for it. At the same time the immense potential for far more beneficiation and employment creation in the value chain are pointed out.

This chapter also examines significant sub-sectors of the metals beneficiation sector in which South Africa has developed important strengths, namely steel, aluminium and precious metals. Other sub-sectors, namely, foundries, metal fabrication, the structural steel industry, stainless steel consumer goods, the tank container industry, and jewellery manufacture will also be analysed. The chapter ends of with a discussion of some cross-cutting issues common to all the sub-sectors that influence the competitiveness of the sector as a whole. These are the pricing practices of base metal corporations, investment in new technology and tooling, and the challenge of skills acquisition.

DEMARCATING THE METALS BENEFICIATION SECTOR

For the purposes of this study the metals beneficiation sector is taken to include the following sectors: manufacture of basic metals, fabricated metal products, manufacture of machinery and equipment and of office, accounting and computing machinery (Division 35), as well as manufacture of electrical machinery and apparatuses (Division 36).[2]

The metal beneficiation sector *excludes* the manufacture of radio, television and communication equipment, as well as professional and scientific

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[1] Metals are any of a number of chemical elements and alloys that are often lustrous, malleable solids, and are good conductors of heat and electricity.
[2] All the Divisions in this paragraph refer to the Standard Industrial Classification (SIC) drawn up by the South African Department of Statistics (StatsSA).

equipment that fall under Division 37. It also *excludes* the manufacture of all transport equipment (Division 38) such as motor vehicles and components, as well as the manufacture of all non-metallic products (Divisions 33 and 34).

The metals sector is a very significant sector in the manufacturing industry as a whole. It constitutes roughly a third of all manufacturing activity (DTI, 2005:18). In 2002 the sectors represented in the Metal and Engineering Industries Bargaining Council (MEIBC) employed 29% of formal manufacturing employment and accounted for 41,5% of total manufacturing sales[3] (FRIDGE, 2003a:1). The manufacturing industry itself is the second largest sector in the economy (DTI, 2006:11). It contributes 16,4% of GDP (Statistics SA, 2007a: 4, Table A) and employs 1,33 million or 16,2% of people in employment in South Africa (Statistics SA, 2007b: 27).

The metals beneficiation sector almost inevitably entails engineering skills and processes. It is therefore appropriate to refer to it as the metal and engineering sector when wishing to highlight both aspects of metal beneficiation. This is generally done in the remainder of the report.

The next section provides a brief historical sketch of the major historical forces that drove and shaped the metal and engineering sector to become what it is at present.

CATALYTIC FORCES SHAPING THE METAL AND ENGINEERING SECTOR

Unlike other single mineral exporting countries, South Africa's unique endowment of precious metals as well other base and non-base metals has given impetus to a particular industrialization path. Large deposits of precious minerals were a fundamental catalyst to this process. The geological formation in which these mineral deposits were located posed unique organizational challenges to the entrepreneurs who were intent on bringing this underground wealth to the surface. The corporate economy that was built on the mining industry gained a shape and structure in which a number of very large enterprises dwarfed much of the rest of the economy and consolidated control into only a few hands. This enabled the mineral industrialization process to unfold in a particular way. (Feinstein, 2005: Chapter 5)[4]

Initially the large mining companies were the nodes around which a network of suppliers of infrastructure and services came to be established. However, the enterprises that emerged to provide specialized services to the core operations of these mining companies, including metal and engineering firms,

[3] The FRIDGE study represents a broader section of the metal and engineering industry than is included in this study because it includes the automotive components and plastic converters sectors. The figures thus overstate the share of the metals beneficiation sector in manufacturing industry.
[4] In addition to his remark about a 'catalytic agent' to manufacturing (p.182), Feinstein's discussion to these processes is absolutely sublime.

found markets in the agricultural, transport and manufacturing sectors that created opportunities for the enterprises to expand their operations beyond maintenance and repair. Thus, the activity of large-scale mining with very specific technical demands created a supporting industrial infrastructure to meet the engineering challenges, which in turn provided a catalyst for a much wider range of operations. (Feinstein, 2005: 115; Rosenthal, 1981)[5]

This initial impetus from the mining industry was followed by others at key points in South Africa's industrial development, mostly driven by surges of foreign direct investment. The first impetus came from mining sector capital that was raised on overseas bourses or investment houses based in London and New York. The refined and processed precious ores mined were mostly exported. As major mining companies such as Anglo American diversified into other sectors the flow of investment provided the basis for the support and repair firms that were linked to the mining industry so that they became larger and increasingly derived earnings within other industries. (Feinstein, 2005: Chapter 8, particularly pp.172-176)

This relative independence from the mining sector saw companies emerge that were able to produce for the local as well as the international market. A good example is provided by Boart and Hard Metals, which was established in 1936 as a support company within the Anglo American/De Beers stable but which branched into developing improved drilling techniques for the mines (Innes, 1984:75-77). This in turn led the firm to produce a range of specialized drilling tools for the mining sector as well as tools and abrasives for general industrial drilling, grinding and cutting. A large proportion of its output was exported and the firm became an acknowledged world leader (Feinstein, 2005:176).

The second catalytic force that impacted on the structure and growth of the metal and engineering sector was state policy to develop the automobile manufacturing industry. Motor vehicles were first sold in South Africa as fully assembled units. However, by the early 1920s Ford and General Motors had established assembly plants in South Africa. Initially, a large percentage of the components that were used in these early plants were imported. Local maintenance and repair services and components manufacturers tended to become involved only indirectly by serving as a source of non-functional parts such as tyres, window glass and batteries. This changed fundamentally with the introduction of the government's local content programme, which over the years evolved through three phases. The third phases of the local content programme required the motor vehicle manufacturers to source 66% of the vehicle weight from components manufactured in South Africa. The catalytic effect of the investment by foreign vehicle manufacturers coupled with state policy on local content impacted significantly on the development of the metal and engineering sector. (Black, 2001)

[5] In contrast to Feinstein's analytical presentation of the processes that have shaped South Africa's industrialization, Rosenthal documents the actual personalities and the firms that played a key role in the development of structural steel engineering.

The particular form of state involvement in the South African economy has also had a strong influence on firms in the metal and engineering sector. The state's involvement in the economy was primarily through state-owned enterprises and infrastructure. In the metal and engineering sector state-owned enterprises were established to stimulate the sector and provide a ready supply of cheap energy and material inputs (i.e. ingots and ancillary products derived from pig iron and scrap iron) to firms within the sector.

The impact of expenditure on the military constitutes the final major impetus to the development of the metal and engineering sector, particularly through enabling specialized and sub-contracted firms to emerge. The Second World War created an opportunity for certain companies to become inserted into the military industrial apparatus. Products made for the military during the Second World War included explosives, shells, radio equipment, aircraft wings and propellers, bomb castings, tools and gauges, precision instruments, and electric motors and equipment (Martin & Orpen, 1979, DGWS Annexure: Factories and their Production).

The military industrial complex continued to grow after the Second World War as the apartheid regime sought to bolster its defences. From the 1970s until the fall of apartheid this complex included a wide spectrum of metal and engineering firms that were sustained by the state's armament acquisitions. The firms spawned a range of supporting firms and a skilled labour force. (Lundall, 2005)[6] The impact was however not only quantitative: an interviewee highlighted the pressure that the South African military exerted firms in respect of quality and standards.[7] He gave the example of firms being required to develop precision and quality measurement systems that had to be calibrated to minute tolerances. It is conceivable that where such firms shifted to civilian applications these technologies would have been able to enter a number of niches within the metal and engineering sector.

The historical driving forces have resulted in a geographic distribution of the metal and engineering sector. Gauteng, where almost 80% of enterprises are based (Merseta, 2006:57), has had a strong association with mining and large firms engaged in the assembly of military vehicles and gun turrets. Motor industry firms are associated with Gauteng, the Eastern Cape and Durban, while Cape Town has a concentration of precision engineering firms, many of which tend to be medium sized and even smaller, as well as the Saldanha Steel mill nearby.

The fundamental drivers and influences on the metal and engineering sector outlined above did not exclude the possibility of firms emerging that focused on other markets. Thus highly innovative firms, not tied to either the mining industry, state infrastructural support projects as well as state owned enterprises, or the automobile sector, or the military industrial sector, have

[6] Even though the evidence was masked by state secrecy, a subsequent email exchange in late July 2007 with Dr Ewald Wessels confirmed that this periodisation corresponded with personal experience as an owner of a firm which subcontracted into the military industrial complex.

[7] Dr Ewald Wessels, Cape Manufacturing Engineers, email communication, July 2007.

prospered. The key factors in their success appear to be a highly competent technical management team that have ensured that they can operate flexibly and harness skills needed to penetrate niche markets and win export contracts. These firms are usually run by skilled engineers who have consciously sought to establish strategic alliances with larger firms, often benefiting in the process from technological transfers as well as management systems.[8]

METALS BENEFICIATION AND THE VALUE CHAIN

There are generally four stages involved in metals beneficiation.

- Stage 1 involves the primary stage of mining and producing an ore or concentrate.
- Stage 2 converts the ore or concentrate into an intermediate product such as a metal or alloy. The production of intermediate products usually takes place in capital- and energy-intensive smelters and refineries (DTI, 2005:15). This stage is referred to as the **milling** stage. Milling firms in South Africa are chiefly involved in the production of pig iron and the conversion of pig iron into a range of wrought iron and steel materials. These materials are produced to be available in different forms, e.g. ingots, plate, sheet, and coil.

- Stage 3 transforms an intermediate good into a refined, semi-fabricated product suitable for use by both small and sophisticated enterprises. This stage of transformation takes place in blast furnaces and foundries using heat-treating and/or cold finishing processes. Employment levels are high and the degree of value added increases substantially due to the inclusion of other resources and inputs such as skills and technology (DTI, 2005:15). Much of the activity takes place in South Africa in **engineering or machine shops** that are responsible for the manufacture of products, parts, components, tools, forgings and moulds as well as the fabrication of products and structures.

- Stage 4 transforms the processed metal further into finished products of a large variety. The range of employment opportunities is significantly larger at this stage and firms in this stage of production include small, medium and large manufacturers (DTI, 2005:15). Of particular importance are the **machine builders**, which generally tend to source parts and components from engineering or machine shops and control systems from electrical and electronics firms. They assemble these in conjunction with the core features of the machines that they design and produce.

Stage 1 falls outside the scope of this study and is thus not discussed any further. Stages 2, 3 and 4 are the focus of this report and are frequently referred to as the milling firms (Stage 2), engineering or machine shops

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(Stage 3), and machine builders (Stage 4). Some characteristics of these three stages are discussed below.

Although enterprise size differentiates the milling firms from engineering or machine shops and machine builders, all three tend to share overlapping skill sets with respect to their human resource requirements. Milling firms have to produce large volumes to be economically viable and usually core operations function continuously using multiple shift systems. As a result, most milling firms employ a workforce of over a thousand and are classified as large or very large firms. There are exceptions such as the Saldanha Steel, which is a fully integrated mill that was described by an interviewee as a 'mini mill'.[9]

The nature of the production process at milling firms - a number of steps to treat and purify materials under conditions of controlled high temperatures – means that they must conform to more onerous environmental and systems regulations and standards. The operations at such mills are energy intensive, and produce a lot of waste as well as environmental hazards. Furthermore, to ensure product integrity and quality consistency, production operations that take place under such conditions of extreme temperature variations generally tend to be subjected to more periodic shutdown and maintenance procedures. The interviews with the milling firms indicated that shut-downs are a routine procedure which these firms have to follow. A rule that was tacitly followed in South Africa in the past was that shut-down and maintenance work would be carried out at an iron and steel milling plant every six weeks.[10] Therefore, apart from the key production workers, such firms also had to retain a corps of maintenance and repair workers.

Engineering or machine shops and machine building firms use the final outputs derived from iron and steel mills to make many different types of products and machines. These shops and firms are generally smaller than the iron and steel mills because their competitive advantage derives from specialization rather than economies of scale. In the South African context such firms are generally in the small (10 to 49 employees) and medium (50 to 199 employees) range, but there are some in the larger employment size category (201 to 500 employees).

According to the DTI (2005:15) employment opportunities tend to be low at the milling i.e. refinery stage, but can become very high at the mass semi-manufacturing and final production and machine building stages Table 1.1 presents some interesting and important information in the carbon steel pipeline, the most important pipeline in terms of volumes. It shows that Stages 2 and 3 are very capital intensive with investments of R1.5 million to R8.5 million required per job. The employment-output ratio is also extremely low with only 1 to 7 people employed per 1000 ton of steel produced. On the other hand Stage 4, the finished product and machine building stage, is much more labour intensive. Investment per job ranges from only R0.1 million to R0.6 million while employment per 1000 ton of steel output ranges from 75 to 150.

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[9] Interview: Frikkie van der Merwe, Saldanha Steel, 23 July 2007.
[10] Interview: Joe Mabena, Louis Kraucamp and Emelia Badenhorst, Columbus Steel, 5 September 2007.

Thus the potential for employment creation is far greater at the downstream finished product end of the metals beneficiation pipeline. At the same time the selling price per unit weight of steel increases dramatically (Table 1.1).

Table 1.1 Benefits of Beneficiation: selling price, employment and investment in different stages of carbon steel

Nature of product	Selling price per ton of steel ($)	Employment per 1000 ton of steel	Investment (R million per job)	Stage
Iron Ore	30	0.12	n.a.	1
Iron	120	0.6	R2m	2
Hot rolled Steel	300	1.1	R6m	3
Cold rolled Steel	500	1.6	R8.5m	3
Pipe and Tube	650	7	R1.5m	3
Structural Steel	1000	75	R0.1m	4
White Goods	5000	100	R0.4m	4
Mining Equipment	13000	150	R0.6m	4

Source: DTI, 2005:16

Currently a very small proportion of most metals is beneficiated through to stage 4 where by far the most employment creation occurs. This is quantitatively demonstrated in Table 1.2. The table clearly reflects the overall underdevelopment of the downstream metal products industries. In each column it indicates the percentage of a particular metal that reached the stage of beneficiation indicated by the column. For instance, 100 percent of gold mined in South Africa is refined (Stage 2), but only 2 percent is beneficiated into a final product (Stage 4). Developing and growing the downstream higher value-added end of the metals production chain should therefore become a top priority. Great attention and emphasis would have to be given to the skills required to grow this stage of metals beneficiation.

Table 1.2 Stages of Beneficiation and Levels Achieved

Commodity	Stage 1 Ores / Concentrates (%)	Stage 2 Processed / Refined Ore (%)	Stage 3 Primary Manufacture (%)	Stage 4 Finished Manufacture (%)
Gold	100	100	5	2
PGM (Platinum Gp of Mts)	100	100	n.a.	6
Iron ore to steel	100	30	30	15
Chrome to stainless steel	100	85	9	3
Aluminium	0	100	30	11
Zinc	100	100	90	60
Manganese	100	50	25	22
Titanium	100	15	4	Small
Copper	100	100	65	50

Source: DTI, 2005:16

The reasons for the low levels of beneficiation are wide-ranging. They include 'weak linkages and import-parity pricing by upstream metals producers at stages 2 and 3,' as well as 'factors impacting on the competitiveness of downstream firms at stage 4', such as a shortage of skills and low levels of investment (DTI, 2005:16).

Performance of the Metals Beneficiation Sector in South Africa

The upstream basic metals industries (basic iron and steel and non-ferrous metals) are highly capital intensive and have registered very high rates of growth while reducing their labour force at the same time. They are also characterized by very large economies of scale, and a very small number of producers with monopoly powers to set prices. By contrast, the downstream labour-intensive metal products industry has grown very slowly (DTI, 2005:18). Different levels of investment in the value chain help to explain these trends.

During most of the 1990s investment in the upstream ferrous and non-ferrous metals was very high. From 1993 to 1995 gross investment in non-ferrous metals was in excess of 75% of the sectors value-added. Then, from 1996 to 1998 investment in basic iron and steel averaged around 50% of the sector's value added. By way of contrast, investment in the metal products sector remained low throughout, never rising above 18% of value-added and averaging 14% over the decade from 1994 to 2004 (DTI, 2005:20).

Trade Performance

The extensive investments in basic iron and steel and non-ferrous metals brought about high rates of growth and large trade surpluses. In 2004, 45% of basic iron and steel and 26% of non-ferrous metals were exported. The high levels of exports of basic metals were partly a result of poor growth of the downstream beneficiating industries brought about to some extent by the pricing policies of the upstream producers. Table 1.3 demonstrates the weak growth and trade performances of downstream metal products. It also shows that import penetration of basic iron and non-ferrous metals declined from 1994 to 2004, but increased for metal products over the same period. Even so, employment decreased for all the categories, but at the lowest rate in the metal products stage.

Table 1.3 Trade Performance in Stages of Metals Beneficiation

	Basic iron and steel	**Non-ferrous metals**	**Metal products**
Average annual VA growth, %, 1994-2004	5.8	5.7	1.3
Average annual employment growth, %, 1994-2004	-5.0	-4.2	-0.8
Employment, 2003	40 428	11 960	109 667

% Semi & unskilled labour, 2002	55	55	64
Capital: Labour ratio (R1000 per employee), 2003	830	2 004	74
Export: Output ratio, 2004, %	45	26	13
Imports: Consumption ratio, 1994, %	19	27	9
Imports: Consumption ratio, 2004, %	9	22	13
Net export ratio, 2004 (X-M)/(X+M)	0.80	0.86	-0.11

Source: DTI, 2005:21

Hence, despite government's strategy to encourage beneficiation of metals and growth of downstream industries, the reverse has been occurring, with South Africa being increasingly a producer of relatively unbeneficiated upstream metal products (DTI, 2005:21).

SUB-SECTOR ANALYSIS OF THE METALS BENEFICIATION SECTOR

In order to understand the dynamics of how firms operate and the key drivers of change in the metals beneficiation sector it is necessary to analyse how the main industry groupings are structured and function. This section briefly discusses the following main industry groupings: carbon steel; stainless steel; aluminium; foundries; fabrication of metal products, and jewellery.[11]

Carbon Steel

Carbon steel consists of a combination of iron and small quantities of carbon and other elements. It is the most widely used engineering metal, despite its relatively limited corrosion resistance. Carbon steel is used in large volume in marine applications, nuclear power and fossil fuel power plants, transportation, chemical processing, petroleum production and refining, pipelines, mining, construction, processing equipment, motor vehicles and household durables.

The two main forms in which carbon steel is produced are flat and long steel products. Flat-rolled products consist principally of coils and plates while long products consist of wire rods and bars.

South Africa produces 3,6 million tonnes of flat steel and 2,7 million tonnes of long steel each year, of which around 44% is exported. The biggest industrial consumers of carbon steel have been building and construction (22%), cables, wire products and gates (14%), and tube and pipe (12%). Over the past 20 years there has been major restructuring within the industry, with older and less efficient plants being closed, upgrading of remaining mills, and new more capital-intensive investments, notably in Saldanha Steel. Employment in the industry is currently only around one-quarter of the levels in 1980.

Arcelor Mittal SA (formerly Mittal SA and before that Iscor) is dominant in the primary steel industry, with only Highveld Steel competing with it in the flat steel products market. In the long products market Highveld Steel, Scaw

[11] This and the next section draw extensively from the highly informative DTI (2005) study of a development strategy for the metals sector.

Metals, Cape Gate and Cisco compete with it (DTI, 2005:24). By contrast the global steel industry has remained relatively unconcentrated with the ten largest steel companies accounting for only about 26% of world steel output in 2004 (DTI, 2005:23-25).

The majority of primary steel production takes place in Mpumalanga because of the availability of raw material in the province. To a lesser extent it also takes place in Gauteng, but most value added production takes place in the latter province due to extensive metals fabrication. There are also production plants in Newcastle and Saldanha near Cape Town (Merseta, 2006:32).

One of the reasons for the inhibition of downstream steel production is the pricing policy of the dominant supplier, Arcelor Mittal SA. In September 2007 the Competition Tribunal imposed a fine of R691 million on Mittal for 'price fixing' and 'the manipulation of supply' (Financial Mail, 14 Sept 2007:12). Analysts said that Mittal had in the past been able to charge a US$100/tonne premium on the steel it sold locally (Financial Mail, 14 Sept 2007:64). Mittal charged different prices to different customers and ran a complex system of rebates, which customers got only if they proved to Mittal that they added value to the steel and exported it, rather than reselling it on the local market (Mail & Guardian, Business, 14-20 Sept 2007:6). The Tribunal also ordered Mittal to cease placing conditions on the resale or use of its products (Financial Mail, 14 Sept 2007:64).[12]

Stainless Steel

Stainless steel is a generic term given to a group of corrosion resistant metals containing at least 10,5% chromium and varying amounts of nickel, molybdenum, titanium, and other elements[13].

The global stainless steel industry is highly concentrated with the top ten producers (TK Steel; Arcelor; Acerinox Group; Avestra Polarit; Posco; Yusco, NSC, and three others) accounting for 60% of world output.

In South Africa Columbus Steel is the dominant producer of stainless steel. It has become part of the third largest global producer, the Spanish Acerinox Group. South Africa is a major net exporter of stainless steel. Exports increased in recent years due to increasing production, but also because of weak domestic demand due to the challenges faced by the producers of beneficiated products.

Even so, domestic market consumption of stainless steel has more than doubled over the past decade. The biggest sectoral consumer is the automotive industry. There has been a sharp decline in the demand for stainless steel in the tank containers industry (discussed below), while the South African industries in electronics, metal goods, engineering and

[12] At the time of writing Mittal was taking the Competition Tribunal's fine and order to the Competition Appeal Court. The Court had not yet made its ruling, but it should be noted that it has frequently overturned the Tribunal's orders.

[13] There are four major types of stainless steel that vary in their corrosion resistance, weldability and formability.

construction appear under-developed. There is thus a potential range of opportunities that could be pursued in the fabrication of stainless steel (DTI, 2005:26-29).

Aluminium

Aluminium is a strong, light and durable metal that is resistant to corrosion, a good reflector, and good conductor of electricity and heat. The main uses of aluminium are in the building and construction sectors, in containers and packaging, for electrical application, in road, air and seagoing transport, and industrial machinery and equipment. Due to its favourable properties and the environmental benefits the consumption of aluminium has increased significantly over the past decade. There has, for instance, been a shift towards the use of aluminium alloys for car bodies and engines that suggests a strong future growth in the aluminium sub-sector. In 2004 South Africa was the tenth largest primary aluminium producer with an output of approximately 850 thousand tonnes.

The global aluminium industry is dominated by five big companies, comprising three American firms (Alcoa, Kaiser and Reynolds), and one Canadian (Alcan) and one European firm (Alusuisse).

However, according to the DTI, 'South Africa has no economically exploitable deposits of bauxite and no alumina production facilities. Thus, all alumina feedstock used in primary aluminium production is imported, predominantly from Australia. The domestic primary aluminium industry exists only because it has access to cheap electricity.' Upstream aluminium production also includes aluminium produced through recycling. It is cost-effective as it takes 95% less energy than is used in producing primary aluminium from bauxite.

Production of primary aluminium in South Africa is controlled entirely by BHP Billiton, the world's largest diversified resources company. It has majority ownership of two aluminium smelters in South Africa, Hillside Aluminium and Bayside Aluminium, both in Richards Bay. Alcan is in the process of building a third aluminium smelter at Coega in the Eastern Cape.

Only 32% of South Africa's aluminium output is sold to domestic downstream firms. The remainder is exported, mainly to Asia. Of the aluminium sold to the domestic industry an estimated 60% is exported after only limited value addition. Hence only about one-eighth of primary aluminium produced in South Africa is retained in the domestic market after further processing.

South Africa's downstream aluminium industry has thus remained relatively small. One reason it has failed to grow is the climbing price of domestic scrap. About half of aluminium scrap generated in South Africa is exported, mostly to Asia. The major producers of secondary aluminium in South Africa include Zimalco, Future Alloys, Metlite Alloys, and Aluminium Granulated Products. Zimalco is the largest secondary producer, producing 50% of secondary aluminium.

The main aluminium users in South Africa are the automotive and packaging sectors. The automotive sector has become the largest single aluminium user. Given the surge in the motor industry, the automotive market should hold a lot of promise for the South African aluminium industry. The challenge is to get the pricing right. Primary aluminium production is a vulnerable industry as it relies on the provision of cheap electricity and it is not clear whether South Africa can sustain the production of cheap electricity over the long run (DTI, 2005:30-33).

Foundries

Foundries fit into the third stage of the metal beneficiation process by producing intermediate goods. There has been significant restructuring and consolidation in the South African foundry industry over the past 10 to 15 years. The number of firms shrunk from 450 in the early to mid-1980s to just over 200 in 2003. The industry is very small compared to its global competitors. For instance, in 2003 China had 12 000 foundries and India had 4 500.

No new foundries were established and no major investments in capital equipment took place in the foundry industry until the late 1990s. Change came in 2000 when a R35 million plant was opened by Eclipse Foundry (part of Ozz Industries). Two major new foundries were also opened in 2002 in the Port Elizabeth area.

The foundry industry in South Africa is geographically clustered. More than half of all the foundries are located in Gauteng, while more than 65% of all foundries in Gauteng are situated in Ekurhuleni. The Western Cape, Eastern Cape, and KwaZulu-Natal all have significant, but far smaller, foundry industries.

The foundry industry is quite concentrated, being dominated by a small number of large groups or individual companies that include Murray & Roberts, Ozz Industries, Scaw Metals, Tiger Wheels, Guestro Castings, Auto Industrial, and Hayes Lemmerz SA. Together these account for around 60% of tonnes cast each year.

The foundry industry is crucial. It provides critical inputs to most of the manufacturing sectors, with mining, automotive, and general engineering being the largest industries it supplies. Approximately 40% to 50% of South Africa’s casting production in value is automotive components, while about 85% of all aluminium castings are for use in the automotive industry. The production of aluminium cast components for the automotive industries is where the most significant growth opportunity exists for the South African foundry industry.

Challenges faced by the industry include international competition due to continuous technological improvements and cost-competitiveness. A further impediment to growth of the industry is a skills shortage at all levels of the production chain from product design to process control (DTI, 2005:35-38). This is discussed in more detail under the Skills section below.

Fabrication of Metal Products
This sub-sector fits into the fourth and final stage of the metals beneficiation process in which finished products are made. It is primarily engaged in forging, forming, stamping, turning and joining processes to produce ferrous and non-ferrous products. These products are wide-ranging, including cutlery and hand-tools, bolts, nuts and screws, spring and wire products, hardware, construction and architectural metal products, boilers, tanks and shipping containers.

Internationally the metal products industry is characterized by clusters of firms developing niche capabilities and drawing on shared services, including technical and design services, skills development, and research and development (R&D) facilities. There are also metal products where economies of scale are important, such as in the manufacture of tank containers and automotive components. According to the FRIDGE study, in Ekurhuleni Metro South African firms had lower design and customization costs in products than their main competitors in Europe and the USA. But research has repeatedly shown that the local pricing of steel has undermined the competitive advantage of steel products.

Structural Steel Industry

Structural metal products are largely linked to construction and building activities (where construction is seen as mainly civil projects and building refers to offices and residential housing). In recent years, the global world trade in structural steel products grew at 11% per annum in value terms.

In South Africa the structural steel industry is dominated by the big five: Group-5, Murray & Roberts, Grinaker-LTA, McBride and Status. The South African construction sector has experienced revived growth in recent years and should continue to do so up to 2010 at least. The soccer World Cup is creating a construction upsurge with the building or upgrading of stadiums, airports, roads and hotels.

Stainless Steel Consumer Goods

Over recent years this sub-sector has been driven by the cookware and cutlery sector. There are further opportunities in a broad range of consumer goods including garden furniture. However, the downstream industries are dominated by imports. No less than 75% of stainless steel consumer goods are imported, mostly from Asia. There is thus a great potential for growth in this sector, but in the face of tough competition.

Automotive Industry

There is enormous potential for the consumption of steel, aluminium, chrome and PGM in metal products fabricated for the automotive industry. Aluminium is used to make cast and forged products, such as rims, while stainless steel (that includes chrome) and PGM are used extensively in various components of the exhaust system, particularly in catalytic converters. The production and export of catalytic converters have grown enormously over the past ten years. South Africa supplies about 12% of world demand and in 2003 exports of no less than R8,1 billion took place.

Tank Container Industry

The tank container industry was the third largest consumer of stainless steel in South Africa up to 2003. From 1996 to 2003 the industry produced about 6 000 tanks per year and generated annual export earnings in excess of R800 million. The main use of tanks is for bulk transportation of foodstuffs, beverages and chemical liquids including petroleum.

However, as from 2004 the industry started to shrink. Its consumption of stainless steel in 2004 had fallen to slightly more than a third of its 1998 consumption. This contraction of the industry led to the closure of Trencor Containers and Consani Engineering.

One reason for the contraction of the tank container industry was that the entry of competitors into the market, particularly China, led to a fall in tank prices.[14] Another reason was the increase in stainless steel prices (DTI, 2005:40-44).

Jewellery

The beneficiation of precious metals into jewellery is extremely underdeveloped in South Africa. The country produces about 25% of all raw materials worldwide for jewellery production, but produces less than 0,5% of the world's fabricated jewellery.

South Africa is one of the world's main producers of gold (400 tonnes per annum), yet it only beneficiates 18 tonnes per annum. By way of contrast, world leaders India and Italy produced 596 tons and 500 tons of gold jewellery respectively in 1999. Similarly, South Africa produces around 60% of the world's platinum, but makes less than 0,5% of its jewellery (DTI, 2005:46). In addition, South Africa holds 22% of the world's reserves in titanium, but no titanium metal production takes place in the country. Even though some custom-made jewellery is produced locally, companies actually import titanium (Metals and Minerals Core Team, n.d.:4). The *Metals Sector Development Strategy* study of the Department of Trade and Industry (DTI) therefore validly argues that:

> South Africa must develop the means to transform its comparative advantage as a leading producer of precious metals and stones into competitive advantage in the production and marketing of jewellery for the rapidly growing international jewellery business (2005:45).

[14] In 2004 China opened a tank container manufacturer with the capacity to produce 6000 tanks per year, the same volume as the entire South African tank container industry.

There is thus an enormous potential for growing the jewellery metals beneficiation sub-sector in South Africa. There are already a number of initiatives to do so such as the Jewellery Cluster Manufacturing Initiative, a partnership between the government and gold industry. In line with this the DTI, in partnership with AngloGold and Rand Refinery, created the African Gold Zone. It consists of 23 500 square metres of factory housing independent manufacturers. (DTI, 2005:49)

Jewellery design and manufacture are however a craft and much training will have to be undertaken to make South Africa's jewellery globally competitive and marketable internationally.

CROSS-CUTTING COMPETITIVENESS ISSUES

Although there are differences between the sub-sectors in the metal benefication sector, there are a number of cross-cutting issues that affect all of them. These include input prices, technology and tooling, and skills. These three are discussed below.

Input Prices

The most important inputs in the metals beneficiation sector are the basic metals. The market power of the basic metal firms has resulted in local firms being charged higher prices than firms in other countries in spite of the fact that South Africa has amongst the lowest production costs in the world for basic metals (DTI, 2005:50). Import parity pricing was repeatedly mentioned in the FRIDGE survey as an impediment to growth and employment creation by the downstream sectors (FRIDGE, 2003a:3). This means that the capital-intensive upstream metal industry is fundamentally impeding the growth and production of value-added labour-intensive downstream metal products. Table 1.4 demonstrates the competitive disadvantage faced by the steel beneficiation sub-sectors.

Table 1.4 Mark-ups of basic metals prices 2003/04

	Carbon steel	Stainless steel	Aluminium
SA net export price	100	100	100
EU price	122	120-139	107
East Asian price	101	113	104
SA buyer price	146	130	105-109

Source: DTI, 2005:51

Another important input in the whole metals beneficiation value chain is electricity. Stage 2 of metal beneficiation, that is, the smelting and refinery processes, are very energy intensive, as are blast furnaces and foundries in Stage 3. However, the pricing agreements differ between different stages in the value chain. The primary and secondary producers get their supply directly from Eskom at pre-negotiated rates while the downstream producers have to pay higher municipal rates. Unfortunately, there is no information available to indicate how much more downstream producers pay for electricity, but it is clear that the primary and secondary producers (Stages 1 and 2) are the main beneficiaries of the country's competitive advantage in electricity (DTI, 2005:52).

The increased price of electricity and high prices of basic steel facing the downstream producers inhibit the growth of the higher value added metal sub-sector. There is also a lack of collaboration between the downstream and upstream sectors (FRIDGE, 2003a:7). This accounts for the fact that a very large proportion of the production of basic metals continues to be exported (DTI, 2005:51).

Technology and Tooling
Low investment rates in South Africa over the past decade have resulted in metal firms falling behind the technological progress experienced elsewhere in the world. Research findings have shown that when firms invest in modernizing their production techniques there is an overall improvement in competitiveness in the downstream metals industries. Because of a lack of co-ordinated research and development (R&D) most firms have resorted to product adaptation rather than new product development.

The machine tool industry forms a vital base for a whole range of industries, namely the automotive, aerospace, marine, defence, electronic, and machinery industries. Tooling is particularly important for the auto industry as automotive related products account for more than 50% of tool-making globally.

Tool producers in South Africa often cater for much lower production runs than their counterparts in Europe and North America. This has tended to lead to the production of lower priced and lower quality tools. The situation has been aggravated by the lack of formal training programmes for the tooling industry, coupled with a severe shortage of skills (DTI, 2005:55-56).

Skills
It is important to note that the downstream metal industries employ a large proportion of unskilled and semi-skilled labour. In 2004 unskilled and semi-skilled labour accounted for 63% of total employment in metal products. Combined with the fact that these industries are labour-intensive, there is a great job creation potential in the downstream metals sector, which is important given the country's large reserve of low-skilled labour.

However, these industries also require skilled labour and face severe skills shortages at artisan, technical and engineering levels. The shortage of skilled artisans exists across the manufacturing industry as a whole. In 1982 there were 13 000 artisan apprentices registered, but this figure had dwindled to only 2 000 in 2003, a completely inadequate number.

Historically, state-owned firms such as Eskom, Iscor and Spoornet used to provide apprenticeship training for young people, thereby providing a pool of skilled people from which industry could draw. But since these enterprises have scaled back their training programmes the skills shortages have accelerated (DTI, 2005:54). Consequently, one of the biggest constraints faced by sectors in the metal industry is a general shortage of artisans.

Critical artisan skills required include the following: welders, patternmakers, toolmakers, machinists, moulders, fitters, turners, cutters, millwrights, boilermakers, CNC (computer numerical control) operators, draughtsmen experienced in CAD (computer-aided design), and IT (information technology) technicians.

The other major type of skill required by the industry is engineering. The following fields of engineering are in high demand: metallurgical, process, chemical, mechanical, mining, electrical, and software.

Most graduate engineers are sourced from the universities with established engineering faculties such as the Universities of the Witwatersrand, Pretoria, Cape Town and Stellenbosch, as well as Mintek, and some of the Universities of Technology (former Technikons).

It is important to note that the skills required have gradually been changing due to the introduction of automation and mechanization using CAD and IT software (DTI, 2005:52-54).

In the face of these challenges a number of firms have developed their own in-house training programmes. But a major problem with these independent initiatives is that 'they are neither formally recognized nor accredited by the SETA concerned.' (DTI, 2005:39). A further problem is that the Seta for this sector, Merseta, is not seen as effective by the management of firms. Especially the smaller firms have claimed to experience administrative difficulties with Merseta. (FRIDGE, 2003a:6) In the basic metals sub-sector 80% of small firms surveyed considered Merseta to be ineffective. (FRIDGE, 2003b:103) A gap has thus been left between the ending of apprenticeship programmes of many firms and the establishment of new learnerships (DTI, 2005:41).

CONCLUSION

South Africa is remarkably well-endowed with metals and has been a major exporter of basic metals for more than a century. However, it has failed to build up a substantial beneficiated metal sector in spite of having the comparative advantage of metal ores and cheap electricity. For instance, South Africa only beneficiates 15% of its iron ore and 3% of its chrome into finished steel products, 6% of its platinum group metals into final products of one kind or another, and 5% of its gold into jewellery (see Table 1.2).

The reasons why South Africa has not built up a substantial beneficiated sector are manifold. A prime reason in the steel industry has been the pricing policies of monopolistic producers of primary iron and steel. Their practices of import parity pricing and differential pricing have put local firms at a cost disadvantage compared to their international competitors (see Table 1.4).

Another major reason for the low level of beneficiation has been a shortage of skills at the artisanal, technical, engineering and managerial levels. The range of artisanal skills, and technical and engineering expertise required in the country have been indicated in this chapter. The following two chapters explore the supply and demand for these skills in far greater depth, while the penultimate chapter examines the dynamics of growth and skills acquisition at firm level. The final chapter draws the findings together and makes conclusions and policy recommendations.

Chapter 2

The Demand for Skills

This chapter examines employment demand within the metal and engineering industries of South Africa. While the total level of employment within the metal and engineering industries constitutes the foundation for the analysis of demand in this chapter, the data is broken down further to examine other characteristics of employment demand. These include the racial breakdown of demand, the occupational segmentation of demand within industries of the metal and engineering sector as well as the educational levels of the working population in these industries.

There are two principal sources from which the data discussed in this chapter is derived. These are the Standardised Employment Series data that is produced by the Development Bank of Southern Africa that is used to map employment levels in the metal and engineering industries and household survey data.[15] The Standardised Employment Series data for the metal and engineering sector is not arranged to capture the diversity of the population in the sector. However, data embodying social categories are contained in the household survey data.[16] But the demand level information generated from the household surveys data is not a mirror image of Standardised Employment levels. This must be borne in mind when comparing the tables in this chapter.

EMPLOYMENT LEVELS IN THE METAL AND ENGINEERING INDUSTRIES: 1996 TO 2005

Changes in Actual Employment

Table 2.1 depicts the Standardised Employment Series levels of employment in the metal and engineering industries in South Africa over the period 1996 to 2005. We have grouped these into approximate production or beneficiation activities within the sector. Three distinct types of enterprises characterise these production or beneficiation activities. These are iron and steel mills, engineering or machine shops, and machine building firms. Although given a distinguishing label in the tables shown in Chapter 2, basic iron and steel and basic non-ferrous metal activities have similar types of production and manufacturing processes. In the rest of the report we therefore refer to these collectively as 'iron and steel mills'. Table 2.1 also includes separate employment data for non-electrical machinery and equipment builders (machine builders – non-electrical) in contrast to employees associated with

[15] The Standardised Employment Series is presented at a higher level of aggregation and does not necessarily mirror the way in which data from the household surveys is broken down within the three-digit specification of the standard industrial classification system.

[16] Between 1995 and 1999, household surveys were conducted annually in the month of October. These surveys were known as the October Household Surveys. In 2000, a new survey format replaced the OHS. Two surveys were thereafter conducted, one in February and the other in September, using a revised questionnaire. These surveys are known as the Labour Force Surveys.

the building of electrical machinery and apparatus (machine builders – electrical).

The data in Table 2.1 shows a significant haemorrhaging of employment in the metal and engineering sector, especially over the period 1996 to 2001. Overall employment for this period (1996 to 2005) declined by 13.3% or 44 950 jobs. But there is a turnaround and improvement in employment growth that starts to manifest itself from 2001 to 2002, and is sustained on aggregate up to 2005. However, in only one industry, the Machinery and Equipment Industry (i.e. machine builders – non-electrical), does employment in 2005 exceed the level recorded in 1996.

There is merit in reviewing the data shown in Table 2.1 in more detail. The numerical and percentage decline in employment from 1996 to the low point in 2000 to 2001 was even more severe than for the entire period (the low point for each industry is highlighted in yellow). In only one industry was the turnaround in the period after this trough sufficient to exceed the prior loss of jobs. This occurred for the Machinery and Equipment Industry, where 8 573 new jobs were created, signifying a 9.2% growth in employment. In the upturn from 2000 to 2005, employment in Machinery and Equipment (non-electrical) increased by 15 549 or 17.9%.

This was not the case for the other three industries. The employment decline in Basic Iron and Steel for the period 1996 to 2005 was 37.4% or 19 276 jobs. In Basic Non-Ferrous Metals for the same period 6 474 jobs were lost to represent a 24.6% decline. The combined Basic Iron and Steel and Non-Ferrous Metals (milling processes) resulted in 25 749 jobs being lost between 1996 and 2005, which constituted a 33% decline.

A similar tempo of employment decline was recorded for Electrical Machinery, where 17 549 jobs were lost over the period, which amounts to 30.2%. Even though the employment decline in the Metal Products Industry only amounted to 9.4%, it still accounted for a decline of 10 224 jobs.

Table 2.2 summarises these employment shifts. In Table 2.1 employment change was recorded from 1996 to 2005. This is presented in summary form in the first column of Table 2.2. In the next two columns the period is broken down into the downturn from 1996 to 2001 and the upturn thereafter.

Table 2.1: Employment Levels in the Metal and Engineering Industries, 1995-2005

Years	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	∆1996-2005
Basic iron and steel	51572	47673	41165	35486	30759	32444	32079	32488	33293	32296	-19276
Basic non-ferrous metals	26350	26118	25948	24490	20014	19273	20461	20537	20002	19876	-6473
Basic Iron and Steel and Non-Ferrous Metals (Milling Processes)	**77921**	**73791**	**67113**	**59977**	**50773**	**51717**	**52541**	**53025**	**53295**	**52172**	**-25749**
Metal Products(Engineering & Machine Shops) excluding machinery	**108957**	**106549**	**100769**	**91964**	**89746**	**89710**	**93667**	**95856**	**99561**	**98733**	**-10224**
Machinery and Equipment (Machine Builders Non-Electrical)	**93731**	**92117**	**90198**	**89865**	**86755**	**88877**	**92796**	**94982**	**99320**	**102304**	**8573**
Electrical Machinery and Apparatus (Machine Builders Electrical)	**58094**	**54706**	**54444**	**49078**	**47333**	**42997**	**40937**	**38536**	**38630**	**40545**	**-17549**
Total Metals	**338703**	**327163**	**312524**	**290884**	**274607**	**273302**	**279940**	**282399**	**290805**	**293753**	**-44950**

Table 2.2: Employment Changes

Industry	96-2005	96-2001	2001-2005
Basic Iron and Steel and Non-Ferrous Metals (Milling Processes)	-33.05	-23.03	0.88
Metal Products(Engineering & Machine Shops) excluding machinery	-9.38	-15.60	10.06
Machinery and Equipment (Machine Builders Non-Electrical)	9.15	-4.13	15.11
Electrical Machinery and Apparatus (Machine Builders Electrical)	-30.21	-15.52	-5.70
Total	-13.27	-14.12	7.48

The table highlights that the period 1996 to 2001 largely accounted for the decline in employment within the sector, whereas the data for the period 2001 to 2005 shows the onset of gradual employment growth.

The Formal and Informal Economy within Metals and Engineering

It is interesting to note that by far the greater share of employment in the metal sector is created in the formal economy. Table 2.3 shows that only about one in twelve employees (8.3%) in the metal and engineering sector was engaged in the informal economy over the period 1997 to 2005.[17]

Table 2.3: Formal and Informal Employment in the Metal and Engineering Sector: 1996 to 2005

Metal and Engineering Sector	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total Number Engaged in Formal Employment	253641	279346	264497	292506	284963	301278	334473	323987	350454	350725
Total Number Engaged in Informal Employment		10964	10293	9346	28977	32147	24231	30727	38072	33092
Total Number in Formal and Informal Employment		290310	274790	301852	313940	333425	358703	354714	388526	383817
Total Percent Engaged in Formal Employment		96.2	96.3	96.9	90.8	90.4	93.2	91.3	90.2	91.4
Total Percent Engaged in Informal Employment		3.8	3.7	3.1	9.2	9.6	6.8	8.7	9.8	8.6
Total Percent of Formal and Informal Employment		100	100	100	100	100	100	100	100	100

Source: October Household Surveys, 1999-1999 and Labour Force Surveys, September 2000 to September 2005

In 2005 91.4% of all employment in the metal and engineering sector was classified as formal, versus 8.6% that was classified as informal.

Racial and Occupational Changes

Table 2.4 depicts changes in the occupational and racial composition of the workforce in the metal and engineering industries at two points in time: 1999 and 2005. Unlike the data showing Standardised Employment levels in Table 2.1, the data in Table 2.4 is obtained from the October Household Survey of 1999 and the Labour Force Survey of September 2005. It is unlikely that this data gives an accurate picture of the situation that it depicts and it is even less likely that it is even vaguely accurate for populations that are less than 10 000. Evidence for this pessimistic view of the data is found in some of the implausible findings among the smaller population groups. For instance, the number of Black managers is found to decrease by 50% from 4637 in 1999 to 2331 in 2005. So, apart from the craft and lower occupational categories, it is

[17] Note that there is a discontinuity in informal employment when the October Household Surveys were replaced by the Labour Force Surveys in 2000: informal employment more than trebles between 1999 and 2000.

important to focus on the overall totals to obtain a more reliable picture of this evidence.

Table 2.4 suggests that the overall number of managers and technicians increased over the period 1999 to 2005 in spite of the decrease of Black managers over this period. This is because there was a very large increase (86%) of White managers. The Table also suggests that the total number of people employed increased by 25% between 1999 and 2005.

When we look at the change in the number of craft workers employed in the sector across racial divisions, an upward trend is shown for the period 1999 to 2005. The overall number of craft workers is shown to have increased by 48%, comprising a 54% increase in African craft workers and increases of 43% in Coloured craft workers and 36% in White craft workers. The total number of operators also increased with Black operators increasing by 27% to 75 813 over the period to make up 80% of all operators in the sector. Incongruously, the number of White operators almost doubled over the same period to 10 214.

Elementary labour declined by 9% over the period 1999-2005. Surprisingly, the only population group to experience a decline is Black African. Elementary employment for Blacks decreased by 31% to 30 070 while all the other population groups experience major increases, ranging from 81% for Coloured workers to 168% for Indians.

An alarming finding, if it is reliable, is the decrease in the number of professionals, mainly comprising engineers, in the metal and engineering industries between 1999 and 2005. According to the data in Table 2.4, the total number of engineers declined by almost 50% over this period, with White professionals decreasing by 63% from 6076 in 1999 to only 2219 in 2005. . This apparent decline is difficult to understand. Even in very large firms that have become more technologically intensive it is hard to explain why there should be a decline in the number of engineers. In smaller owner-managed firms, engineers may be embodying the roles of managers as well as engineers, a trend which would be difficult to capture in the survey data.

As noted above, there is a question regarding the accuracy of this data: the household survey data suggests quite an optimistic 25% growth trajectory in employment, whereas the standardised employment data shows positive growth for the same period of only 1%.

Table 2.4: Occupation and Racial Composition of the Workforce in the Metal and Engineering Industries: 1999 to 2005

Race Group	Managers	%	Professionals	%	Technicians	%	Clerks	%	Sales & Services	%	Craft Workers	%	Operators	%	Elementary	%	Total	%
African/Black																		
1999	4637	22	1257	16	4596	28	12258	45	1334	58	43793	57	59501	77	43342	83	171020	61
2005	2331	9	1201	29	11964	55	13704	36	3531	71	67535	60	75813	80	30070	64	206486	59
Percentage Change	-50		-4		160		12		165		54		27		-31		21	
Coloured																		
1999	2374	11	322	4	783	5	3556	13		0	12651	17	7896	10	5214	10	32856	12
2005		0	366	9	961	4	2678	7	1048	21	18051	16	8357	9	9461	20	40989	12
Percentage Change	-100		14		23		-25				43		6		81		25	
Indian/Asian																		
1999	1404	7	436	5	1762	11	1779	6		0	2596	3	4250	6	854	2	13120	5
2005	245	1	379	9	761	3	2099	6	430	9	4063	4	579	1	2289	5	10876	3
Percentage Change	-83		-13		-57		18				57		-86		168		-17	
White																		
1999	12678	60	6076	75	9029	56	9871	36	975	42	17259	23	5238	7	2652	5	64077	23
2005	23567	90	2219	53	8170	37	19594	51		0	23418	21	10214	11	5382	11	92828	26
Percentage Change	86		-63		-10		98		-100		36		95		103		45	
Total																		
1999	21093	100	8090	100	16170	100	27464	100	2309	100	76298	100	76886	100	52062	100	281072	100
2005	26143	100	4166	100	21856	100	38074	100	5008	100	113067	100	94962	100	47202	100	351177	100
Percentage Change	24		-49		35		39		117		48		24		-9		25	
Occupational Distribution (%)																		
1999		8		3		6		10		1		27		27		19		100
2005		7		1		6		11		1		32		27		13		100

Source: October Household Survey, 1999 and Labour Force Survey, September 2005

Occupational and Industry Level Changes within the Sector

How have the occupational dynamics that we explored with respect to Table 2.4 resonated within the industries that constitute the metal and engineering sector? Table 2.5 provides an answer, once again subject to reservations about its reliability.

The milling firms (Basic Iron and Steel and Non-Ferrous Metals) are the only ones to show a decline in employment between 1999 and 2005; the decline was 13%. The other two stages of production experienced employment increases over the period. Machinery and Equipment Industry (in our terminology, the building of non-electrical machines), showed the highest growth trend within the sector of 144%. Significantly, the employment growth for craft workers (150%), Operators (214%) and Elementary Workers (177%) was higher than the overall growth. Professional employment was shown to decline by 77%.

A somewhat similar trend is recorded within the Electrical Machinery and Apparatus Industries (i.e. the industries associated with the building of electrical machines). The overall employment growth for the sector between 1999 and 2004 was 42%, but the employment of Craft Workers increased by 131% and that of Elementary Workers by 72%. The employment of operators declined marginally by 10%. The 86% decline in the employment of professionals suggests sampling error in the data.

Table 2.5 highlights the fact that positive employment growth in the sector is associated with accelerated demand for the skills of Craft workers and in most cases operators. This is not the case for Elementary workers, who are being shed from the sector as a whole. However, if one looks at each of the industry groupings within the metal sector, the displacement of elementary workers takes place mainly in the Basic Iron and Steel and Non-Ferrous Metals industry and the Metal Products industry. On the other hand, elementary workers have better than average growth in the machine building industries (i.e. the machinery and equipment and the electrical machinery and apparatus industries). One can therefore hypothesise that employment growth in a more developed machine building industry in South Africa would compensate for employment losses among milling plants and engineering and machine shops. Furthermore, a more developed machine building industry would contribute to the expansion of contracts from this industry to the engineering and machine shops, especially in the sourcing of specialised components and parts that go into producing machines. Thus the employees shed in the iron and steel mills (basic iron and steel and non-ferrous metals) should be taken up in more developed and labour intensive downstream industries of the metal and engineering sector.

Table 2.5: Formal Employed in the Metal and Engineering Sector using Two Digit SICS Division 1999 to 2005

Two Digit SICS Division	Managers	%	Professionals	%	Technicians	%	Clerks	%	Sales&Services	%	Craft Workers	%	Operators	%	Elementary	%	Total	%
Basic Iron & Steel and Non-Ferrous Metals (Milling)																		
1999	5000	24	1686	21	5295	33	10529	38	317	14	20609	27	35988	47	18458	35	97882	35
2005	6372	24	2020	48	4629	21	4158	11	1102	22	18283	16	37129	39	11914	25	85609	24
Percentage Change	27		20		-13		-61		248		-11		3		-35		-13	
Metal Products(Engineering & Machine Shops)																		
1999	7337	35	1854	23	4913	30	6393	23	593	26	40609	53	24071	31	21025	40	106795	38
2005	6146	24	1323	32	9118	42	10541	28	586	12	58517	52	31752	33	9886	21	127868	36
Percentage Change	-16		-29		86		65		-1		44		32		-53		20	
Machinery & Equipment (Machine Builders Non-Electrical)																		
1999	2614	12	2006	25	2381	15	3882	14	975	42	7721	10	4894	6	3608	7	28082	10
2005	11677	45	456	11	3210	15	8125	21	515	10	19269	17	15365	16	9999	21	68616	20
Percentage Change	347		-77		35		109		-47		150		214		177		144	
Electrical Machinery & Apparatus (Machine Builders Electrical)																		
1999	6141	29	2545	31	3580	22	7233	26	424	18	7359	10	11933	16	8971	17	48185	17
2005	1949	7	366	9	4899	22	15250	40	2806	56	16999	15	10716	11	15402	33	68386	20
Percentage Change	-68		-86		37		111		562		131		-10		72		42	
Total Metal & Engineering Industries																		
1999	21093	100	8090	100	16170	100	28036	100	2309	100	76298	100	76886	100	52062	100	280944	100
2005	26143	100	4166	100	21856	100	38074	100	5008	100	113067	100	94962	100	47202	100	350477	100
Percentage Change	24		-49		35		36		117		48		24		-9		25	
Occupational Distribution (%)																		
1999		8		3		6		10		1		27		27		19		100
2005		7		1		6		11		1		32		27		13		100

Source: October Household Survey, 1999 and Labour Force Survey, September 2005

These employment trends are compatible with the analysis in Chapter 1 that indicates the very capital intensive nature of milling. The downstream machine builders are far less capital intensive and have a far higher ratio of employment per ton of steel output than the milling stage. This demonstrates the employment gains to be made from greater beneficiation of metal products.

The Crisis of Professional Employment?

The trends which the demand-level data depict for professional employment in the metal and engineering industries between 1999 and 2005 must be viewed with great caution. These findings are derived from household surveys conducted by Statistics South Africa that have severe limitations. First, it should be noted that 'engineers' only make up a component of the total numbers for professional employment. Second, we could not derive a meaningful time series depicting the curve of professional employment for each successive year between 1996 and 2005. Third, if one uses engineering employment as the axis of analysis, the data cannot be assembled on a sector (e.g. manufacturing sector), an industry (e.g. metal and engineering industries), or an industry-specific level (e.g. machinery and equipment or machine building industry). One can only reach such an occupationally specific level of representation for 'engineers' by discussing the aggregation of every discipline which contains engineers from aeronautical and agricultural engineers, on the one extreme, to nuclear and transport engineers on the other. Such an analysis was done in 2003 (Steyn and Daniels, 2003). While pointing to insufficient data, they indicated that the household data suggested 'erratic fluctuations around a moderately declining trend' (Steyn and Daniels, 2003: 568). The data also illustrated a deracialisation of professional engineering employment, a reduction in the employment of younger engineers, and an acceleration in the permanent or temporary migration of engineers from South Africa.

If one looks at the broad trend in engineering employment, the data sources used by Steyn and Daniels suggest that it actually hovered around the 70 000 mark between 1990 and 2001. Furthermore, the Engineering Council of South Africa (ECSA) figures show that the number of all classes of engineers registered with it has been relatively stable at just under 26 000 over much of this period with an upward trend to the 27 000 mark in 2005 and 2006 (although it should be noted that not all engineers in employment are registered with ECSA). The analysis of the educational supply level data in Chapter 3 (below) paints a similar picture: consistent engineering skills provision with a moderate upward trend. It therefore appears that the household survey data is providing an inaccurate picture of engineering employment. Contrary to what this data suggests, there appears to be moderate demand for engineers. Our qualitative research, however, goes further; it points to a strong demand that is not being matched by supply.

Educational and Human Resource Embodiments within the Metal and Engineering Sector Labour Force

Underpinning our analysis of racial, occupational and industrial employment expansion in the metal and engineering sector is the question of the human resource or human capital embodiments of the labour force. How has this changed for the period that our data generally refers? Table 2.6 compares the changes in the highest educational qualifications that the labour force within the different industries of the metal and engineering sector reached in 1999 and 2005. Qualifications are used as a proxy for human capital embodiments of the labour force. Viewed in its totality, the shifts in human capital embodiments are more prominent for specific educational levels. Only marginal changes were recorded for individuals within the labour force holding the following qualifications:

- Grade 9 (NQF1 or ABET4)
- Grades 10 to 11, including certificates or diplomas that were less than a Grade 12 qualification.
- Degrees.
- Post-Graduate qualifications.

More significant changes in the qualifications, and by proxy the skills embodiment of the labour force, were recorded for individuals that held qualifications below Grade 9 and for those holding a Grade 12 or NTC3 Certificate or Grade 12 with any other type of post-matriculation certificate or diploma.

If we examine the changes in the number of individuals with less than a Grade 5 level of education, it can be seen that the proportion working in the metal and engineering sector declined from 9% in 1999 to 6% in 2005. Similarly, the proportion of individuals in the sector with a level of education ranging from Grade 5 to Grade 8 (ABET 2 to 3) also declined between 1999 and 2005 from 25% to 13%. Further, in 1999 34% of the labour force held a qualification that was lower than Grade 9, whereas by 2005 this proportion had been eroded to roughly 19%. On the face of it this represents a positive outcome because it suggests that elements of a low educational embodiment in the sector are fast disappearing, possibly because they acquired training which elevated their educational embodiment. However, it could be that these individuals were displaced from the sector. The data regarding elementary workers would tend to suggest the latter.

Table 2.6: Educational Levels of Individuals Formally Employed in the Metal and Engineering Sector using Two Digit SICS Division 1999 to 2005

Two Digit SICS Division	G5<	%	G5-8 (ABET 2-3)	%	G9 (NQF 1/ABET 4)	%	G10-11, NTC1-2, Cert/Dip<Gr 12	%	G12, NTC3	%	Cert/Dip+G12	%	Degree	%	PG	%	Total	%
Basic Iron & Steel and Non-Ferrous Metals (Milling Processes)																		
1999	12621	52	22557	33	4790	28	25435	37	25791	30	3136	51	1234	21	2031	72	97594	35
2005	7617	34	9704	22	8025	32	22429	27	27149	20	6823	26	3215	47	549	23	85511	25
Percentage Change	-40		-57		68		-12		5		118		160		-73		-12	
Metal Products(Engineering & Machine Shops)																		
1999	7906	33	30957	45	6597	38	27397	40	28007	33	90	1	1873	33		0	102828	37
2005	7868	35	21502	48	8629	34	33450	40	47806	35	8569	32		0		0	127825	37
Percentage Change	0		-31		31		22		71		9417		-100				24	
Machinery & Equipment (Machine Builders Non-Electrical)																		
1999	218	1	5870	9	1439	8	4953	7	11012	13	2072	33	2020	35	616	22	28201	10
2005	2427	11	7026	16	6049	24	13786	17	29816	22	5223	20	1692	25	1767	73	67786	19
Percentage Change	1015		20		320		178		171		152		-16		187		140	
Electrical Machinery & Apparatus (Machine Builders Electrical)																		
1999	3395	14	9245	13	4417	26	11483	17	20376	24	900	15	620	11	187	7	50623	18
2005	4393	20	6810	15	2567	10	12942	16	31935	23	5910	22	1916	28	94	4	66566	19
Percentage Change	29		-26		-42		13		57		557		209		-50		31	
Total Metal & Engineering Industries																		
1999	24139	100	68629	100	17244	100	69268	100	85186	100	6198	100	5747	100	2835	100	279247	100
2005	22305	100	45043	100	25271	100	82607	100	136705	100	26525	100	6822	100	2409	100	347688	100
Percentage Change	-8		-34		47		19		60		328		19		-15		25	
School Level Distribution																		
1999		9		25		6		25		31		2		2		1		100
2005		6		13		7		24		39		8		2		1		100

Source: October Household Survey, 1999 and Labour Force Survey, September 2005

Sharp declines took place in the number of individuals with Grade 5 and lower and Grade 5 to Grade 8, particularly in iron and steel milling firms. Similar declines occurred for those with Grade 5 to Grade 8 occurred in Engineering and Machine Shops and Electrical Machine Builders (Electrical Machinery and Apparatus). Although measured from a low base, there were increases recorded in the number of individuals working for Non-Electrical Machine Builders (Electrical Machinery and Apparatus) with Grade 5 and lower and Grade 5 to Grade 8 educational levels.

If we shift our attention to individuals who held a Grade 12 or NTC3 Certificate in 1999 and 2005 as well as individuals who held such a certificate plus a higher level certificate or diploma, we see an upward shift from 1999 to 2005: for those with a Grade 12 or NTC3 Certificate the improvement was from 31% of all employees in the metal and engineering sector to 39%. In quantitative terms, 60% more people held a Grade 12 or NTC3 Certificate in 2005 compared to 1999. For individuals who held an additional post-secondary school certificate or diploma with their Grade 12 certificate, there was a remarkable 328% increase between 1999 and 2005. The proportion of these workers rose from 2% to 8% of total employees in the metal and engineering sector. If educational credentials are a proxy for educational and human resource endowments, we can say that the growth in the proportion of the labour force in the sector with Grade 12, or Grade 12 and an additional certificate or diploma, represents an improvement in the labour resource endowment for the sector.

Which industries in the metal and engineering sector were primarily responsible for this shift? All four industries that we have been discussing experienced an increment in the number of individuals holding either Grade 12 or Grade 12 combined with a post-secondary school certificate or diploma. The increase in individuals holding Grade 12 was more concentrated within the Metal Products (engineering and machine shops) (71% increase), Machinery and Equipment (non-electrical machine builders) (171% increase), and Electrical Machinery and Apparatus (electrical machine builders) (57% increase), compared to Basic Iron and Steel and Non-Ferrous Metals (milling processes) (5% increase). Although the number of individuals involved was smaller, the same upward improvement in qualifications involving Grade 12 combined with a post-secondary school certificate or diploma was evident across all four industries within the metal and engineering sector.

Earlier analysis had highlighted a 49% decline in the employment of professionals in the combined metal and engineering industries. This trend was shown to be particularly pervasive within the Machinery and Equipment (machine builders non-electrical) and the Electrical Machinery and Apparatus (machine builders electrical) industries. As a rule, professionals would have a high concentration of degree holders within their ranks. While we do not have the data to make an exact correlation, we can ascertain to what extent incumbents in the labour force with degrees exhibit the trends that were shown for the employment of professionals. The proportion of individuals holding degrees within the metal and engineering industry labour force increased by 19% between 1999 and 2005. Although this increase is dwarfed by the 328% increase recorded for holders of certificates or diplomas among other post-secondary educated personnel within the sector, it surpassed the 15% decline that was recorded for post-graduate qualifications. Over the same period, Machinery and Equipment (machine builders non-electrical) recorded a 16% decline in degree holders within the labour force, while Electrical Machinery and Apparatus (machine builders electrical) showed a 209% increase for this educational cohort. In both instances the data is at odds with that which showed a decline in professional employment for the two sectors. It is therefore possible that the decline depicted in professional employment numbers within the sector is either due to statistical error or the masking of greater managerial roles which professionals have had to carry out. In the latter instance the survey data would tend to capture professionals undertaking a dual professional and management role as 'managers'.

CONCLUSION

This chapter has mapped and discussed the pattern of labour demand in the metal and engineering sector and the industries which constitute it over the period 1996 to 2005. Importantly, while the chapter confirms that significant labour shedding has taken place, particularly from 1996 to 2001, it also shows that labour force growth has been experienced since 2001.

The chapter provides a detailed analysis of relative labour demand shifts by race, occupation, sector and education. The data shows that elementary workers, and workers with low educational endowments, have and will experience greater levels of employment losses. A converse situation prevails for craft workers and workers with higher educational levels, particularly at the Grade 12 level and above where there has been significant increases.

If the data is reliable, a finding of great concern would be the decline in the number of professionals in the sector. According to a survey in which the sample base is small the number of professionals had fallen by 2005 to only half of what it was in 1999. As these professionals are mostly engineers this loss would be a serious haemorrhage of highly skilled professionals from the industry. However, this data confounds the widely held perception that there is a shortage of engineers. We have, furthermore, shown that the data conflicts with the trends depicted by other indicators. Given this confusion it is not possible to confirm what the situation is one way or the other, but it is very unlikely that there has been a decline in the number of engineers of the order depicted by the data. What is more likely is that many engineers have been captured in the managerial category thereby distorting the data.

With respect to the industrial make up of the metal and engineering sector, the evidence shows that employment losses, especially for elementary workers, were more pervasive in the basic iron and steel and non-ferrous metals industry (milling processes) and within the metal product industries (engineering and machine shop industries). Since the employment of elementary workers has remained positive over the 1999 to 2005 period in the machine building industries (both the building of non-electrical and electrical machine), this evidence suggests that a stronger machine building industry would have had the potential of largely nullifying the employment losses of elementary workers that was indicated for the iron and steel milling processes and the engineering and machine shops. A stronger machine building industry could furthermore assist in alleviating the types of losses that occurred for Metal Products (engineering and machine shops) because there would be a higher demand from machine builders for components and customised parts that machine builders would require if the industry was more developed.

Chapter 3

The Supply of Skills in Metal Industries

I

INTRODUCTION

In Chapter Three we provide a detailed analysis and discussion of education supply data pertaining to metal and engineering and related programmes offered within Further Education and Training Institutions (FETs) and Higher Education Institutions (HEIs). We commence with an explanation of the different routes by which a person could acquire skills in the metal sector. Then we examine the entries, throughputs and outputs in FETs, followed by a similar examination of acquiring qualifications through HEIs. We end of the chapter with a summary of the main findings.

Paths to become artisans, technicians and engineers

Although the FET system is undergoing a curriculum change the period for which the data is applicable precedes this change. Within this older FET system, all the qualifications offered were referred to as National Education (NATED) qualifications. Within the technical fields these were normally offered on a trimester system. Subjects in the non-technical fields were usually offered on a semester system. Individuals being trained in a technical occupational field get theoretical instruction through a FET institution to obtain national certificate qualifications such as NTC 3 or NTC 4 (sometimes abbreviated further as N3 or N4).[18] The NTC 3 courses have a content and conceptual level that is equivalent to the national educational certificate or matriculation certificate. To qualify as an artisan requires that students achieve the NTC 2 level, but in the newer technology programmes this minimum requirement can be raised to NTC3.

Similar qualifications pegged at a higher level were offered through the Technikons. Initially these Technikon level courses were offered on a trimester system as well as through part-time evening classes. Over time the trimester system evolved into a semester system. Although organized in a semester system, the Technikon courses are whole-year courses that lead to a national diploma. The first-year level of a Technikon course is designated as T1 and the further levels as T2 and T3. Normally a matriculation certificate with exemption is a prerequisite to enter these courses, particularly in the scientific fields of engineering, accounting, medical technology, etc. Graduates in the engineering and scientific fields who qualify from Technikons (now referred to as Universities of Technology) with a national diploma are usually designated as Technicians while those with a B Tech degree are usually referred to as engineers.

University courses are usually divided into undergraduate and post-graduate courses. The feeder qualifications of high level human resources that enter the metal and engineering sector from the university system are either an

[18] NTC stands for National Technical Certificate

engineering degree (e.g. an engineering degree in metallurgy, chemistry or mechanical engineering) or an undergraduate bachelors degree in a science discipline (e.g. metallurgy, chemistry, etc.). The university system furthermore provides for a wide spectrum of more specialized studies that can be undertaken at a post-graduate level. Individuals who hold university engineering degrees or undergraduate or post-graduate degrees in specific science disciplines are referred to as engineers or scientists.

It is important to recognize that there are a number of different paths that can be followed to become an artisan, technician or engineer. The routes to artisan status are as follows:

- A four year traditional apprenticeship at a firm with block-releases to attend sandwich courses (N1 and N2) in trade theory subjects at an FET college. Admission to such apprenticeship programmes at a firm would normally be a minimum of a Grade 9 school leaving certificate with a credit in mathematics. Credits in Science, Technical Drawing and other technical related subjects would be a bonus. The firm is required to release the apprentice in blocks lasting for up to four months (15 weeks) to attend trimester N-courses in theory subjects of the trade in which the apprentice is engaged. Learnership programmes that contain an equivalent theoretical and practical content will result in similar admission routes into the artisan ranks. But even under traditional apprenticeship programmes, an apprentice who reached a trade competence and fulfilled the theoretical requirements could with the consent of the employer undergo a trade test within the four year apprenticeship period and gain admission to artisan status. This is the normal route that is followed to become an artisan.

- An accelerated apprenticeship programme leads to the same result but it is done over a shorter period. Instead of taking four years, it can be done in just over 80 weeks. This embodies 60 weeks of in-house training and theoretical instruction either at a training centre attached to the firm or a FET college, coupled with a further 24 weeks of on-the-job training in a normal working environment. Usually the on-the-job training takes place in a normal working environment in the industry in which the trade skill is largely embedded. Firms with their own training centre would merely transfer the apprentice or learner from the training centre to the factory floor. A training centre at an FET college would seek to place the apprentice or learner for 24 weeks with a reputable firm that will provide the candidate with practical on-the-job experience.

- A further route emerged some time ago under the Metal and Engineering Industry Bargaining Council. Known as the Artisan Training and Recognition Agreement for the Metal Industry (ATRAMI), it has been endorsed by the new institutions of skills development such as the Merseta. The ATRAMI system is designed for two types of learners. First, those who are under 21 years and have not been able to secure an apprenticeship contract with an employer. Second, learners with more than five years' working experience and the competence to do similar skilled work as artisans, and who have competence in all the perquisite theoretical modules for the trade, can immediately apply to undergo a skills recognition test. If successful, they would be granted artisan status. If not successful, the result will indicate at what level each trainee has to undergo further training. Under ATRAMI, trainees have to proceed through a sequence of modules. A competence test is undergone at the end of each module. The trainee must pass this competence test before embarking on the next module. Once all the prescribed modules have been successfully completed, the trainee can apply to the Merseta to undergo a national trade test under section 28 of the Manpower Training Act, 56 of 1981, at an accredited trade test centre. Success in the national trade test automatically leads to the granting of artisan status.

Across these three routes into artisan occupations, there is high degree of overlap and substitutability between the apprenticeship route and the learnership route. Both routes represent old and new institutional forms for the creation of a corps of artisan workers in the metal and engineering industries by deepening the interaction between learning and the activity of work.

As this chapter does not discuss the supply of artisans directly it is worth giving a short overview of their supply over the last 25 years. Throughout much of the 1980s, over 10 000 artisans graduated annually within South Africa. The number of artisans qualifying began to fall from 1989. In 1991, 7200 artisans qualified and by 2004 this had systematically declined to only 2548. Similarly, in 1991, 3911 new metal sector apprentices were registered in South Africa but this number declined to only 320 in 1998 and again in 1999 (Kraak, 2008, Tables 22.1 and 22.2). While not reaching the levels that had been attained in the mid-1980s, the total number of apprenticeships enrolled under the first phase of the National Skills Development Strategy (NSDS) between 1 April 2001 and 31 March 2005 amounted to 12 577 and was dramatically higher than the figures recorded in 1998 and 1999.

To become an engineer, a plurality of routes can be pursed by an individual intending to become an engineer. The most prominent is through academic study in order to obtain an engineering degree. Thereafter recently graduated engineers can acquire experience by working on-the-job under the supervision of highly experienced engineers. Such programmes are referred to as an engineering pupilage and bear some semblance to the experiential workplace training that is recommended for individuals at the senior level of their Technikon or University of Technology diploma studies.

An artisan can also become an engineer, mainly through part-time studies at a local Technikon. These theoretical studies are combined with applied practical work in the field of engineering that eventually culminates in sitting an examination for the government certified engineers ticket. This route is open to individuals in the mechanical engineering, chemical engineering, electrical engineering and marine engineering fields. Although it has lost a lot of its popularity, it can still be used by individuals to develop their careers in the engineering field and eventually be admitted to the engineering profession.

FET INSTITUTIONS' ENROLMENTS, THROUGHPUTS AND OUTPUTS

Table 3.1 provides aggregate enrolment, examination and output data for theoretical engineering courses that were offered at FET institutions throughout the country at N level. These N level courses were mainly offered on a trimester basis.

We will start by temporarily ignoring the subject-specific orientation of these courses and instead look at the patterns between enrolment and success outputs. These engineering-related courses range from level one to six of the national technical certificate. Although there were differences in teaching methodologies and the length of programmes, level one was assumed to be the equivalent to standard eight or grade ten within the academic or schooling stream. Thus, level three was designated to be equivalent to standard ten or grade twelve, and levels four to six were perceived to be at levels that were higher than matric.

Consistent Enrolment Increases but Fluctuating Pass Rates

Table 3.1 provides a national aggregated picture of enrolments, examination sittings and passes for all FET engineering subject offerings from levels one to six for the period 1996 to 2005. It also shows pass rates in relation to candidates who sat for the examination.

We have also provided a further measure of performance which we refer to as the 'dropout rate'. This represents the proportion of candidates that enrolled but did not write the examination. It is important to note that the dropout process occurs across all FET levels. Since we are using data which covers a ten-year period, the time series allows us to construct a general pattern in the performance in engineering education within the FET system as a whole. In the extreme right-hand column of Table 3.1 the percentage growth or decline over the whole period (1996-2005) is shown for all the measures.

Viewing the data in terms of numerical performance for the period 1996 to 2005 reveals an improvement in the numbers who entered for each course level. The same applies to the numbers of candidates who eventually write the examinations and the number of candidates who pass. Thus the aggregate growth change for the period 1996 to 2005 is positive for 'entered', 'wrote' and 'passed' from levels one to six. In the extreme right hand column of Table 3.1 this is shown as a positive growth. In this sense the FET system, in so far as engineering education is concerned, appears to have improved.

Table 3.1: Natonal Enrolments, Examinations and Success Outputs in in FET N Level Theoretical Engineering Courses

Theoretical Courses	Level		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	% Growth:96-05
Level 1 Theoretical Courses	1	Entered	2934	2915	3188	3359	2911	2855	2903	3698	4287	4436	51.2
	1	Wrote	2521	2517	2735	2946	2493	2516	2522	3266	3735	3891	54.3
	1	Passed	1022	1145	1161	1175	1106	1305	1335	1600	1903	1945	90.3
		P/E %	34.83	39.28	36.42	34.98	37.99	45.71	45.99	43.27	44.39	43.85	25.9
		P/W %	40.54	45.49	42.45	39.88	44.36	51.87	52.93	48.99	50.95	49.99	23.3
		D/O b W	14.08	13.65	14.21	12.3	14.36	11.87	13.12	11.68	12.88	12.29	-12.7
Level 2 Theoretical Courses	2	Entered	2066	2271	2294	2392	2119	2135	2606	2967	3509	3817	84.8
	2	Wrote	1847	2002	2081	2138	1917	1946	2311	2700	3209	3463	87.5
	2	Passed	1051	1119	1146	1169	1048	1142	1309	1599	1748	1891	79.9
		P/E %	50.87	49.27	49.96	48.87	49.46	53.49	50.23	53.89	49.81	49.54	-2.6
		P/W %	56.9	55.89	55.07	54.68	54.67	58.68	56.64	59.22	54.47	54.61	-4.0
		D/O b W	10.6	11.85	9.285	10.62	9.533	8.852	11.32	8.999	8.549	9.274	-12.5
Level 3 Theoretical Courses	3	Entered	597	621	511	411	427	403	489	494	640	714	19.6
	3	Wrote	475	506	434	338	362	373	433	429	574	642	35.2
	3	Passed	263	313	297	235	223	211	244	305	442	494	87.8
		P/E %	44.05	50.4	58.12	57.18	52.22	52.36	49.9	61.74	69.06	69.19	57.1
		P/W %	55.37	61.86	68.43	69.53	61.6	56.57	56.35	71.1	77	76.95	39.0
		D/O b W	20.44	18.52	15.07	17.76	15.22	7.444	11.45	13.16	10.31	10.08	-50.7
Level 4 Theoretical Courses	4	Entered	1115	1994	2033	1625	1479	1442	1363	1332	1544	1609	44.3
	4	Wrote	915	1652	1698	1447	1301	1280	1214	1189	1363	1419	55.1
	4	Passed	526	737	844	812	782	745	736	759	772	852	62.0
		P/E %	47.17	36.96	41.52	49.97	52.87	51.66	54	56.98	50	52.95	12.2
		P/W %	57.49	44.61	49.71	56.12	60.11	58.2	60.63	63.84	56.64	60.04	4.4
		D/O b W	17.94	17.15	16.48	10.95	12.04	11.23	10.93	10.74	11.72	11.81	-34.2
Level 5 Theoretical Courses	5	Entered	4396	4631	5117	4653	4978	5044	4922	5288	5476	5406	23.0
	5	Wrote	3549	3849	4321	4117	4516	4561	4308	4673	4739	4705	32.6
	5	Passed	1829	1837	1889	2152	2290	2431	1936	2131	2071	2074	13.4
		P/E %	41.61	39.67	36.92	46.25	46	48.2	39.33	40.3	37.82	38.36	-7.8
		P/W %	51.54	47.73	43.72	52.27	50.71	53.3	44.94	45.6	43.7	44.08	-14.5
		D/O b W	19.27	16.89	15.56	11.52	9.281	9.576	12.47	11.63	13.46	12.97	-32.7
Level 6 Theoretical Courses	6	Entered	1795	1922	2019	2093	2206	2504	2440	2376	2358	2619	45.9
	6	Wrote	1345	1459	1612	1736	1890	2174	2086	2002	1971	2186	62.5
	6	Passed	664	698	834	1004	1203	1164	1146	1065	896	950	43.1
		P/E %	36.99	36.32	41.31	47.97	54.53	46.49	46.97	44.82	38	36.27	-1.9
		P/W %	49.37	47.84	51.74	57.83	63.65	53.54	54.94	53.2	45.46	43.46	-12.0
		D/O b W	25.07	24.09	20.16	17.06	14.32	13.18	14.51	15.74	16.41	16.53	-34.1

Source: Calculated from HSRC data obtained from EMIS.
Key: E=Entered; W=Wrote; P=Passed; D/O b W= Dropout Rate before Wrote.

When we consider the more important ratio of passes in relation to candidates who wrote the examination and the percentage of dropouts from courses prior to writing the examination, the evidence depicts a gradual improvement across most levels. For the period 1996 to 2005, the dropout levels from the time of enrollment to the time when candidates actually sit their examinations declines for all six levels. In Table 3.1 this improvement is designated as a negative value. For example, at level 1, the dropout rate improved by 12.7% (from 14.08% to 12.29%) between 1996 and 2005; at level 2 by 12.5% (from 10.6% to 9.274%); at level 3 by 50.7% (from 19.27% to 12.97%); at level 4 by 34.2% (from 17.94% to 11.81%); at level 5 by 32.7% (from 19.27% to 12.97%); and at level 6 by 34.1% (from 25.07% to 16.53%). In some instances the improvement is marginally better for the period 2000 and 2001 than it is for 2004 and 2005.

There is, however, a fall in the pass rates at three of the levels, namely levels 2, 5 and 6. While the fall in pass rate was very slight at level 2, it was more pronounced at level 5 and level 6. The pass rates of those writing the examination declined from just over 50% in 1996 to 44% in 2005 for level 5, and from 49% in 1996 to 43% in 2005 for level 6. This contrasts with levels 1, 3 and 4 where the pass rates for those writing improved from 40% to 49% for level 1, improved from 55% to 76% for level 3, and improved marginally from 57% to 60% for level 4.

The fact that enrolments and passes increased over the ten year period at all levels provides evidence that the FET system has the potential to grow in this area of educational delivery. This potential capacity is especially pertinent to the intermediate labour force members who do not hold any post-school vocational education and training.

Lack of Steady Progress through the Levels

Arranging the data for greater systemic interrogation by clustering data for all entrants, examination takers and passes separately, we can ascertain to what extent the engineering student profile at FET institutions is being transmitted from the lower to the higher levels. This evidence will provide us with probable reasons for the patterning of the data.

Table 3.2 shows entrance into all engineering programmes from N1 to N6 at FET institutions nationally for the period 1996 to 2005. There is a drop-off in numbers of enrollments from the lower grade N1 to the higher grade N3. But this is followed by dramatic increases up to grade N5, only to fall heavily again when moving up to N6. The drop from N1 to N2 is not very large, with the percentage decline in enrollments decreasing from 29% in 1996 to 14% in 2005. The enrollment decline from N2 to N3 is more dramatic, and it worsens from 71% in 1996 to roughly 80% and over from 1999 to 2005. The issue here is that N2 learners do not proceed to N3. The numbers show that the enrolments at N3 amounted to no more than 18.7% of those recorded at the preceding N2 level. Learner retention in the system is therefore a concern as is the fact that the lower technical hierarchy of the metal and engineering labour force is supplied with individuals who are endowed mostly with only an N2 certificate.

There is a ten-year pattern of dramatic increases in enrolments from the N3 to the N4 level and then again from the N4 to the N5 level. The increase from N3 to N4 ranges from 86% in 1996 to 125% in 2005, but for particular years over this period the increase is even higher. From N4 to N5 the increase is even larger, ranging from 294% in 1996 to 236% in 2005. This trend, however, is reversed from N5 to N6. In fact, the decline in enrollments from N5 to N6 amounts to more than half across the ten-year period 1996 to 2005.

The inconsistency in enrolments across educational levels tends to suggest that the FET system does not incorporate a coherent group of learners that are exposed to a common technical educational endowment. When N4 enrolments are more than double N3 enrolments and when N5 enrolments are three times more than N4 enrolments, there is a high likelihood that the entry point into the FET system is being made at a higher level.

Explanation of Piece-Meal Certification

In the context where we have identified higher enrolment numbers, especially at the N4 and N5 levels compared to preceding levels (i.e. N3 and N4), we are still not exactly certain whether the source of these enrolments is the return of previous graduates from the labour market or whether it represents an inflow from the general education system. It seems quite possible that school leavers with a matriculation certificate who are unable to enter the higher education system will proceed with further studies in the FET system. Such individuals are more likely to enter the FET system at the N4 level and as suggested above would be joined by past FET graduates returning to the system from the world of work. But it is unlikely that the increase in N5 enrolments is the result only of entrants from the general education stream or returning FET graduates. It is probable that a large proportion of the N5 enrolments in engineering courses enter the FET system after dropping out of the HE system on academic, financial or other grounds. It implies that such learners will come in from the HE system with subject credits which would enable them to gain exemption from some or most N4 level courses in the fields in which they are studying. This explanation was viewed as quite credible by a provincial education department official whom we interviewed. If it is correct it means that the FET system serves as a net where the HE engineering programme drop-outs can continue their studies in the engineering field.

Table 3.2: Performance Transmission Across FET N Level Theoretical Engineering Courses

	Level		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Entered												
Level 1 Theoretical Courses	1	Entered	2934	2915	3188	3359	2911	2855	2903	3698	4287	4436
Level 2 Theoretical Courses	2	Entered	2066	2271	2294	2392	2119	2135	2606	2967	3509	3817
Proportionate Change: N1 to N2			**-29.6**	**-22.1**	**-28**	**-28.8**	**-27.2**	**-25.2**	**-10.2**	**-19.8**	**-18.1**	**-14**
Level 3 Theoretical Courses	3	Entered	597	621	511	411	427	403	489	494	640	714
Proportionate Change: N2 to N3			**-71.1**	**-72.7**	**-77.7**	**-82.8**	**-79.8**	**-81.1**	**-81.2**	**-83.4**	**-81.8**	**-81.3**
Level 4 Theoretical Courses	4	Entered	1115	1994	2033	1625	1479	1442	1363	1332	1544	1609
Proportionate Change: N3 to N4			**86.77**	**221.1**	**297.8**	**295.4**	**246.4**	**257.8**	**178.7**	**169.6**	**141.3**	**125.4**
Level 5 Theoretical Courses	5	Entered	4396	4631	5117	4653	4978	5044	4922	5288	5476	5406
Proportionate Change: N4 to N5			**294.3**	**132.2**	**151.7**	**186.3**	**236.6**	**249.8**	**261.1**	**297**	**254.7**	**236**
Level 6 Theoretical Courses	6	Entered	1795	1922	2019	2093	2206	2504	2440	2376	2358	2619
Proportionate Change: N5 to N6			**-59.2**	**-58.5**	**-60.5**	**-55**	**-55.7**	**-50.4**	**-50.4**	**-55.1**	**-56.9**	**-51.6**
Wrote												
Level 1 Theoretical Courses	1	Wrote	2521	2517	2735	2946	2493	2516	2522	3266	3735	3891
Level 2 Theoretical Courses	2	Wrote	1847	2002	2081	2138	1917	1946	2311	2700	3209	3463
Proportionate Change: N1 to N2			**-26.7**	**-20.5**	**-23.9**	**-27.4**	**-23.1**	**-22.7**	**-8.37**	**-17.3**	**-14.1**	**-11**
Level 3 Theoretical Courses	3	Wrote	475	506	434	338	362	373	433	429	574	642
Proportionate Change: N2 to N3			**-74.3**	**-74.7**	**-79.1**	**-84.2**	**-81.1**	**-80.8**	**-81.3**	**-84.1**	**-82.1**	**-81.5**
Level 4 Theoretical Courses	4	Wrote	915	1652	1698	1447	1301	1280	1214	1189	1363	1419
Proportionate Change: N3 to N4			**92.63**	**226.5**	**291.2**	**328.1**	**259.4**	**243.2**	**180.4**	**177.2**	**137.5**	**121**
Level 5 Theoretical Courses	5	Wrote	3549	3849	4321	4117	4516	4561	4308	4673	4739	4705
Proportionate Change: N4 to N5			**287.9**	**133**	**154.5**	**184.5**	**247.1**	**256.3**	**254.9**	**293**	**247.7**	**231.6**
Level 6 Theoretical Courses	6	Wrote	1345	1459	1612	1736	1890	2174	2086	2002	1971	2186
Proportionate Change: N5 to N6			**-62.1**	**-62.1**	**-62.7**	**-57.8**	**-58.1**	**-52.3**	**-51.6**	**-57.2**	**-58.4**	**-53.5**
Passed												
Level 1 Theoretical Courses	1	Passed	1022	1145	1161	1175	1106	1305	1335	1600	1903	1945
Level 2 Theoretical Courses	2	Passed	1051	1119	1146	1169	1048	1142	1309	1599	1748	1891
Proportionate Change: N1 to N2			**2.838**	**-2.27**	**-1.29**	**-0.51**	**-5.24**	**-12.5**	**-1.95**	**-0.06**	**-8.15**	**-2.78**
Level 3 Theoretical Courses	3	Passed	263	313	297	235	223	211	244	305	442	494
Proportionate Change: N2 to N3			**-75**	**-72**	**-74.1**	**-79.9**	**-78.7**	**-81.5**	**-81.4**	**-80.9**	**-74.7**	**-73.9**
Level 4 Theoretical Courses	4	Passed	526	737	844	812	782	745	736	759	772	852
Proportionate Change: N3 to N4			**100**	**135.5**	**184.2**	**245.5**	**250.7**	**253.1**	**201.6**	**148.9**	**74.66**	**72.47**
Level 5 Theoretical Courses	5	Passed	1829	1837	1889	2152	2290	2431	1936	2131	2071	2074
Proportionate Change: N4 to N5			**247.7**	**149.3**	**123.8**	**165**	**192.8**	**226.3**	**163**	**180.8**	**168.3**	**143.4**
Level 6 Theoretical Courses	6	Passed	664	698	834	1004	1203	1164	1146	1065	896	950
Proportionate Change: N5 to N6			**-63.7**	**-62**	**-55.8**	**-53.3**	**-47.5**	**-52.1**	**-40.8**	**-50**	**-56.7**	**-54.2**

Source: Calculated from HSRC data obtained from EMIS

Exactly the same pattern is replicated for those who wrote examinations for theory subjects at FET institutions. Unsurprisingly, this pattern is mirrored for the number candidates who passed these examinations. From N1 to N2, the numbers decline for those who wrote the examinations from between 26% to 11% for the period 1996 to 2005, and more modestly for those who passed over the same period at roughly 3%. This is followed by a dramatic decline in the numbers who write and pass the examinations from N2 to N3.

The numbers pick up again at the N4 level for examinees and for passes registered. From N4 to N5 there is again a dramatic increase in examinee numbers and in the number of candidates who passed. Similarly, as was the case for the trend in those entering N6, a correspondingly significant decline is shown for the number writing and passing the examinations for the entire period from 1996 to 2005. Thus, the patterns observed above suggest that with the exception of those who proceed to gain artisan status with the basic minimum requirements, individuals who study through the FET system seem to acquire piece-meal certification. It is either geared to overall industry standards and requirements (e.g. theoretical instruction to N2) or standards and requirements which firms themselves impose (matric certicate or its N-level equivalent) to enter apprenticeship or learnership programmes.

It is apparent from the data that the enrolments from one level to another are not consistent. The evidence suggests that different cohorts of FET learners participate in the system at different levels. One group would probably be those who aim to undergo the trade test with the minimum education prerequisites. This group is likely to comprise learners who either do not hold the matriculation certificate or just scraped through. The second group would be made up of matriculatants who have mathematics and science subjects. Some of this group probably enter the FET system because that is the only entrance point they have to study further and progress beyond the artisan layers of the labour force. Probably, with only minor exceptions, those who enroll at the N1 and N2 levels generally do not participate beyond this point once the theoretical requirements to be admitted to artisan status have been fulfilled. Such learners are not likely to reach the higher N4 and N5 levels. There is a third group of learners who appear to enter the FET system as drop-outs from the HE system. The entry point of this third group is the N5 level and accounts for the more than three-fold increase in enrolments from the N4 to the N5 level. We do not have data to ascertain whether the group that enters the FET system from the HE system eventually attempt to get back into the HE system once they have acquired a FET national certificate (i.e. N5 and N6).

These three participating groups in the FET system, particularly in the engineering programmes, enter the system from different avenues. Those who enter N1 are more likely to continue and complete N2. Since the minimum theoretical requirement to become an artisan is to undergo instruction at the N2 level, followed by practical workshop instruction and experiential learning for a certain duration within industry, apprentices that have fulfilled the minimum requirements of N2 theoretical instruction are not obliged to proceed further within the FET system.

An influx of entrants into the system, exceeding the numbers that were enrolled at N3, is evident at the N4 and N5 levels. Where do these learners come from? The data suggests that these are matriculation students. Since at least the early 1990s many firms have become more stringent in the entrance requirements demanded from those intending to undergo an apprenticeship in the engineering trades. They select from candidates who have at least obtained a matriculation certificate with mathematics and science as subjects. It is these apprentices that make up the numbers for candidates in the N4 and upper levels at FET institutions. So, while the entrance requirements to qualify as an artisan have remained intact for at least two decades (i.e. N2 theoretical instruction coupled with subsequent practical and theoretical instruction), firms are setting their own academic requirements that entrants have to fulfill.

The FET supply data therefore tends to suggest that there are two cohorts of learners who enter the artisan trades: those who fulfill the minimum theoretical requirements and thereafter proceed to undertake their practical training and probably take their trade tests; and those learners with a better academic standing, who proceed with their theoretical training at a higher level within the FET bands. This segmentation is probably replicated within the labour market: many small engineering plants probably adhere to the historical minimum academic prerequisite for their apprentices whereas the larger firms, which are also likely to have in-house training facilities, are setting the bar higher. The interviews that are analyzed in Chapter 4 suggest that most firms with apprenticeship training programmes require a matriculation certificate with mathematics and science as a minimum entrance.

An interviewee gave a nuanced interpretation of the above with institutionally specific insights[19]. He confirmed that the majority of enrolled learners at the N1 and N2 levels are made up of individuals who have fallen out of the schooling system or passed with poor symbols that do not allow them to access the public higher education system. For these learners, enrollment at an FET institution represents a second chance to obtain a qualification. Many, however, do not continue beyond N2, mainly because they do not cope with the standard demanded by FET institutions. Their departure from the FET system after N2 coincides with the departure of learners that are indentured into artisan programmes after having fulfilled the minimum theoretical requirements. These two groups largely account for the massive decline in N3 enrollments. The interviewee stated that N3 enrollments were largely generated internally as throughputs from N2.

Enrollments at N4 and beyond were perceived to derive from a number of different sources. These were throughputs from N3, the return of previous drop-outs, the admission of matriculated school leavers, and learners transferring, either temporarily or permanently, from the HE system. The return of drop-outs is being generated by the demand by employers for prospective apprentices to have higher educational qualifications. The N-levels within which students from the HE system were placed depended on the types of courses that they had previously studied and the credits that they had obtained. Although less popular today, partially technically educated individuals had in the past enrolled for national certificate level engineering courses at FET colleges as a route to gaining a government certificate of competence for engineers. Our informant suggested this alternative stream may still be taking place.

[19] Interview with Dr Clarence Pereira conducted telephonically, 16 January 2008.

Table 3.3: Distribution of Passes in Metal and Engineering Trade Theory Examinations at the FET National Level for the Period 1996 to 2005

Subject	Level	Status	1996	%	1997	%	1998	%	1999	%	2000	%	2001	%	2002	%	2003	%	2004	%	2005	%
Level 1 Theoretical Courses																						
AIRCRAFT METALWORK THEORY	1	Passed	5	0.5	1	0.1	9	0.8	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
METAL WORKERS' THEORY	1	Passed	620	60.7	711	62.1	710	61.2	656	55.8	711	64.3	805	61.7	811	60.7	909	56.8	1117	58.7	1096	56.3
PLATING AND STRUCTURAL STEEL DRAWING	1	Passed	361	35.3	384	33.5	411	35.4	498	42.4	387	35.0	495	37.9	508	38.1	682	42.6	771	40.5	847	43.5
FERRO-ALLOY THEORY	1	Passed	18	1.8	46	4.0	24	2.1	16	1.4	6	0.5	2	0.2	13	1.0	6	0.4	11	0.6	1	0.1
FOUNDRY THEORY	1	Passed	11	1.1	3	0.3	7	0.6	5	0.4	2	0.2	3	0.2	3	0.2	3	0.2	4	0.2	1	0.1
IRON, STEEL AND FERRO ALLOY PROCESS THEORY	1	Passed	7	0.7	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
TOTAL	1	Passed	1022	100	1145	100	1161	100	1175	100	1106	100	1305	100	1335	100	1600	100	1903	100	1945	100
Level 2 Theoretical Courses																						
AIRCRAFT METALWORK THEORY	2	Passed	1	0.1	3	0.3	15	1.3	6	0.5	4	0.4	12	1.1	16	1.2	13	0.8	3	0.2	12	0.6
METALLIFEROUS MINING	2	Passed	33	3.1	35	3.1	58	5.1	48	4.1	47	4.5	60	5.3	49	3.7	140	8.8	167	9.6	205	10.8
MOULDERS' THEORY	2	Passed	9	0.9	8	0.7	4	0.3	2	0.2	1	0.1	3	0.3	2	0.2	0	0.0	0	0.0	3	0.2
PLATERS AND STRUCTURAL STEELWORKERS' THEORY	2	Passed	515	49.0	549	49.1	121	10.6	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
PLATERS' THEORY	2	Passed	0	0.0	13	1.2	409	35.7	558	47.7	527	50.3	560	49.0	700	53.5	810	50.7	822	47.0	916	48.4
PLATING AND STRUCTURAL STEEL DRAWING	2	Passed	466	44.3	451	40.3	517	45.1	550	47.0	462	44.1	504	44.1	542	41.4	625	39.1	752	43.0	744	39.3
FERRO METAL ROLLING AND SHAPING PROCESS THEORY	2	Passed	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
FERRO-ALLOY THEORY	2	Passed	0	0.0	29	2.6	19	1.7	5	0.4	7	0.7	3	0.3	0	0.0	11	0.7	4	0.2	11	0.6
IRON PRODUCTION AND CASTING THEORY	2	Passed	2	0.2	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
SHEETMETAL WORKERS' THEORY	2	Passed	23	2.2	31	2.8	3	0.3	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
STEEL PRODUCTION AND CASTING THEORY	2	Passed	2	0.2	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
TOTAL	2	Passed	1051	100	1119	100	1146	100	1169	100	1048	100	1142	100	1309	100	1599	100	1748	100	1891	100
Level 3 Theoretical Courses																						
AIRCRAFT METALWORK THEORY	3	Passed	4	1.5	2	0.6	7	2.4	10	4.3	6	2.7	9	4.3	7	2.9	8	2.6	4	0.9	18	3.6
METALLIFEROUS MINING	3	Passed	53	20.2	20	6.4	21	7.1	28	11.9	45	20.2	28	13.3	45	18.4	62	20.3	117	26.5	141	28.5
MOULDERS' THEORY	3	Passed	2	0.8	1	0.3	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
PLATERS AND STRUCTURAL STEELWORKERS' THEORY	3	Passed	82	31.2	115	36.7	74	24.9	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
PLATING AND STRUCTURAL STEEL DRAWING	3	Passed	119	45.2	161	51.4	172	57.9	164	69.8	156	70.0	168	79.6	183	75.0	225	73.8	318	71.9	322	65.2
FERRO-ALLOY TECHNOLOGY	3	Passed	0	0.0	13	4.2	14	4.7	33	14.0	16	7.2	6	2.8	9	3.7	10	3.3	3	0.7	13	2.6
IRON PRODUCTION AND CASTING THEORY	3	Passed	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
SHEETMETAL WORKERS' THEORY	3	Passed	2	0.8	1	0.3	9	3.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
STEEL PRODUCTION AND CASTING THEORY	3	Passed	1	0.4	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
TOTAL	3	Passed	263	100	313	100	297	100	235	100	223	100	211	100	244	100	305	100	442	100	494	100
Level 4 Theoretical Courses																						
BUILDING AND STRUCTURAL CONSTRUCTION	4	Passed	509	96.8	640	86.8	684	81.0	714	87.9	669	85.5	593	79.6	572	77.7	594	78.3	649	84.1	725	85.1
PLATING AND STRUCTURAL STEEL DRAWING	4	Passed	16	3.0	20	2.7	28	3.3	16	2.0	23	2.9	35	4.7	42	5.7	42	5.5	38	4.9	51	6.0
INTRODUCTION TO METALLURGY	4	Passed	1	0.2	1	0.1	0	0.0	5	0.6	6	0.8	4	0.5	1	0.1	1	0.1	2	0.3	7	0.8
MACHINES AND PROPERTIES OF METALS	4	Passed	0	0.0	76	10.3	132	15.6	77	9.5	84	10.7	113	15.2	121	16.4	122	16.1	83	10.8	69	8.1
TOTAL	4	Passed	526	100	737	100	844	100	812	100	782	100	745	100	736	100	759	100	772	100	852	100
Level 5 Theoretical Courses																						
BUILDING AND STRUCTURAL CONSTRUCTION	5	Passed	302	16.5	354	19.3	418	22.1	493	22.9	461	20.1	432	17.8	405	20.9	388	18.2	348	16.8	441	21.3
METALLURGY	5	Passed	1	0.1	0	0.0	0	0.0	0	0.0	0	0.0	1	0.0	0	0.0	1	0.0	0	0.0	0	0.0
STRENGTH OF MATERIALS AND STRUCTURES	5	Passed	1394	76.2	1352	73.6	1380	73.1	1517	70.5	1669	72.9	1809	74.4	1369	70.7	1539	72.2	1507	72.8	1446	69.7
STRUCTURAL STEEL DETAILING	5	Passed	132	7.2	131	7.1	91	4.8	142	6.6	160	7.0	189	7.8	162	8.4	203	9.5	216	10.4	187	9.0
TOTAL	5	Passed	1829	100	1837	100	1889	100	2152	100	2290	100	2431	100	1936	100	2131	100	2071	100	2074	100
Level 6 Theoretical Courses																						
BUILDING AND STRUCTURAL CONSTRUCTION	6	Passed	165	24.8	172	24.6	220	26.4	245	24.4	343	28.5	311	26.7	311	27.1	235	22.1	325	36.3	371	39.1
STRENGTH OF MATERIALS AND STRUCTURES	6	Passed	499	75.2	526	75.4	614	73.6	759	75.6	860	71.5	853	73.3	835	72.9	830	77.9	571	63.7	579	60.9
TOTAL	6	Passed	664	100	698	100	834	100	1004	100	1203	100	1164	100	1146	100	1065	100	896	100	950	100

Source: Calculated from HSRC data obtained from EMIS

Choice of Subjects in FET Institutions

Table 3.3 presents the pass rates for engineering subjects at different levels in the FET system. An analysis of the predominant subject offerings highlights two significant points. The first concerns the very big bias towards certain subjects, i.e. a clustering of learners in specific subjects. It occurs particularly from N1 to N4 (e.g. N2 Platers Theory, N4 Building and Structural Construction).

The second phenomenon is the absence or disappearance of enrolments and examinations in specific subjects (e.g. N2 Sheet-Metal Workers Theory, N3 Iron Production and Casting Theory). The trend emerged in the late 1990s, continuing into 2005. The extent of this enrolment decline in specific subjects suggests that the subject is offered only on paper and that over time a lack of students will probably result in these subjects being abandoned within the FET institutions. An interview with the Western Cape Education Department confirms that this has indeed been the case. Nationally, a number of subject offerings at the FET and general education level have already been rationalized, but this rationalization process has not permeated the system equally and to the same extent in the engineering fields. As a result, FET colleges can still offer engineering courses for which enrolments have declined to insignificant levels. In some instances the subjects on offer have migrated to more widely endorsed programmes and qualifications that are offered within HE institutions. A subject such as Aircraft Metalwork Theory would be an example of such a process.

Returning to the first points, that is the bias towards certain subjects, at the N1 to N4 levels no more than three subjects account for over 90% of student passes. At the N1 level in 2005 two out of six subjects account for almost all examination passes registered: Metal Workers' Theory (56%) and Plating and Structural Steel Drawing (43%). At the N2 level, three subjects out of ten account for almost all the passes: Platers and Structural Steel Workers' Theory (48%), Plating and Structural Steel Drawing (39%), and Metalliferous Mining (11%). However a shift begins to occur at the N3 level. Up until 1998, Platers and Structural Steel Work Theory accounted for approximately 30% of the passes, but then the subject appears to be abandoned, with candidates transferring to Plating and Structural Steel Drawing. Metalliferous Mining also appears to become more popular after 1998. Thus, out of the nine subjects that were available for N3 candidates to choose from in 2005, over 90% enrolled in only two: Plating and Structural Steel Drawing (65%) and Metalliferous Mining (28%). The significant drop in overall numbers who enroll, sit the examinations and pass the courses from N2 to N3, coupled with the virtual merging of Platers and Structural Steelworkers' Theory and Plating and Structural Steel Drawing, suggests that the candidates who participate at the N2 and N3 levels will enter the artisan occupational ranks.

The subjects on offer from N4 to N6 are quite different to those that are available to candidates from N1 to N3. The principal difference is that a shift is made from theoretical support for trade-related occupational training to an introduction to technical knowledge of more general fields. Two examples of this can be discerned. The first is shown with respect to an introductory course in metallurgy at N4 and the course on metallurgy at N5. The second involves a course on machines and properties of metals at N4, which progresses into courses on the strength of materials and structures at N5 and N6. Furthermore, running from N4 to N6 are courses on building and structural construction within the metal and engineering field. While the orientation to these subject offerings at the N4 to N6 levels may be interpreted as a supplement to the traditional occupational trade courses designed for individuals to become artisans, it is also probably driven by FET institutions themselves as they attempt to advance a higher standard of instruction and capture a wider segment of potential recruits to their programme offerings.

A subsidy formula that awards institutions that have a higher proportion of graduations at the higher programme level (i.e. N6 instead of N3), may too have the effect of enhancing a supply-driven provision of academic credentials within the engineering fields.

The second problem which we noted above was the virtual disappearance of certain subjects from the FET curriculum. However, because we do not have time-series data which extends back further than 1996, we are not able to positively say whether this phenomenon was already in evidence much earlier. The abandonment of these courses is symptomatic of having ancillary courses which are meant to support occupational trades in specific niche areas but have to compete for student numbers with subjects that support more general occupational trades (such as platers' theory and plating and structural steel drawing). The disappearance may also be due to a trade no longer obtaining a qualification from a traditional source (e.g. an FET institution). The qualifications could also have evolved beyond the further education and training sector and is now being offered through a higher education institution such as a technikon. The disappearance of aircraft metal work theory at the N1 level may be symptomatic of this trend. As stated above, the trend towards subjects virtually being discarded from the course offering of FET engineering institutions tends to be concentrated in the N1 to N3 levels.

The story becomes interesting when we look at the subjects affected by the disappearance of enrolments and student participation. At the N1 level two subjects fall into this category, while there are five subjects at the N2 and N3 level. It appears that one subject came under similar pressure at the N5 level.

Although Aircraft Metalwork Theory shows zero enrolments from 2001 at the N1 level, the subject is still visible at N2 and N3 levels. There are no courses in Aircraft and Metalwork Theory offered beyond N3.

At N1, Iron, Steel and Ferro Alloy Production begins to show zero enrolments from 2001, but there are no passes recorded for the subject after 1996, a situation which prevails until 2005. The subject Iron, Steel and Ferro Alloy Production does not appear as a subject offering at N2 and beyond, but seems to be replaced by five subject offerings at the N2 level (i.e. Ferro Metal Rolling and Shaping Process Theory, Iron Production and Casting Theory, Sheet Metal Workers Theory, Steel Production and Casting Theory and Platers and Structural Steelworkers' Theory). Four of these subjects are included among the five disappearing subjects at the N3 level. The addition of Moulders' Theory makes up the five subjects where zero enrolments and passes are evident (the four other subjects are Iron Production and Casting Theory, Sheet Metal Workers' Theory, Steel Production and Casting Theory and Platers and Structural Steelworkers' Theory). In fact, Iron Production and Casting Theory did not register one pass between 1996 and 2005 and no registrations since 1998.

If the subject content has been transferred to ones which revise, incorporate and consolidate new subject matter, why do these subjects which have had zero enrolments for almost ten years continue to be listed as if they are potential offerings on the FET engineering curriculum? Furthermore, only one subject appears to have been phased out and replaced by corresponding subjects, namely Ferro-Alloy Theory/Technology, but it too appears as a relatively marginal subject in terms of student enrolments. At the N2 level it bore the description Ferro-Alloy Theory, but since 1999 it had a national enrolment of under 20 students. In its new guise of Ferro-Alloy Technology it continues at the N3 level to have less than 20 students.

Clearly the enrolment numbers which some courses exhibit within the FET system (N levels) do not warrant these courses being presented as options on the curriculum. Where the numbers are so small it is likely that these courses are competing options to courses on offer for professional qualifications for engineers, or are credits that can be obtained through a number of long and short professional courses at Technikons

HE ENROLMENTS AND OUTPUTS

The higher education enrolment data and the data on the output of qualifications, particularly for the period 1996 to 2005, does not always neatly correspond. This is mainly because the enrolment data presents qualifications with a classification, such as Post Graduate (Technologist) or Post Graduate (Engineer), whereas the output data has a more generic classification by type of qualification, that is, Post Graduate Certificate/Diploma, Honours, Masters and Doctorate/Laureatus. This makes it difficult to compare the relative efficiency of the output performance of some qualifications.

Some qualifications, however, bear data on both student enrolment numbers and the proportion of qualifications awarded for specific years. Using this evidence allows us to calculate a more credible measure of the tempo at which some qualifications have been awarded from 1996 to 2005. A four year qualification which shows a rate of qualification completion that is close to 25% per year of its overall enrolment across all levels of seniority suggests that the throughput rate after four years would be almost 100%. This suggests a highly efficient system of qualifications completion. We use evidence we can glean from the data to nuance our discussion on the provision of engineering education within the South African higher education system.

Enrolments
Table 3.4 depicts enrolment data in Engineering and Engineering Technology programmes for the period 1996 to 2005 within universities and technikons. This constitutes the principle supply of high level skills from the South African higher education system. Gross enrolments increased by 70% over the ten-year period across all types of qualifications. There are however significant variations in rates of enrolment growth for specific qualifications, with higher enrolment growth being recorded for Technikon degrees (221%) and Technikon post-graduate qualifications (113%). Since the growth in enrolments for Bachelor of Technology degrees was measured off a higher starting base, the number of enrolments should command our attention when viewing these percentage increments.

The three most popular qualifications in the engineering field were Technikon National Diplomas, Technikon Bachelor of Technology degrees and University engineering degrees. To give some perspective, 5 910 more students were enrolled for Bachelor of Technology degrees in 2005 than had been the case in 1996, compared to only 259 more students registered for Bachelor of Engineering degrees in 2005 compared to 1996. Even though the increase between 1996 and 2005 in the growth in enrolments for National Diplomas was 71%, this was less than the increase in qualifications enrolment for either bachelors (221%) or post-graduate qualifications (113%) from Technikons. Nevertheless, the National Diplomas still made up 62% of the 23 178 enrolment growth in engineering qualifications that was recorded between 1996 and 2005. As we will later show, this was mainly fueled by a higher enrolment of African students. In 1996, African students made up 30% of National Diploma enrolments; by 2005 this had increased to 70%. So, in terms of the potential engineering labour force which enrolls in the higher education system, the bulk are targeting the National Diploma as an entry point to eventually compete for jobs on the labour market. Of course, the enrolment trend does not necessarily translate into completion outcomes (below we look at data that shows award of qualifications).

In contrast, for the same period enrolments for professional engineering degrees, which are awarded by universities, only increased by 41%, while post-graduate university engineering enrolments showed a 43% increase in 2005 over enrolments in 1996.

Table 3.4: Enrolment: Engineering and Engineering Technology

Qualification	1996	%	1997	%	1998	%	1999	%	2000	%	2001	%	2002	%	2003	%	2004	%	2005	%	1996-2005
N Dip	20426	62	23188	64	22965	63	17993	60	17270	50	15231	41	16157	42	20926	50	27033	58	34874	62	14449
B Tech	1840	6	2503	7	2599	7	2838	9	6635	19	10676	29	10603	27	7612	18	4739	10	5910	11	4070
PG (Technologists)	229	1	206	1	158	0	219	1	237	1	273	1	325	1	346	1	416	1	488	1	259
Prof B degree	7895	24	7850	22	7967	22	6050	20	7188	21	7656	21	8135	21	8901	21	10886	23	11159	20	3264
PG (Engineers)	2653	8	2746	8	2800	8	2796	9	3065	9	3241	9	3479	9	3728	9	3817	8	3789	7	1136
Total	33042	100	36493	100	36489	100	29895	100	34394	100	37077	100	38699	100	41513	100	46890	100	56220	100	23178
% Enrolment Growth	1996	%	1997	%	1998	%	1999	%	2000	%	2001	%	2002	%	2003	%	2004	%	2005	%	% Change
N Dip	20426		23188	14	22965	-1	17993	-22	17270	-4	15231	-12	16157	6	20926	30	27033	29	34874	29	71
B Tech	1840		2503	36	2599	4	2838	9	6635	134	10676	61	10603	-1	7612	-28	4739	-38	5910	25	221
PG (Technologists)	229		206	-10	158	-23	219	38	237	8	273	15	325	19	346	6	416	20	488	17	113
Prof B degree	7895		7850	-1	7967	1	6050	-24	7188	19	7656	7	8135	6	8901	9	10886	22	11159	3	41
PG (Engineers)	2653		2746	4	2800	2	2796	0	3065	10	3241	6	3479	7	3728	7	3817	2	3789	-1	43
Total	33042		36493	10	36489	0	29895	-18	34394	15	37077	8	38699	4	41513	7	46890	13	56220	20	70

Source: Calculated from HSRC Data derived from HEMIS

Comparing the proportion of enrolments in higher education engineering programmes, those in National Diplomas made up the bulk of enrolments within engineering programmes. In 2005, 62% of enrolments in higher education engineering programmes were for National Diploma qualifications, followed by 20% for Professional bachelors degrees at universities, and a further 11% for Bachelor of Techology degrees at Technikons.

The FET enrolment and graduation data showed periods in which enrolments and graduation levels flattened and in some instances even declined during the mid-1990s. The same trend appears to have occurred with respect to enrolments in higher education engineering programmes. Thus, a dip in enrolments was evident between 1999 and 2000. Over the ten years from 1996 to 2005, total enrolments for all qualifications increased annually from 1996 to 1998. In 1999 there was an aggregate enrolment decline from 36 489 to 29895. However, by 2001 the lost ground had been recovered with enrolments exceeding the 1998 levels.

For specific qualifications the outcome was somewhat different. Unfortunately this enrolment reversal appears to have affected programmes that bear the lowest cost burden in terms of student fees and the actual costs of subscribing to these programmes at a broader institutional level. It meant that the least costly academic programmes witnessed the largest decline in student numbers. It was especially pervasive for National Diplomas where the downward trend in enrolments begins to occur in 1998, with further falls in 1999, 2000 and 2001. The lowest enrolment level over the ten year period for those doing the National Diploma was recorded in 2001. For National Diploma enrolments the recovery to pre-1998 levels only begins to emerge from 2004.

Conversely, for Bachelor of Technology enrolments there is quite a strong annual enrolment growth from 1996 until 2001, with a slight dip in enrolments in 2002 and a severe fall thereafter. The highpoint of 10 676 B Tech enrolments was reached in 2001. By 2005, when enrolments for this qualification had started to recorded a growth improvement, it was still significantly below the enrolment numbers recorded for 2001.

This trend corresponds to earlier research by Cooper and Subotzky (2001). There were significant increases in African enrollment throughout the 1990s, in particular at university and technikon levels. However, from 1997 onwards these science and technology programmes started to exhibit enrollment reversals. At the same time, new African enrolments were skewed towards the social sciences and humanities. This meant that potential African science and technology enrolments lagged their enrolments in non-science and technology programmes.

It is important to note that corresponding to the declining B Tech enrollment in engineering and engineering technology programmes – pervasive from 1992 – B Tech outputs in these programmes within the technikon system, exhibited a continuous and incremental growth from a low point in 2000 to be more than double this output level in 2005.

For the period 1996 to 1998 enrolments for professional university engineering degrees remained rather static. There was, however, a 24% decline in enrolments for professional university engineering degrees in 1999, with a gradual recovery taking place over the next few years until enrolment numbers in 2002 exceeded those that were recorded in 1998.

In the next section we examine whether the patterns that were observed for enrolments across a wide spectrum of qualifications are mirrored in data on the successful completion of these qualifications. The award of qualifications provides their holders with better prospects to pursue career paths.

Output

The output in qualifications awarded between 1996 and 2005 for the field of Engineering and Engineering Technology in the higher education system is depicted in Table 3.5. Because qualifications require a minimum number of years of enrolment, course attendance and successful completion in a number of areas of subject specialization, data on completions and the award of qualifications can only be compared with enrolment data once the minimum length required to successfully complete a qualification is known. Using this parameter enables a minimum throughput rate to be calculated. An attempt to provide calculations on this output performance will be shown below. The aggregate improvement in qualifications awarded can be deduced by comparing the qualifications output that was recorded in 1996 and then comparing this with what was recorded ten years later in 2005.

The 70% enrolment growth that we observed previously with respect to enrolments in engineering and engineering technology programmes offered by higher education institutions was mirrored in a lower qualifications output change over the same period. From Table 3.5, aggregate outputs for engineering and engineering technology increased by 30% between 1996 and 2005.

Like the enrolment data, the overall growth in the qualifications output data encompasses variations in growth between qualifications. For the series of data stretching from 1996 to 2005 it furthermore highlights upward and downward cycles in outputs for particular years. In outlay, Table 3 contains an upper and a lower segment. The upper segment depicts the distribution of output for each year from 1996 to 2005. The lower segment repeats the depiction of annual qualifications output for 1996 to 2005 but alongside this it represents the percentage change from one year to the next in the output of qualifications. The extreme right hand column of Table 3.5 gives an aggregate picture to the numerical change and the percentage change that is represented in each segment for the period 1996 to 2005.

Table 3.5: 0800 Engineering and Engineering Technology: Outputs in Qualifications

Qualification	1996	%	1997	%	1998	%	1999	%	2000	%	2001	%	2002	%	2003	%	2004	%	2005	%	1996-2005
Cert/Dip	10	0.2	8	0.2	2	0.0	10	0.2	31	0.8	25	0.6	27	0.5	23	0.4	6	0.1	2	0.0	-8
N Dip	2330	45.9	2248	45.0	2140	44.6	1967	45.1	1386	34.6	1710	37.6	2104	40.4	2196	40.8	2564	42.5	2910	43.9	579
B Tech	812	16.0	800	16.0	691	14.4	573	13.1	433	10.8	641	14.1	687	13.2	772	14.3	952	15.8	1131	17.1	318
B Degree	10	0.2	14	0.3	15	0.3	32	0.7	18	0.4	55	1.2	54	1.0	99	1.8	84	1.4	53	0.8	42
Prof B Degree	1341	26.4	1243	24.9	1277	26.6	1051	24.1	1292	32.2	1287	28.3	1306	25.1	1356	25.2	1424	23.6	1466	22.1	125
PG Cert/Dip	97	1.9	125	2.5	116	2.4	159	3.6	178	4.4	155	3.4	149	2.9	121	2.3	114	1.9	114	1.7	17
Honours	107	2.1	140	2.8	133	2.8	148	3.4	173	4.3	165	3.6	199	3.8	241	4.5	295	4.9	300	4.5	194
Masters	319	6.3	345	6.9	366	7.6	375	8.6	428	10.7	430	9.5	462	8.9	495	9.2	510	8.4	570	8.6	251
Doctorate/Laureatus	53	1.0	72	1.4	58	1.2	46	1.1	63	1.6	77	1.7	82	1.6	75	1.4	81	1.3	79	1.2	26
Other	0	0.0	0	0.0	0	0.0	0	0.0	9	0.2	.		139	2.7	4	0.1	4	0.1	.		
Total	5079	100.0	4995	100.0	4798	100.0	4361	100.0	4009	100.0	4544	100.0	5208	100.0	5383	100.0	6035	100.0	6624	100.0	1545
% Output Growth	1996	%	1997	%	1998	%	1999	%	2000	%	2001	%	2002	%	2003	%	2004	%	2005	%	% Change: 1996-2005
Cert/Dip	10		8	-20.0	2	-75.0	10	400.0	31	210.0	25	-18.5	27	5.9	23	-13.1	6	-74.2	2	-66.7	-80.0
N Dip	2330		2248	-3.5	2140	-4.8	1967	-8.1	1386	-29.6	1710	23.4	2104	23.1	2196	4.4	2564	16.8	2910	13.5	24.9
B Tech	812		800	-1.5	691	-13.6	573	-17.1	433	-24.5	641	48.1	687	7.3	772	12.4	952	23.3	1131	18.7	39.2
B Degree	10		14	38.0	15	6.8	32	108.5	18	-43.7	55	209.4	54	-2.6	99	84.7	84	-14.6	53	-37.7	413.2
Prof B Degree	1341		1243	-7.3	1277	2.7	1051	-17.7	1292	22.9	1287	-0.3	1306	1.5	1356	3.9	1424	5.0	1466	3.0	9.3
PG Cert/Dip	97		125	28.6	116	-7.5	159	37.6	178	11.9	155	-13.1	149	-3.8	121	-18.5	114	-5.8	114	0.0	17.5
Honours	107		140	31.2	133	-4.8	148	10.8	173	17.3	165	-5.0	199	21.1	241	20.7	295	22.5	300	2.0	181.4
Masters	319		345	8.1	366	6.2	375	2.5	428	14.0	430	0.6	462	7.5	495	7.1	510	3.0	570	11.8	78.7
Doctorate/Laureatus	53		72	35.8	58	-19.4	46	-20.7	63	37.0	77	22.2	82	5.8	75	-8.0	81	8.0	79	-2.5	49.1
Other	0		0		0		0		9		.		139		4	-97.0	4	-4.0	.		
Total	5079		4995	-1.7	4798	-3.9	4361	-9.1	4009	-8.1	4544	13.3	5208	14.6	5383	3.4	6035	12.1	6624	9.8	30.4

Source: Calculated from HSRC Data derived from HEMIS

From the evidence in the upper segment of Table 3.5 for the period 1996 to 2005, at least 90% or more of the qualifications that were awarded in Engineering and Engineering Technology were distributed between four qualification types. These four qualification types were for National diplomas, which actually still constituted the largest cohort of qualifications awarded, Professional bachelors degrees in Engineering awarded through universities, Bachelor of Technology degrees that were primarily awarded through the previous Technikons and more recently the Universities of Technology, and lastly masters degrees in Engineering and Engineering Technology. In 2005, the contribution of the above four qualification types to overall higher educational qualifications was as follows: national diplomas (43.9%), professional bachelors degrees in engineering (22.1%), bachelor of technology degrees (17.1%), and masters degrees (8.6%).

Although overall output in qualifications in Engineering and Engineering Technology awarded by higher education institutions in South Africa had increased by 30% from 1996 to 2005, this growth trend was not the same across qualification types. A slower overall rate of growth in qualifications awarded was evidently experienced for National diplomas and professional bachelors degrees in Engineering. On the other hand, a high increase in awards for the period 1996 to 2005 was recorded for the bachelors degree[20], honours, masters and doctorates, although starting from low numbers. Again, focusing on the growth pattern for the four types of qualifications that dominate in the engineering and engineering technology field, a significant marker in the pattern of output was the decline that was recorded for qualifications derived through the technikons or universities of technology during the mid and late-1990s. The data shows that outputs for National Diplomas and BTech degrees declined in successive years from 1996 to 2000. A gradual upturn began to take place after this but the output levels recorded for 1996 were only succeeded for both qualifications from 2004. As we stated above, the outputs of professional engineering degrees remained quite static during this period, increasing by only 9% over the period 1996 to 2005. But there were periods of output decline during the 1990s, with a severe fall in outputs being recorded in 1999. The output levels of professional engineering degrees recorded in 1996 was only breached from 2003 and beyond. Table 3.5 shows that the only output which showed a consistent growth over the ten year period occurred for masters degrees.

The simultaneous expansion of postgraduate outputs in engineering with the contraction of outputs for undergraduate and professional degrees means that additions in the stock of new engineering qualified personnel was expanding at a slower rate. It is probably a result of enormous uncertainty about labour market conditions which potential students and recruits to the engineering profession were having to confront during the early years of the democratic dispensation in South Africa.

[20] The bachelors degree is a non-professional degree that includes subjects relevant to the metal industry such as metallurgy.

Qualifications Efficiency

Table 3.6 provides partial evidence of the efficiency in which engineering qualifications have been produced within the public higher education system in South Africa. Although there is quite a lot of missing data, Table 3.6 shows that for qualifications where data exists there was a decline in graduations as a proportion of enrolments for the National Diploma, the B Tech Degree and the Professional Engineering Degrees. In 1996 11.4% of enrolled National Diploma students graduated compared to only 8.3% in 2005. For the B Tech degree the decline was even more noticeable. In 1996 44.1% of B Tech enrolments graduated compare to 19.1% in 2005. A similar decline can be seen for the Professional Engineering degree. In 2005 13.1% of enrolments for the qualification graduated compared to 17% in 1996.

Table 3.6: 0800 Engineering and Engineering Technology: Enrolment and Output Data

Qualification		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Cert/Dip	E										
	O	10	8	2	10	31	25	27	23	6	2
	P										
N Dip	E	20426	23188	22965	17993	17270	15231	16157	20926	27033	34874
	O	2330	2248	2140	1967	1386	1710	2104	2196	2564	2910
	P	11.4	9.7	9.3	10.9	8.0	11.2	13.0	10.5	9.5	8.3
B Tech	E	1840	2503	2599	2838	6635	10676	10603	7612	4739	5910
	O	812	800	691	573	433	641	687	772	952	1131
	P	44.1	32.0	26.6	20.2	6.5	6.0	6.5	10.1	20.1	19.1
PG (Technologists)	E	229	206	158	219	237	273	325	346	416	488
	O										
	P										
B Degree	E										
	O	10	14	15	32	18	55	54	99	84	53
	P										
Prof B Degree	E	7895	7850	7967	6050	7188	7656	8135	8901	10886	11159
	O	1341	1243	1277	1051	1292	1287	1306	1356	1424	1466
	P	17.0	15.8	16.0	17.4	18.0	16.8	16.1	15.2	13.1	13.1
PG Cert/Dip	E										
	O	97	125	116	159	178	155	149	121	114	114
	P										
Honours	E										
	O	107	140	133	148	173	165	199	241	295	300
	P										
Masters	E										
	O	319	345	366	375	428	430	462	495	510	570
	P										
PG (Engineers)	E	2653	2746	2800	2796	3065	3241	3479	3728	3817	3789
	O										
	P										
Doctorate/Laureatus	E										
	O	53	72	58	46	63	77	82	75	81	79
	P										
Other	E										
	O	0	0	0	0	9	.	139	4	4	.
	P										
Total	E	33042	36493	36489	29895	34394	37077	38699	41513	46890	56220
	O	5079	4995	4798	4361	4009	4544	5208	5383	6035	6624
	P	15.4	13.7	13.1	14.6	11.7	12.3	13.5	13.0	12.9	11.8

Source: Calculated from HSRC Data derived from HEMIS

The Gender of Engineering Qualifications

Over the period from 1996 to 2005, the gender distribution in the award of new qualifications in the engineering field within the higher education sector shows a two- to three-fold increase of female graduates. However, this increase was off a very small base with the result that at the end of the period females still constituted only about one-fifth of the total number of graduates in metal and engineering.

For the National Diploma the number of female graduates increased from 7% in 1996 to 22% in 2005. For B Tech Degrees the rise was from 5% to 20%. A similar situation prevailed for the award of Professional Bachelors Degrees; between 1996 and 2005 the proportion of females graduating with these degrees increased from 10% to 22%. This means that in 2005 there were 325 female graduates from engineering programmes out of the total of 1 466.

Table 3.7: The Gender Distribution of Higher Education Qualifications Obtained: 1996 to 2005

Qualification	Gender	1996	% Distribution	1997	1998	1999	2000	2001	2002	2003	2004	2005	% Distribution
Cert/Dip	Male	5	50	6	2	7	12	11	21	20	5	2	100
	Female	5	50	2	0	3	19	14	6	4	1	0	0
	Total	10	100	8	2	10	31	26	27	24	6	2	100
N Dip	Male	2172	93	2094	1926	1738	1157	1341	1700	1715	1932	2260	78
	Female	159	7	155	213	229	229	369	404	482	632	650	22
	Total	2330	100	2248	2140	1967	1386	1710	2104	2196	2564	2910	100
B Tech	Male	769	95	750	651	516	372	531	575	643	759	910	80
	Female	43	5	50	41	58	60	110	113	129	193	221	20
	Total	812	100	800	691	573	433	641	687	772	952	1131	100
B Degree	Male	8	80	11	12	23	10	39	39	74	56	31	58
	Female	2	20	3	3	9	8	16	15	25	28	22	42
	Total	10	100	14	15	32	18	55	54	99	84	53	100
Prof B Degree	Male	1212	90	1119	1146	920	1130	1099	1103	1130	1156	1139	78
	Female	129	10	124	132	131	162	189	204	227	268	328	22
	Total	1341	100	1243	1277	1051	1292	1287	1306	1356	1424	1466	100
PG Cert/Dip	Male	91	94	102	103	137	159	122	113	94	98	90	79
	Female	6	6	23	12	22	19	33	36	27	16	25	21
	Total	97	100	125	116	159	178	155	149	121	114	114	100
Honours	Male	99	93	127	120	129	155	145	171	207	235	230	77
	Female	7	7	13	13	19	19	19	28	34	60	70	23
	Total	107	100	140	133	148	173	165	199	241	295	300	100
Masters	Male	288	90	312	319	329	379	367	404	440	445	491	86
	Female	31	10	32	47	46	49	63	58	55	65	79	14
	Total	319	100	345	366	375	428	430	462	495	510	570	100
Doctorate/Laureatus	Male	43	81	65	52	38	52	67	74	64	71	64	81
	Female	10	19	7	6	8	11	10	8	11	10	15	19
	Total	53	100	72	58	46	63	77	82	75	81	79	100
Other	Male	0		0	0	0	7	0	105	4	4	0	
	Female	0		0	0	0	2	0	34	0	0	0	
	Total	0		0	0	0	9	0	139	4	4	0	

Source: Calculated from HSRC Data derived from HEMIS

Because the engineering sector in South Africa is still largely a male dominated sector, the flow of newly qualified female engineering and technology graduates will need to increase significantly and then continue at this level for a number of years before there is a discernible impact on the gender distribution within the high skilled occupations in the sector.

The Racial Distribution of New Engineering Qualifications

Probably the most dramatic trend in the award of higher education level qualifications within the engineering sector is the rapid growth in qualifications awarded to the Africans. In 2005 Africans constituted the majority of new awards that were made for National Diplomas (70%), B Tech Degrees (53%) and for Post Graduate Certificates or Diplomas (56%).

Table 3.8: The 'Racial' Distribution of Higher Education Qualifications Obtained: 1996-2005

Qualification	Race	1996	% Distribution	1997	1998	1999	2000	2001	2002	2003	2004	2005	% Distribution
Cert/Dip	African	1	10	1	2	8	13	6	16	17	6	2	100
	Coloured	0	0	4	0	0	0	0	0	0	0	0	0
	Asian	0	0	0	0	0	0	0	0	0	0	0	0
	White	9	90	3	0	2	6	6	9	4	0	0	0
	Other	0	0	0	0	0	13	13	3	2	0	0	0
	Total	10	100	8	2	10	31	26	27	24	6	2	100
N Dip	African	707	30	776	923	1019	754	953	1259	1460	1739	2033	70
	Coloured	227	10	135	135	173	110	155	195	201	199	174	6
	Asian	135	6	191	75	97	94	76	74	49	126	153	5
	White	1260	54	1146	1006	658	428	526	576	486	501	551	19
	Other	0	0	0	0	20	1	0	0	0	0	0	0
	Total	2330	100	2248	2140	1967	1386	1710	2104	2196	2564	2910	100
B Tech	African	126	16	128	157	137	127	262	275	337	498	604	53
	Coloured	44	5	39	53	33	37	40	63	59	65	71	6
	Asian	52	6	49	49	65	52	65	82	83	85	72	6
	White	591	73	583	432	329	217	273	267	294	305	383	34
	Other	0	0	0	0	9	0	0	0	0	0	1	0
	Total	812	100	800	691	573	433	641	687	772	952	1131	100
B Degree	African	1	10	3	6	8	9	7	13	15	29	22	42
	Coloured	0	0	0	0	1		3	1	1	1	2	4
	Asian	0	4	1	0	2	1	1	2	4	5	2	4
	White	9	90	10	8	21	8	44	38	79	51	27	51
	Total	10	100	14	15	32	18	55	54	99	84	53	100
Prof B Degree	African	126	9	151	201	210	252	272	277	307	329	363	25
	Coloured	55	4	40	39	37	40	47	46	36	36	44	3
	Asian	126	9	145	129	61	170	165	165	170	202	173	12
	White	1035	77	907	908	742	830	803	818	841	858	887	61
	Other	0	0	0	0	0	0	1	0	2	0	0	0
	Total	1341	100	1243	1277	1051	1292	1287	1306	1356	1424	1466	100
PG Cert/Dip	African	9	9	23	26	62	81	60	55	47	47	64	56
	Coloured	1	1	2	1	5	2	3	3	6	4	0	0
	Asian	9	9	13	14	12	19	18	15	10	7	15	13
	White	78	80	87	75	80	76	73	76	58	55	36	32
	Other	0	0	0	0	0	0	0	0	0	1	0	0
	Total	97	100	125	116	159	178	155	149	121	114	114	100
Honours	African	1	1	5	11	6	28	29	47	64	68	86	29
	Coloured	1	1	0	0	1	1	4	1	3	6	10	3
	Asian	0	0	1	1	3	15	4	11	24	34	33	11
	White	106	99	134	121	138	130	128	140	150	187	171	57
	Total	107	100	140	133	148	173	165	199	241	295	300	100
Masters	African	20	6	25	41	49	57	77	89	107	119	150	26
	Coloured	6	2	6	6	16	11	13	11	16	13	19	3
	Asian	16	5	13	17	24	36	31	54	54	55	47	8
	White	277	87	301	302	287	324	310	309	319	323	354	62
	Other	0	0	0	0	0	0	0	0	0	0	0	0
	Total	319	100	345	366	375	428	430	462	495	510	570	100
Doctorate/Laureatus	African	0	0	4	3	1	4	7	4	6	12	19	24
	Coloured	0	0	0	0	1	0	3	1	1	2	0	0
	Asian	0	0	1	1	1	4	3	5	6	4	7	9
	White	53	100	67	54	43	55	64	72	62	63	53	67
	Total	53	100	72	58	46	63	77	82	75	81	79	100
Other	African	0		0	0	0	5	0	108	1	0	0	
	Coloured	0		0	0	0	2	0	2	0	3	0	
	Asian	0		0	0	0	1	0	11	4	1	0	
	White	0		0	0	0	1	0	18	0	0	0	
	Total	0		0	0	0	9	0	139	4	4	0	

Source: Calculated from HSRC Data derived from HEMIS

However, the trend for the award of Professional Bachelors Degrees, i.e. engineering degrees and post-graduate level qualifications, is more modest. In 1996 Africans received 9% of Professional Bachelors Degrees awarded in the Engineering fields. By 2005 the proportion had risen to 25%.

The Unity in Action of Demand and Supply

Labour market studies are not conclusive about whether demand level factors or supply level factors shape and structure labour markets. It may therefore be prudent to accord equal prominence to both under the mantle of 'unity in action'. The institutionalization of a flow in educational qualifications requires that the flow is met by a corresponding level of effective demand. An established market where effective demand exists will generate endogenous supply and if this is insufficient there will be pressure for it to be met exogenously.

This tension can be seen in the marine engineering industry of the metal and engineering sector. The industry has been in decline for the last twenty years. The supply of labour, particularly as exhibited through the provision of higher educational qualifications, mirrors the static labour demand situation. The annual supply of higher education graduates in marine engineering and naval architecture, particularly from public higher education institutions in South Africa, only reached the fifty-person mark in 2004. Moreover, Table 3.9 shows that these graduates were all from a Technikon or University of Technology and until 2001 the majority held National Diplomas. It was only after 2001 that B Tech graduates outnumbered National Diploma graduates. Not one of the coastal universities contributed graduates with qualifications in marine engineering and naval architecture. This is a signal that the marine engineering and naval architecture industry in South Africa, although well established, is in a state of limbo.

Table 3.9: Higher Education Qualifcations Awarded in Marine Engineering and Naval Architecture

Industry	Qualifications	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0817 Marine Engineering and Naval Architecture	Qualifications	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	Cert/Dip	0	0	0	0						
	N Dip	12	6	23	11	10	20	26	17	22	25
	B Tech	1	1	3	5	3	5	10	32	29	25
	B Degree	0	0	0	0						
	Prof B Degree	0	0	0	0						
	PG Cert/Dip	0	0	0	0						
	Honours	0	0	0	0						
	Masters	0	0	0	1						
	Doctorate/Laureatus	0	0	0	0						
	Other	0	0	0	0						
	Total	13	7	26	17	13	25	36	49	51	50

Source: HSRC Data derived from HEMIS

The small size of the marine engineering industry, even in a major port such as Cape Town, is a constraint on enterprise growth. Consequently, marine engineering firms are by international standards tiny. Furthermore, the inconsistency of demand for services from the marine engineering industries meant that firms were able to engage only a limited permanent labour force and encouraged a high use and dependence on contract and casual labour.

In the case below we show the effects that the situation has on clients making use of the marine engineering services in Cape Town. The case gives an example of the perceptions that one such client held about the Ship Repair and Maintenance Services in Cape Town.

CASE 1: South African Client using the Ship Repair and Maintenance Services in Cape Town

The first company is a major customer of ship repair services in Cape Town. Four to six of the client's vessels are assigned to the dry docking facilities in the Cape Town harbour each year. This routine maintenance work is contracted to firms in the sector, but the client is required to employ a large number of additional personnel to oversee the work that is assigned to contractors and overcome problems. A large part of these problems have to do with skills that the contractors have available in their firms. Not only is there a shortage of skills, in many cases the skills that contractors assemble exhibit deficiencies. So the client has to bring its own labour on board to rectify workmanship which has been unsuccessfully dealt with by the contractor. In other instances, the additional personnel are used to oversee and supervise contractors.

The client recognises that within the ship repair and maintenance environment in Cape Town there is a shortage of all types of skills. It was argued that if all the marine electrical and electronic instrumentation companies in Cape Town was considered, one would be limiting oneself to no more than a few individuals: 'probably six people!'.

A further concern of the client was the possible disappearance for economic and profitability reasons of the only relatively large dedicated ship repair company in Cape Town. This would contribute to a further erosion and depletion of the skills which are necessary to keep its ships in operation without requiring the client to have to resort to ports in Western Europe for basic repair and maintenance work. In view of the disappearance over the last two decades of many ship repair firms in Cape Town, fears of a similar plight in store for the only dedicated ship repair firm in Cape Town are not unfounded. Because its ships operate mostly within South African coastal waters, the client firm puts a high premium on having a decent port from which basic repair and maintenance work can be done. In the words of the interviewer: 'The best port is the nearest port'. If a situation arose in which 'Cape Town' was not able to provide services which it had historically performed, the client would have to consider sending its ships to Durban.

A depletion in the skills that contractors are able to deploy is well advanced. This was noticeable to the client through an insufficient adherence to safety standards by workers. It did not appear that the companies employing them made any attempt to correct these practices. Furthermore, it appeared to the client that a similar erosion in the quality of supervision could be observed because more supervisors were required to supervise as task than in the past. It is also apparent that within many companies involved in the ship repair industry there are insufficient programmes for on-the-job training.

As a consequence of the above problems, repair work that would typically require a ship to be berthed for seven days in the dry-dock could take up to thirty days in Cape Town, with work being assigned to a plethora of companies. This was an inefficiency that the local market place was not able to dispel. The client furthermore complained about the poor security that existed to protect ships brought in for repairs; it was required to hire its own security personnel to secure its vessels. This situation was confirmed by another interviewee, who complained about liabilities that were sustained because copper piping and brass valves and fittings disappeared from vessels. The interviewee said the situation was giving Cape Town harbour the reputation of having one of the highest rates of theft from sea going vessels.

Thus the client depicted the ship and maintenance industry as lacking a stable skilled labour base. The industry will require an established trained labour force and also needed a kick-start with respect to higher level skills in marine engineering, hydraulic engineering and other specialized fields.
Source: Lundall (2006)

CONCLUSION

The present chapter has provided a very detailed discussion of the pattern of enrollment in engineering educational programmes at FET and HE levels. The evidence from our data indicates that the higher education system has released more graduates with higher education certificates, diplomas and degrees than the FET system releases in certificates. The difference is more pronounced when it is realized that the FET qualifications were awarded on a trimester system, which means that an individual potentially could progress through three N level certificates in a year. This means in turn that the number of individuals included in the total qualifications awarded in a year could include double counts. So the number of individuals that obtain FET qualifications in a single year is probably lower than the total qualifications awarded by the system. The average annual number of N level certificates issued over the period 1996 to 2005 was 6 775. Using the data contained in Table 3.6 we calculate that the average annual qualifications awarded by the HE system in the engineering fields over the period 1996 to 2005 for which data exists was 5 103. It is not possible for an individual to obtain more than one HE level qualification in a single year. This means that the total number of individuals obtaining qualifications in the HE system for the metal and engineering industries is probably larger than the total in the FET system. Therefore the HE system appears to have a bigger impact on the labour market. This anomaly existed prior to the data that we have analysed above and it will probably continue for some time into the future until the student participation levels in engineering and technology programmes in the FET system increase significantly.

Above we show that there is a disturbing pattern in the student participation trends in engineering and technology programmes in the FET system. There are dramatic bulges in the data, with high proportions of qualifications awarded at the N1 and N2 levels, a very steep falloff in qualifications awarded at the N3 level, and then a doubling in qualifications awarded at the N4 level. The bulge expands with a tripling in qualifications from the N4 to the N5 level, followed by a collapse in qualifications awarded at the N6 level. This pattern suggests that the engineering programmes in the FET system do not build up a coherent cadre of intermediate technical and production-related certification outputs. Until it builds such a coherent cadre the FET system will be perceived as a stop gap measure and will have low credibility. We have also highlighted evidence which suggests that a blurring is taking place between further education and general education, with students from the school system entering the FET system at higher N levels. This can have negative implications in that low quality levels are transmitted from the schooling system into the FET system. In the past, school leavers participated at a grade level that was lower than the level they attained when leaving the schooling system. This contributed to some extent to preserving the technical qualities of engineering training in the FET system.

Not all problems arose from the limitations of education and training institutions. Some trade union interviewees lamented the lack of pathways to enable individuals that were in the operator ranks to qualify and enter the artisan trades. However, we found that only two of the three institutional pathways that can be pursued to qualify artisans were actively embraced: the traditional artisan route of serving an apprenticeship for a fixed duration that normally spanned four years, and the accelerated artisan route that graduated an apprentice to an artisan in under two years. The output of artisans from these two routes was seen as insufficient to meet the demand for artisans from the metal and engineering industries. It was therefore surprising that the third pathway, the ATRAMI route, has not been actively pursued. It is unclear why this was the case.

Finally, it is disconcerting that the HE system exhibited an erosion in quality over the period 1996 to 2005 when compared to the FET system. We highlighted this point in relation to throughput rates or the ratio of enrolments to N level certificates awarded (see Table 3.1), compared to enrolment and outputs in HE engineering and engineering technology programmes (see Table 3.6).

Chapter 4

Sector Case Studies

The chapter below provides insight into the skills development process as it has unfolded at individual firms in the metal and engineering industry. Interviews, using a detailed interviewing schedule, were conducted with key personnel at eleven firms. The interviews explored, amongst other things, the interaction between the firm and the broader institutional skills development system as well as the constraints that skills shortages imposed on firms.

THE SAMPLE OF FIRMS

The firms were selected on the basis of leads that were provided from SEIFSA as well as individual contacts in the industry established during prior research. Firms were selected in order to secure a spread across small, medium and large size classes. We also sought to include firms at different stages of the value-adding or beneficiation processes, i.e. producers of raw materials (milling firms), constructors of intermediate products (engineering and machine shops), and builders of machines (this conceptual breakdown is discussed in Chapter One). The firms at which interviews were conducted are shown in Table 4.1.

The employee size classes of the firms are represented by the permanent employment complement, i.e. the numbers do not reflect temporary and contract workers in the labour force. The latter will vary considerably according to fluctuating demand at the firm level.

Table 4.1: Size and Sub-Sectoral Distribution of Firms in Case Studies

Firm Size by Employee Numbers	Milling Firms	Engineering and Machine Shops	Machine Builders
1-49		Hansing Engineering (Saldanha) (20?)	Seecor (CT) (12)
50-99		Belmet Marine (CT) (76) CME (CT) (80?) SP Metal Forging (Boksburg) (100)	
100-199	Zimalco (Germiston)		
200+	Saldahna Steel (Saldanha) (570) Columbus Steel (Middleburg) (1576) Highveld Steel (Witbank) (3500)		Alstrom John Thompson (CT) (551) ABB Transformers (Pretoria) (600)

Table 4.1 shows that the metal processing or milling firms in the sample are generally large firms with a staff complement in excess of 200 employees, and the engineering or machine shops, which are mostly involved in intermediate production activities, tend to occupy the medium and small employee size class. There is variation in the distribution of machine builders in terms of size. Machine building firms that are foreign-owned and controlled have a higher likelihood of occupying the medium to large employee size category.

All the milling and machine building firms are inserted into international export markets. In addition, the four engineering and machine shops either directly or indirectly supply products and services that generate foreign earnings.

The firms are not discussed individually, but placed within a broader context, namely the sub-sector within which they fall (as in Table 4.1 above). Pertinent issues relating to each sub-sector are then discussed, drawing on the information obtained from the firm interviews. Where interesting details arise at particular firms they are included in boxes in order to illustrate the points being made. The reason for adopting this approach is to try to make the information more useful and widely applicable by contextualizing the findings.

MILLING FIRMS

Historical Background

In South Africa milling firms, almost from their inception, dwarfed general engineering firms in terms of scale of operations and size of the workforce. Enterprises that were an extension of the state, such as the South African Railways and Harbours, as well as newly formed state-owned enterprises such as the Iron and Steel Corporation of South Africa (ISCOR), bore similar traits to the milling firms in terms of scale and size. These new ventures were often initiated with collaboration from statutory development agencies such as the Industrial Development Corporation. They all had in-house training facilities that included workshops and in some instances even the basic infrastructure for classroom instruction. At these different enterprises such in-house training facilities, coupled with public or state supported further education and training programmes, were used to train the cohort of apprentices needed as the sector grew. While there was supporting legislation with regard to artisan training, it gradually became the norm that large firms would operate their own in-house training programmes or training schools with dedicated instructors in various trade specializations.

At the same time, a plethora of large, medium and small enterprises arose that were not able to run comprehensive in-house training programmes. This was because many did not have spare production machinery for the purposes of training younger workers that were indentured to the firm. It necessitated making use of public technical colleges to perform this training function.[21] By

[21] Interview: Dr Ewald Wessels, Cape Manufacturing Engineers, 19 July 2007.

the mid-1980s a system of training provision was in existence that could be selectively accessed at the level of the firm, either through the technical college system or through the training programmes that were available on a industry-level basis. A more common form of firm-level training occurred through the apprenticeship system. Many firms that participated in these initiatives had an ongoing programme in place. Larger firms tended to operate a company training school that was integrated into the production process.[22] Firms that were not able to afford such schemes allowed their apprentices time off from work to attend technical college instruction through a process known as 'block-release' (usually for a trimester at a time). The industry training centres attempted to combine the function of training schools and technical colleges, and were financed through government grants or levies diverted from the Industrial Training Board.

The mid-1980s heralded the pinnacle of this system but also signaled its turning point. The expansion of the sector was no longer guaranteed. Disinvestment and trade sanctions were some of the reasons for this reversal. Under these changing conditions, it had become more difficult for many of the state-owned enterprises and large private firms to sustain the same levels of training. It was roughly from this point that a gradual decline began in the number of people that were undergoing training. The reduction in the training done by large employers resulted in the total number of newly trained workers (e.g. artisans, operators and general workers) falling in roughly similar proportions. Employers began to poach artisans rather than training them, luring them away with inducements of higher wages.

Until this time, ISCOR and the large parastatals involved in projects linked to the metal and engineering sector (e.g. ESKOM, SASOL), which had built up powerful internal staff training systems, had borne a greater responsibility for training for the sector. However, the shift towards the commercialization of these state assets from the late 1980s contributed to the gradual reduction in the output of training, especially of new artisans.

Training outputs that continued to be supported by the Industrial Training Boards (ITBs) tended to have a supply-led orientation. Over-supply only became prominent in a cyclical downturn in the economy, but because firms obtained tax breaks for training the burden of over-supply largely shifted to newly qualified artisans. They had to obtain positions in a temporarily over-saturated economy once their period of indenture had successfully ended. Though episodic and linked to troughs in the business cycle, this situation of a skills deficient economy experiencing unemployment among newly qualified artisans contradicted the rationale for firms having made an investment to train skilled labour. By the late 1980s the such episodes were part of a large set conflicting forces that were generating unforeseen outcomes. The first was the gradual decline in artisan training within parastatals. Despite the availability of tax breaks, private firms were now required to bear a higher burden of training including the costs associated with it. While apprentices

[22] Some of the Cape ship repair firms continue to operate such training schools (e.g. Dorbyl). (See interview data in Lundall, 2006: 34-49).

undergoing training were employed throughout their indenture or contract of apprenticeship, the pressure to minimize the cost of training borne by employers contributed to modularization being seen as a more efficient alternative to four-year apprenticeship training. The modularization in the training of skilled labour contributed to the gradual decline in the indenture of new artisans, especially in the metal and engineering sector. In the motor retail industries, modularization seems to have had a more positive impact on artisan admissions.

Similar processes were underway in other sectors of the economy. For instance, in the Western Cape construction industry the influx of African casual workers, coupled with the onset of modularized training, created a situation in which the traditional routes to the training of construction artisans were put under pressure (Krafchik, 1991: 41-42). Firms that trained apprentices and released them onto the restricted employment market once they had acquired artisan status were accused of perpetuating market failure. Consequently, to give an example, many young people from families rooted in occupational trades within the construction industry were themselves dissuaded from joining the industry.

Policy reform after 1990 led to a gradual dismantling of the direct tax benefits that firms could derive from training activities and resulted in a further downscaling of training by firms. The time that was required to establish new institutions of skills development and put the new system into practice after the promulgation of the Skills Development Act in 1998, meant that the continuity in skills training between the faltering old system (with the parastatals and the ITBs) and the embryonic new system (underpinned by the SETAs) was very uneven (evidence of this is shown in the output data analysed in Chapter Two).

The gradual incorporation of the South African economy into the global economy has witnessed a significant change in the ownership patterns within milling firms. One example is ISCOR, which changed from a state-owned enterprise to a privately owned enterprise. Foreign firms now own the major shares in the three largest ferrous and non-ferrous metal mills in the country, in the process incorporating the mills into international iron and steel conglomerates: Acerinox in the case of Columbus Steel; Evraz for Highveld Steel; and Mittal for Arcelor Mittal (previously ISCOR).

The Current Situation

Recruitment

Some of the managers at the iron and steel mills who are responsible for recruiting new staff have identified the low number of registered students in higher education engineering programmes as a weakness in the system. In the Western Cape, the small pool of school leavers with mathematics, science and basic engineering skills led to us being told that 'you cannot get people'.[23]

[23] Interview: Frikkie van der Merwe, Saldanha Steel, 23 July 2007

When potential recruits are found there are quality issues that have to be resolved before they can be employed (see further in the next section). One consequence of the above is the incidence of poaching. Firms that have built up a reputation of providing comprehensive training are normally the ones who are put under scrutiny by poachers.[24]

If we take the example of metallurgical engineers and scientists, we can start to follow the trail through the education supply system. The discipline of metallurgy engineering is critical to the extraction of pig iron from iron ore and the development of different steel and metal alloys. There is a metallurgy degree at only Pretoria and Witwatersrand universities, although other universities may develop the metallurgists through programmes in the pure sciences as well as in chemical engineering. University students start to branch out into their specialization fields in metallurgy, metallurgical engineering or materials science at the end of the second year of their engineering degree. An informant at a very large iron and steel mill in Mpumalanga indicated that there is an insufficient number of students enrolled for metallurgy degrees at universities in the region to adequately cater for the demand from industry. As is to be expected, the low enrolment rates translate into even lower graduation rates and we were told that the pool of graduates 'will not go very far'.

These sentiments are supported by empirical data provided by the HSRC. The HSRC data shows that over the period 1996 to 2005 there was an annual average of only 132 graduates from either the HE system or from a Technikon with Materials Engineering and Technology and Metallurgical Engineering and Technology. In 2005 the combined national HE output from the two fields of material engineering and metallurgical engineering yielded 88 B Tech degrees, 1 bachelor's degree, 57 professional bachelor degrees (i.e. university engineering degrees), 33 honours degrees and 25 masters degrees. These findings support the perception of the above interviewee that an inadequate pool of graduates is being generated to meet the demands of the industry.

An interviewee at a second very large mill stated that the firm targets graduates from the universities in the region, particularly Witwatersrand University and the University of Pretoria. From the interviews it appears that quite a number of graduates who are employed in either Middleburg or Witbank commute to work every day from their place of abode in Pretoria. This is made possible with a well developed road transport link that has been established from Pretoria. However, metallurgical graduates from Cape Town would normally not settle down in the region and usually move back to Cape Town or go overseas[25].

Graduates who receive bursary funding from a firm are usually obliged to work for it for the same number of years for which the bursary was obtained.

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[24] This is based on the views of a particular spectrum of firms, most of which are large. Their perceptions would not necessarily be supported by all firms in the sector.
[25] Interview: Joe Mabena, Louis Kraucamp & Emelia Badenhorst, Columbus Steel, 5 September 2007.

Such graduates are placed in the firm's thirty-month engineer training programme. This does not however give the firm immunity from the poaching of such staff members. Other milling firms, especially consulting engineering companies, will not baulk at paying a lump-sum for the outstanding bursary fees of the graduate in order to employ him or her[26].

A similar situation arises with regard to artisans, who were described as generally showing no loyalty to firms and jumping ship for higher pay even if this implies a deterioration of the conditions under which they are required to work[27].

Two factors, in addition to the problems that flow from the shortage of artisans and engineers discussed above, pose particular challenges. The first is the increased demand for artisans during maintenance shutdowns. This is particularly the case on the Highveld, where many milling firms are in fairly close proximity to very large operations such as ESKOM and SASOL that periodically have to go through shutdowns.[28] This has resulted in some cooperation amongst firms to try to manage this process. In the Witbank and Middleberg area the Mpumalanga Engineering Skills Forum has been established to coordinate shutdowns. The second factor has arisen in the Cape, where the magnetism of the West African oil fields has been an added drain on skilled labour supplies.[29] One interviewee indicated that the new infrastructural investment that will be directed to the construction of power stations will create an additional demand for skills. In this case the short-term solution will probably be to import of pipe-fitters and welders from Pakistan and Indonesia. However, while some firms might come up with short-term solutions to these challenges they have not addressed the long-term problem that they pose.

CASE 2: Corporate Social Responsibility Embraces Local Schools
To address the problem of schools not delivering a sufficient number of recruits with appropriate competence in mathematics and science, two of the three firms have used their social responsibility programmes to give educational support in these subject areas to certain schools in the locality. One firm has devised a Maths and Science Centre to which fourteen schools in the region send selected learners for additional tuition. The Centre is manned by mathematics and science instructors that have been contracted for this purpose by the firm. A milling firm with its base in Witbank had initiated a similar programme. In this way the firm sought to improve the pass rates in mathematics and science at the designated schools. The firm justified making such a corporate social investment because it had experienced difficulties finding suitable candidates from normal school leavers in the area and also because it believed that it would contribute to the improvement in the quality of teaching in the Witbank area.

[26] Interview: Monita Bohmer, Highveld Steel, 6 September 2007.
[27] Interview: Joe Mabena, Louis Kraucamp & Emelia Badenhorst, Columbus Steel, 5 September 2007.
[28] Interview: Frikkie van der Merwe, Saldanha Steel, 23 July 2007.
[29] Interview: Brian Lister, South African Oil and Gas Alliance, 31 August 2007.

Credentials and the Quality of General Education

Compared with the educational qualifications required of previous recruits to training programmes in milling firms, contemporary recruits for the same positions need to meet higher entrance thresholds. In the case of recruitment to training for artisan positions, the three milling firms that were studied all indicated that a matriculation certificate or an equivalent of NTC 3 (i.e. N3) is the minimum requirement. This is also higher than the statutory requirement of at least the equivalent of NTC 2 in the subject theory for which the trade specialization is being developed. There are a number of reasons why this has occurred. Perhaps the most important of these is the perception of declining standards within the public schooling system. This has led to each of the three milling firms experiencing severe problems recruiting sufficient numbers of school leavers with mathematics and science as subject credits.

The implications of raising the minimum qualifications for potential recruits directly challenges the notion that a Grade 9 certificate, coupled with additional theoretical instruction to a Grade 11 level (NTC 2), is adequate for those intending to sit for a trade test examination. The actions of the milling firms confirm that such criteria are outmoded. Their policy to raise the standards for entrance into artisan training programmes reflects the recognition that *a good general education is a precursor to engaging learners in effective workplace training*. The practice of milling firms in the metal and engineering industries suggests that without such an educational foundation, with demonstrated competence in mathematics and science at the matriculation level, a direct pathway into an artisan training programme and thereafter the artisan ranks is not possible.

An alternative view is that the general decline in the quality of schooling has made the traditional entry standards into artisan or other skills programmes too low. In terms of this argument, the threshold had to be raised because the schooling system is no longer guaranteeing the quality and integrity of the basic educational knowledge that learners were expected to possess for the grade. However, some interviewees stated that the issue is not the quality of education *per se* but rather the unevenness of quality, especially with respect to providing the foundations for engineering programmes, where reading, writing, mathematical numeracy and ability as well as depth perception as developed through technical drawing is critical for further technical training.

Thus firms have had no alternative but to raise the entry standards for their workplace training programmes. At one mill, where they have instituted a metal production qualification (actually a learnership) at level 2 of the NQF (equivalent to Grade 10), admission into the programme is for learners with a matriculation certificate with credits at this level for mathematics and science. The firm had experienced difficulties with the quality standards of FET colleges that had been assigned to take these learners through the theoretical part of the course. It was found that having completed the theoretical part of the course learners tended to struggle with the equivalent level of mathematical application that they needed in the applied environment of the workplace.

The problem is not experienced only with regard to artisan and lower-level training programmes. One of the iron and steel mills in Mpumalanga, which had a substantial bursary programme (60 bursaries at a total cost of R4 million in 2007), had changed its policy for awarding bursaries for national diplomas (generally done at the former Technikons or Universities of Technology) because of the quality of students leaving the school system. Bursaries for such national diploma students are now awarded only after they have successfully completed the fourth semester of their academic programmes. The problem with the quality of matriculants has also resulted in the company discontinuing bursaries to engineering students doing the first year of their university degrees. The company's bursary allocation to university engineering students now commences only after they have successfully completed their first year of study and are entering the second year of an engineering degree.[30]

The two iron and steel mills in Mpumalanga had at least 10% of the labour force actively participating in skills programmes for artisans and lower-level categories. At the same time, both firms served as hosts for technicians undergoing experiential learning and engineers serving pupillages or working a service contract in return for bursary funding. This was referred to as the Engineer Training Programme and it was claimed in interviews that 'all the major companies' (i.e. iron and steel milling firms) operated such programmes.[31] There was constant benchmarking of this programme against other major steel mills as well as the programme run by SASOL.

The stricter bursary rules and raised standards are probably not only about the lower quality of education. Firms have made massive advances with regard to testing and assessment of applicants. The broader national environment in which training and skills development has been given a higher priority has no doubt helped the cause. Before the late 1980s overall passes in trade tests for metal and engineering artisans was less than 50%, in the 1970s it was under 40%, and from the scattered data that is available it was probably even lower in the 1960s (Lundall, 1997: chapter 4). However, one of the steel mills in Mpumalanga boasted a pass rate of 80% for artisan trade tests. This suggests that improved selection and assessment systems for those entering training programmes are taking account of lower school standards while at the same time delivering better pass rates for trade tests.

If a comparison was made between the iron and steel mills and other firms in the metal and engineering sector it would probably reveal a stark difference in the proportion of graduates they employ. At one of these iron and steel mills our informant mentioned that 9% of personnel held degrees and another 10% diplomas. At the sophisticated mini-mill in Saldanha most of the engineers within the management structure of the firm held MBAs.

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[30] Interview: Monita Bohmer, Highveld Steel, 6 September 2007.
[31] Interviews: Joe Mabena, Louis Kraucamp and Emelia Badenhorst, Columbus Steel, 5 September 2007; Monita Bohmer, Highveld Steel, 6 September 2007.

Operator Upgrading using Learnerships

Besides the training programmes for artisans and the experiential training for technicians and engineers, all the iron and steel mills appear to have instituted operator training and other skills programmes. In some cases these initiatives appear to have been prompted by the adoption of a more proactive 'social responsibility' stance that involved purposeful recruiting of unemployed individuals into fixed-term learnership programmes at the firm. In the Western Cape a relationship has been cultivated between Saldanha Steel and the False Bay FET College, specifically with regard to theoretical training that is being offered at the Westlake campus of the College. The firm refers to this programme for operators as an operator/maintainer programme. The firm claims that it has experienced quite a lot of success in this area of training. Furthermore, operators who meet the minimum entrance qualifications and have passed mathematics and science at the N3 level would be earmarked to undergo accelerated artisan training at the firm. The minimum period in which this can be done is 80 weeks and the bulk of this time would be made up of practical and workplace training at the firm.

Gauging from the interviews, many firms which have now formally embraced the provision of certificated training for employees within occupational ranks lower than the artisan level, use a number of different designations to describe this training. At some firms it is referred to as 'the operator programme', at others as the 'metal production learnership', while some firms call the training 'skills programmes'. The different designations suggest that there are a number of institutional vehicles for delivering such programmes. Some form part of the workplace skills development programmes that firms have started to put into place. Others are part of learnership programmes that firms are supporting for their internal labour force. Still others are provided by initiatives that FET institutions have put into place in collaboration with a Sector Education and Training Authority. The difference with respect to past programmes is that these new initiatives appear to incorporate a qualifications progression through which the recipients of the training can eventually qualify as artisans. One of these programmes, in which Saldanha Steel served as a host employer for 50 trainees from Petro South Africa, was registered as a learnership.

Many firms refer to the specialized training courses to which they send staff as 'accredited', but most of these are short courses that are not accredited through a SETA. They are however deemed necessary for the firm to manage its production and operational activities. Firms bear the costs of this training over and above their payroll obligations in terms of the Skills Development Levies Act. A large number of these types of courses are offered and sanctioned by the manufacturers of equipment or systems used by the firm, for example Siemens, Drive Systems, etc. The programmes include training in hydraulic systems, computer systems and drive systems.

Human Resource Management and the Development of the Skill Matrices within Large Firms

The iron and steel mills have developed very detailed and sophisticated systems that align the skills requirements of the firm with the skills possessed by employees. At Columbus Steel a standards-based training methodology is coupled to this system, a portfolio of evidence is assembled for each employee at the firm, and a skills matrix is developed for every machine and operation in the plant. Using this portfolio of evidence enables the managers in unison with specific employees to agree to the setting of an appropriate skills target which these employees can potentially reach. It is an attempt to mobilize the skills development capability of all employees and mobilize the necessary support within the firm to ensure that individual skills development targets are reached. The system links in with a team-based production approach, i.e. there is a team around each machine or operation that possesses the right set of skills to run and maintain that machine or operation. Furthermore, each team leader is a training assessor. They are in turn assessed by the firm's training officers, who act as external assessors. Besides the team leaders being assessed annually there will be re-assessment of everyone involved with any changes in technology. The skills matrices allow the firm to constantly identify skills gaps and trigger training, or in some cases recruitment, to fill the gaps. So training is on-going.[32] The system was said to work very well.

The system closely links training to the production floor and has elements of coaching support, career management and mentoring for individual workers. Each manager or team leader overseeing staff is therefore responsible for the micro-management of skills development; and by each employee raising their skill level the improvement of skills across the firm is achieved. The other milling firms have similar systems in place and also consider them to be highly effective. Nothing as sophisticated as this system was found at any other firms in the metals pipeline.

ENGINEERING OR MACHINE SHOPS: EVOLUTION AND SKILLS TRAINING ORIENTATION

Engineering or machine shops undertake a range of specialized and general engineering work. This work usually involves machining work, welding and fabrication work, maintenance and repair work, work related to the creation of tools and dies, and work related to more specialized casting and forging. The size of the firm will usually determine how many of the above types of work each establishment will do. In most cases the work that is done by such engineering or machine shops is customized for the specific needs of clients and the type of work demanded is continuously changing. Customised work is generally done for larger firms that develop a relatively long-term relationship with the particular engineering or machine shop. But some firms will have a large client base that requires the specific engineering service around which the firm's reputation is built.

[32] The skills matrix will also identify when ancillary training, e.g. safety training, is due.

Interviews were undertaken at four different engineering or machine shops. Each was involved in a different segment of the engineering industry and can be classified as follows:

- Cape Manufacturing Engineers is an engineering firm that provides high precision component servicing for the armaments, food, automotive, printing, and textile Industries. The firm possess a quite wide repertoire of skills, including fitters and turners as well as tool and die-makers and boilermakers.

- Belmet Marine is a diversified steel fabricator operating in the general engineering, manufacturing, oil and gas, diamond mining, fishing, mineral processing, beverage, recycling, marine, and glass industries. It has local and international clients. The main skills at the firm are welders and boilermakers.

- SP Forging is engaged mostly with the hot forging of automotive components and the principal industry that it supplies is the automotive sector. Three types of artisan are critical for the firm: toolmakers, millwrights, fitters and turners, as well as electronics and electrical technicians.

- Hansing Engineering is a high precision general engineering works. Most of the work at this establishment involves turning on an assortment of CNC lathes and drilling machines.

Skill

Skills are critical for the growth and expansion of general engineering and machine shops Skill, however, does not exist outside the context of the prevailing technologies. Many of the machines being utilised in the industry are operated through numerical control technology. Interviewees emphasized the importance of computerisation for the industry; one employer described computerization as the ‘backbone of modern industry’.

The FET institutions have often lagged behind with respect to incorporating the knowledge applications of the technological advances that have occurred. One employer remarked that until the early 2000s, the FET syllabus for the theoretical preparation of artisans did not contain any theory of computing and the FET colleges did not have any CNC equipment. The transition to the new syllabus also took roughly six years to formalise.[33]

Recruitment

The relatively small size of the engineering or machine shops has meant that firms do not experience dramatic fluctuations in the number of staff that they employ. This can have the effect that firms do not see much need for training. At one firm at which we conducted interviews limited training had been done

[33] Interview: Dr Ewald Wessels, Cape Manufacturing Engineers, 19 July 2007.

until it was realized that its best artisans had started aging and if it did nothing it would in future face a problem in renewing skills. Its initial involvement with training was therefore part of a longer term process in forward planning. The firm proceeded to second skilled trainers from France to assist with the transfer of skills for work on duplex steels. It was stated by the interviewee that the firm now had among the best artisans in the Western Cape. [34]

The Gauteng-based metal forging firm indicated that it put a high premium on the hiring of apprentices. An interviewee at the firm indicated that at any one time the firm had at least four apprentice toolmakers on its payroll. The cost of training such high level artisans from the start of an apprenticeship to becoming a qualified toolmaker cost the firm between R180 000 to R200 000. The Department of Labour grant in respect of such training amounted to only R12 000 per annum. Nonetheless the firm would continue to do such training because this is what it believes is necessary, besides being 'the right thing to do'.The firm also engaged other entry-level personnel that it trained.[35] It is inconceivable that the firm would have grown without undertaking such in-house training.

The other engineering and machine shops in the sample were also involved in skill upgrading programmes. The high precision component producing firm had six artisans undergoing training, three of whom were new apprentices.[36]

Credentials and Quality of the General Education

The educational prerequisites to enter trades in the engineering and machine shop sector appears to be somewhat uneven, with most firms requiring at least a matriculation certificate to take on a trainee in the artisan occupations. Welders are an exception: apprentices or learners with a Grade 10 or higher can still find openings to be trained in this occupation within many firms.

The decline in school standards was illustrated starkly by the training manager at the marine engineering firm who spoke about 'old hand' welders and 'new school' welders. Many of the potential new recruits that sit the firm's aptitude test fail the basic arithmetical numeracy requirement. The poor quality of mathematics and science among potential recruits is seen as a major obstacle to developing technical skills at the firm.[37] The owner of a machine shop in Saldanha Bay also makes use of an aptitude test to select learners. His experience is similar to that of the marine engineering firm: even though most of the potential learners hold a matriculation certificate only about 10% pass the aptitude test. He commented that 'many matriculants who have done mathematics at school find it difficult to pass the idiot test'.[38]

A number of interviewees alluded to the poor quality of personnel at FET institutions and claimed that this was a constraint on the delivery of effective class room instruction. The low salaries paid to FET staff are a key factor.

[34] Interview: Peter Binns, Belmet Marine, 18 July 2007.
[35] Interview: Ken Manners, SP Metal Forging, 6 August 2007.
[36] Interview: Dr Ewald Wessels, Cape Manufacturing Engineers, 19 July 2007.
[37] Interview: Peter Binns, Belmet Marine, 18 July 2007.
[38] Interview: Hans Herman, Hansing Engineering, 23 July 2007.

One employer suggested that an additional problem was the quality and content of learning material for apprentices and learners in the engineering fields at these institutions. A German by birth, the interviewee indicated that probably the best reference manual for metal and engineering technical artisans was the German Metal Industry Handbook (*Tabellenbuch Metal*), now in its 43rd edition. However, until it is translated its value is lost to South African apprentices.[39]

Skills Upgrading

Each of the engineering or machine shop firms at which interviews were conducted had skills development initiatives which the firm had either recently embraced or which the firm had traditionally supported. The marine engineering firm in Cape Town had recently established a training facility, that was accredited by Merseta. It had also engaged an instructor with a doctorate in Mathematics and was running learnerships at the NQF 2 to 4 levels. From the firm's perspective, the learnership was designed for its learners to obtain a formal artisan qualification.[40]

Having the training school had allowed the firm to bring boilermakers and welders from Angola to undergo further training. This need arose from the firm's operational presence in Angola due to its sub-sea level fabrication work in the oil fields off the West African coast. Thus far 17 Angolan trainees had graduated from the firm's training school with a Merseta accredited qualification. This training was now being extended to its own staff: four welders and three junior boilermakers were undergoing the same course (at an estimated cost to the firm of about R500 000). In future they plan to open up the training school to the public. This will give them a ready source of recruits.

Human Resource Management and the Development of Skills

The interviews revealed that each of the engineering or machine shops have devised a specific human resources management and skills development strategy. We will highlight examples that show how human resource management and the development of skills has been conceived at each of the firms.

The key feature of the Cape Town marine engineering firm's human resource strategy has been its use of contractual partnerships with very large and successful international clients to affect technology transfer from the partner companies to itself, draw on technical support, and build its skills base. A specific instance of technical support was the quality audit undertaken by Mobil Exxon at the firm. These relationships have also allowed the firm to retain a very large complement of artisans as part of its permanent labour force. Similar firms have a much smaller permanent artisan labour force and must bring in a very large proportion of temporary labour to perform big contracts. As a consequence, a variety of problems regarding quality,

[39] Interview: Hans Herman, Hansing Engineering, 23 July 2007.
[40] Interview: Peter Binns, Belmet Marine, 18 July 2007.

efficiency and meeting deadlines arise. The marine engineering firm, however, has built its reputation by avoiding these problems. As a result, the firm is very critical of opposition in the sector, which it describes as 'bureaucratic, monolithic and slow' and 'who would rather walk away from business'. Understanding the requirements of international clients and the supply chains within which they are located, enables firms such as Belmet to develop relationships with firms that allow it to strategise well into the future.

CASE 3: Management structure and work ethic
One of the unique features at Belmet is the strong management control which has been exerted on the firm by its owner and managing director. Although the firm has compartmentalised its management team according to the functional needs of the firm (e.g. marketing and human resources, finance, and project management), it makes use of a team of five to six project managers who oversee the jobs with which the firm is engaged. All the project managers are mechanical engineers with a university or technikon qualification. The team of artisans is segmented into two streams. The first stream consists of welders who work under a welding foreman. The second stream consists mainly of boilermakers who work under the supervision of a workshop foreman. The foremen and project managers report directly to the managing director. The managing director therefore closely monitors the progress of each project. The firm places a high value on its skilled workers and has a strong work ethic. Each day starts with a 'toolbox talk' at 7am that lasts until 7.10 am and hours are long (this is probably the main complaint of employees at the firm).

The case below represents the perspective of a European client with regard to Belmet. Although the interview was conducted in 2006, it is a pertinent reflection on the cultivation of a relationship between a medium-sized South African firm with a large international client.

Operational Impact and Business Orientation

The marine engineering firm has accrued a number of benefits from the long term partnerships it has developed with international clients. One is the reduced incidence of injuries over the last number of years. It also argues that its scrupulous business conduct has contributed to its success. The firm has a principle that all debtor transactions will be settled within thirty days. This has benefited the firm through very good discounts that it is able to get. This is consistent with a management style that continually seeks to learn what customers require.

The above approach to business corresponds with a more strategic approach to the deployment of technology. At the machine shop in Saldanha we were shown an alloy-analyzing handgun that had cost over R250 000. This had been purchased in cash without qualms because it was simply considered a necessary investment that would enable the firm to remain 'above the competition'. During the course of the factory tour we were also told how important the insulated cold room was to ensure precise measurements on tasks assigned for high precision turning.

CASE 4: An International Client of Belmet

The client insisted on the importance of adhering to international standards, especially in the area of fabrication where a range of gradations of stainless steels were being worked with, some of which were designated as exotic materials. Its experience in this field had been expanded through its North Sea operations, where both British and Norwegian welding standards were required for pressure pipe work. The client was also familiar with operating standards that were set in the United States. One of the reasons why it sought to develop a working partnership with a fabrication company in South Africa was because this capacity was largely absent in Angola. The company had spent a lot of time and energy identifying appropriate firms to work with in South Africa, focusing mainly on Cape Town firms. It discovered that the standards that it had set for its designated contractor were significantly higher than the standards of the average fabricating company in South Africa. It was very complimentary about the working relationship that it had with Belmet, and in particular with the approach of the managing director of the firm. Two representatives of the client were impressed with the desire of the managing director to learn and improve the firm's in-house capability as well as with the 'client-centredness' of the senior management team. The core skills existed in the firm and the client believed that the bar could be raised even higher. The client was therefore committed to continue what is perceived to be a 'joint effort' between itself and Belmet.

Source: Lundall (2006)

We found a similar attitude to technology at the marine engineering firm in Cape Town. Although boiler-making had undergone little technological change in the past 20 years, new technologies were available that could improve productivity as well as the precision with which tasks could be completed. One of the capital goods items that the firm has invested in is a computerized pipe-cutting machine. This was apparently 'one of the very few' such machines in the country. It gave the firm the capability to undertake specialized pipe-making work, which had already generated new business and had the potential of creating much more work in future.

MACHINE BUILDERS: EVOLUTION AND SKILLS TRAINING ORIENTATION

Interviews were conducted with managers at three machine building firms. Two of these firms are relatively large, with over 500 employees, while the third had a staff complement of under 20 employees. Machine builders in the manufacturing sector produce a wide range of products. For this project machine builders are classified in a broad category called 'machinery and equipment manufacturers'. The more detailed labour demand data shown in Chapter 2 uses a three digit breakdown of manufacturing. The machine building firms that were selected for interviews fall within three entirely different three digit groups. The groups and a description of the machines that are produced by these firms are as follows:

- The first firm falls in the group described as 'Manufacture of General Purpose Machinery' (SIC classification: 356). The products manufactured by the firm include a wide range of industrial boilers. The firm started early in the 20th century as a result of French investment. At inception it built boilers for fishing vessels using extensive rivets. Today the firm builds, supplies and services boilers in many industries in South Africa, including the sugar, textile, petrochemical, food and beverage, motor and transport, mining, pulp and paper, power generation, fishing, health, tobacco, packaging, pharmaceutical, wood, agricultural and energy industries.

- The second firm is in the 'Manufacture of Special Purpose Machinery' group (SIC classification: 357). The firm manufactures extrusion blow-moulding machines in which various types of plastic containers are produced for the packaging sector as well as components of these machines. The machines fall within the medium-sized category, weighing up to 15 tons.

- The third firm is part of the 'Manufacture of Electric Motors, Generators and Transformers' group (SIC classification: 361). The firm produces a wide range of transformers and electrical switches that are used predominantly in power stations.

Significantly different problems confront the different kinds of machine building firms.

Skill

The firm that builds industrial boilers has always had a training school for apprentices at its plant. The school has been used for training apprentices as well as technicians and engineers. The envisaged construction of new power stations, upgrading of existing ones, and other infrastructural investments has encouraged the firm to plan for an expansion of its labour force. This involves finding new artisans as well as increasing the number of apprentices to be trained by the firm.

Problems in the schooling system have had a detrimental impact on the availability of skills. Employers comment that the learning background that serves as a base on which to build engineering and scientific skills is often absent in new employees. Also absent is a culture in which measurement and calculation is the basis of normal working practice. New entrants also have a poor knowledge of the metric system and have had no prior exposure to the building blocks (mathematical literacy and accuracy) that are essential to develop engineering skills. This is an urgent signal that the reproduction of the metal and engineering skills base is being compromised.[41]

Recruitment

None of the machine producing firms made a direct link between the shortage of skills and business growth. The small extrusion blow-moulding machine producer was extremely critical and dismissive of the entire skills development

[41] In support of this finding see Lundall 2005 and Lundall 2006.

architecture, but because the firm was small and under the direction and control of a core group of engineers the issue of artisanal skills was not seen as a priority. At one of the large firms skills were not seen as a problem. Neither did the regional location of the firm serve as a deterrent to attracting and keeping engineers and other skilled labour from Gauteng. The second large machine producing firm nuanced its views on skills. Skills *per se* did not affect the growth of the firm; many exogenous factors impacted on growth. However, this did not mean that skills availability was not a problem. The recruitment of individuals with the expected level of skill for the relevant occupational level and job position, from the operator level up to the manager level, had become a serious concern. A gradual erosion of educational capabilities had become endemic in the schooling system and undermined the quality of outputs from the higher educational systems.

Credentials and the Quality of General Education

The human resource manager from the power transformer manufacturing firm complained that many engineering students studying for their national diplomas are not able to produce engineering drawings. Furthermore, many students registered for engineering qualifications at FET institutions lack the technical skills to successfully enter engineering careers once their academic studies are completed. To illustrate this point, the manager maintained that the average 15 year-old overseas would produce better engineering drawings than technical college students in South Africa.

The large Cape Town boiler-maker was able to determine differences in the quality of students at the two technikons in the Western Cape. One example of this was the type of practical projects being done by students in the same mechanical engineering course at the two institutions. The students at Peninsula Technikon were working on a spit braai whereas those at the Cape Technikon were developing a test bed for a helicopter.

Although a differentiated higher education system exists in South Africa – as is the case in most countries – it is problematic when this differentiation is equated with inferior qualification standards. It is equally problematic when employers perceive these differences to be the norm. Such perceptions become the criterion that is used to select and hire personnel. It is problematic because employment selection solely on the basis of institutional affiliation is not a very reliable way of employing the best people and can become an entrenched prejudice. Yet the experience of employers seems to suggest that such a criterion is justifiable.

The same firm however indicated that the average quality of matriculated students from which it draws new entry-level personnel into the firm had actually got better recently. It was attributed to schools in poorer communities delivering a better quality of general education. However he maintained that the quality of learners from rural areas (meaning the rural Eastern Cape) had deteriorated.

Skill Upgrading

Skills development and skills upgrading were not a big concern at the small extrusion machine building firm. However, at the two large machine building firms internal skills upgrading initiatives were taken very seriously. Both of these firms had recognized the importance of an extended skills development system in the country. One of the firms indicated that the skills development legislation had forced many businesses that had never done training before to become actively engaged with skills development. So, despite many criticisms about the bureaucratic administration of the system, one of the key intended consequences was that firms had become much more involved with implementing skills development initiatives. Many firms had also become more strategic in diverting skills development resources into areas of training that the firm was generally better at doing.

At the same time, it was pointed out that existing training initiatives in the industry ought to be given greater recognition The firm in Pretoria stated that the Technical Training Centre run by the Pretoria (Tswane) Municipality had played an important role in supplying the company with entry-level workers with a portfolio of generic skills.[42] This institution was functioning as a quasi-regional training centre and as such was serving as a pipeline for technical skills in the area. Later when the discussion shifted to the Merseta the interviewee argued that it should be adopting the strategy of building more regional technical training centres to perform a similar function.
The objective, it was argued, should be to create the building blocks in technical training which enable firms to offer training in more specialized fields.

HRM and Development of Skills in Machine Building Firms

A skilled labour force is critical to sustain the kind of high level technical production work with which machine builders are associated. The small machine building firms, however, do not appear to need to get involved in the bureaucracy of the skills development system. They can appeal directly to technically trained people who want to apply ideas in the construction of prototypes or control systems or even programming procedures. Because these firms embody such a high level of design and sub-assembly work their employees have a better chance of getting involved in managing the process of manufacture. At such firms there is not a great concern to develop intermediate-level skills and even higher level skills. These firms rely more on the institutional learning that is assembled by different individuals involved in designing and improving the machines that are produced. This learning is mostly tacit; it will probably remain so as long as these firms stay small.

In the larger machine building firms the issues that are only partially visible within the smaller firms are given much more prominence. Certainly, the challenges associated with sustaining and improving the skills repertoire of the labour force are very important. The interview with the producer of power transformers indicated that the technology embedded in these products was still very traditional. The competitive advantage for such firms was not found

[42] Interview: Ronald Graham, ABB Transformers, 8 August 2007.

in the product technology but in the management of the production process. This includes the types of materials used in the products, the time it takes to assemble the system or product, and the quality of the product. Price competitiveness was extremely important to firms in the power transformer market but this was partially off-set by the fact that Chinese producers did not pose a major challenge because their products were often of a poor quality.

Our research indicates that state supported skills development is very important for large firms in the sector but can be enhanced by strengthening supply chain linkages for such firms and improving marketing and purchasing supports for the machines that they produce. Deeper integration between the skills development system and production organization will highlight further areas in which the delivery of skills development and utilization of skills can be strengthened.

CASE 5: Poor intermediate product services constrain local niche producer's competitiveness

The small machine producer was extremely critical of the local producers of components that went into its extrusion blow-moulding machines. The problems were related mainly to delivery times and pricing. For instance, the firm can source the linear rails and carriages from Taiwan at a third of the price that local producers charge and will have them delivered in half the time. The quality of the 'mechanicals' from Taiwan also tend to be better compared to those supplied by the Cape Town firms. One of the reasons cited for this comparative advantage is that there are over 2 000 machine shops in one region in Taiwan where similar machine producers can draw on component supplies. Some of the local component suppliers also tended to make excuses about the reasons for delays, such as equipment breakdowns. But this is because they are using machines made in the 1920s and 1930s and refuse to upgrade. This had encouraged the small machine building firm to source its components directly from engineering and machine shops in Taiwan, which use the latest CNC technology. The success that the firm has had in diversifying its supply sources from Cape Town to Taiwan has convinced the owner to obtain a great deal more of its components in this manner. This of course implies that much less of the firm's business would be dependent on component suppliers in Cape Town.

The firm's contacts with Taiwanese suppliers has convinced it that it would be more advantageous to do a significantly higher proportion of its manufacturing business overseas, principally in Taiwan. Because the bulk of the machines that the firm produces are sold overseas, it wants to organize its business so that the manufacturing of these machines will in the main take place in Taiwan and be exported from there. This will be the case for machines designed by themselves, or partly by themselves and partly by Taiwanese 'partners'. The process management of the manufacturing system will remain located in Cape Town. There are also parts of the machine system that cannot be efficiently produced in Taiwan, e.g. control systems and hydraulics. Besides the process management, the firm will use its local factory for its re-manufacturing and maintenance business, i.e. the re-conditioning of old machines as well as modifications and upgrades of existing extrusion machines. This means that the firm's growth will be overseas rather than in South Africa. Until about a year ago they had plans to invest in their South African operation, but then, as the managing director stated, 'we discovered Taiwan'. The only factor that will make them re-consider would be for the Rand to fall to R12 to the dollar – then they would be competitive.

The shortage of skills in the plastics industry has restricted the market for new extrusion machinery because the sector does not have technicians with the requisite skills to work the new machines. Most of the new machines require technicians who are well versed in computer-controlled technologies. One of their customers in the plastic industry has gone to historically disadvantaged schools to recruit and has then trained people from scratch. The shortage of skills in the sector has created the demand for modifications to older extrusion blowing machines. The situation can be changed by introducing incentives for local plastics manufacturers to invest in new extrusion blowing machines. Such incentives can take the form of preferential finance agreements underwritten by government, so that local machine users are not saddled with onerous interest payments for the purchase of such capital goods.

Operational Impact and Business Orientation

The following section aptly captures some of the operational challenges which a small but highly innovatived machine producer confronts in the local market.

An interview with a representative of SEIFSA indicated that the small machine building firm was not alone in turning its eyes off-shore. It was stated that although many SEIFSA members complain vehemently about the inflow of Chinese products, the same businesses do not hesitate to source intermediate products from China. In fact, many of the products that local producers put onto the market contain inputs from China. It was claimed that the biggest culprits in this regard were generally the ones that complained the most about competition from Chinese products.[43]

WORLD CLASS MANUFACTURING

Conceptions of world class manufacturing along the value pipeline of metal and engineering industries are conditioned by enterprise size in relation to the national and international market for which production is organized. South Africa's competitive and comparative advantage in the metal sector is largely within the milling of iron and steel and precious and non-ferrous metals. Best practice technologies have largely shaped the labour force skills that are necessary to sustain this process. The technologies required to do this have been highly concentrated and capital intensive. Among milling firms world class manufacturing leads to the emergence of the virtual factory where even blast furnaces and raw material inputs are generated by large computer controlled machines. With respect to the international enterprise performance each of the milling establishments form part of international firms which are

[43] Interview: Michael MacDonald, SEIFSA, 8 July 2007.

significant players in the market arena from which they operate. At best there has been only minimal diffusion of this advantage from the milling sector to sectors that embody areas of higher beneficiation: engineering or machine shops, and machine building firms.

In terms of enterprise size, engineering and machine shops and machine building firms are significantly smaller than the large milling firms. Our interviews indicate that machine building firms in South Africa are either made up of foreign-owned subsidiaries or independent South African firms that have become entrenched in specific niche areas. These firms do not have the size and scale to withstand overt competition from corresponding firms that are market predators. Nonetheless within their operational scope these firms are applying more modern manufacturing systems into the production operations. Unlike the large milling firms, which typically operate with over 1 000 employees, the product mixes within these firms put a higher premium on the application of specific skills to carry out the production tasks. In the smallest machine building firm, numerical control technologies such as laser controlled metal cutting machines are used in conjunction with high level employee skills, especially engineers, assemblers and computer systems programmers, to manufacture extrusion blowing machines. Achieving higher levels of local beneficiation requires a combination of elements: the knowledge embodied in highly skilled engineers, appropriate raw material prices, and a network of sub-contracting engineering and machine shops that can deliver orders within designated time-frames, budgets and product quality. An inappropriate mix of these elements often retards what can potentially serve as a world class manufacturing venture embedded within a relatively small enterprise.

Perhaps nowhere is the skill factor as a precursor to world class manufacturing more cogently emphasized than in the spectrum of engineering and machine shops investigated during our fieldwork. While good managerial systems and effective and cutting edge technologies can enhance the production system, skills dictate to what extent such firms are geared to win contracts. Where the operation is solutions based and responsive to rapid customization and adaptability to the required task, it signifies the extent to which beneficiation is visible and successful. In large measure, however, the comparative advantage within the South African metal sector is not at the engineering or machine shop level. It is for this very reason that many machine builders in South Africa, whether local or foreign, seek to source inputs from overseas, typically from South East Asia, rather than locally..

STAFF OUTFLOWS

While the opening up of the world economy has meant increased foreign ownership, as well as opportunities with regard to new technologies and the expansion of production facilities, it has also meant a greater outflow of skilled labour. Countries the interviewees identified as the principal beneficiaries of South African artisan skills include Australia, New Zealand, parts of the Middle East such as Dhubai and Qatar, as well as the oil fields off Angola, where artisans are reputed to earn $10 000 per month.[44]

Even within South Africa the skilled labour force produced by the training programmes of the iron and steel milling firms is preyed on by smaller downstream firms. The attitude that sees poaching rather than training as the solution to skills needs is linked to the size and system constraints of firms. The large milling firms contribute a much larger proportion to the overall training of metal and engineering artisans. However, whereas previously the state-owned enterprises made big contributions to training, today private steel mills are subjected to poaching of skilled labour by the state-owned enterprises (e.g. ESKOM). But this is less severe compared to rivalry for skilled labour between steel mills themselves as well as the plethora of engineering firms, machine building firms and new start-ups in the mining sector. One informant at a steel mill claimed that the high demand for skills in the economy contributed to the firm recording a staff turnover ranging from 10% to 14% per annum, most of which was blamed on competitors.[45] The main categories of skilled labour being lost were millwrights and instrumentation mechanics. However, staff losses along these lines were also experienced for engineers and technicians. The same firm also noted that there was usually not a sufficient stream of outside skills to draw upon when the firm went into a routine shut-down.

Qualified artisans are lured away by wage premiums. The premiums paid to qualified black artisans are estimated to be 30% to 40% higher than for artisans in general. One interviewee stated that all the firm can offer in the face of such competition for skilled artisans is a relaxed culture and working environment.

CLUSTERING, NETWORKS AND ASSOCIATIONAL ORGANIZATION AMONG EMPLOYERS

It is difficult to ascertain to what extent firms are part of networks of one form or another in the industry. The interviews suggest that there are two types of networks: regional and associational. The regional networks arise from the close proximity of some firms and are usually between suppliers and clients, and the associational networks are established by a formalized level of contact between firms. However, even where there is significant associational organization among employers, this does not necessarily translate into initiatives that can be construed as forms of clustering.

Regional networks

One network has emerged in the relatively confined space of Saldanha Bay between an iron and steel mill and an engineering machine shop. The owner of the latter shop was doing more advanced machining and turning work in

[44] Interview: Brian Lister, South African Oil and Gas Alliance, 31 July 2007.
[45] Interview: Frikkie van der Merwe, Saldanha Steel, 23 July 2007.

the region and a contractual relationship had emerged between the firm and the iron and steel mill in the vicinity for very specific machine parts. The relationship led to informal discussions between the owner of the engineering machine shop and the human resource manager at the iron and steel mill. The interview suggests that this discussion is ongoing and some level of collaboration in the area of learnership training is quite probable in the near future.

Associational Organization

Two interviews were carried out with representatives of employers' organizations. The first was an interview with Michael MacDonald of SEIFSA. The second was with Ken Manners, the president of the National Association of Automotive and Component Manufacturers (NAACM), and also the director of a firm (SP Forgings).

SEIFSA is primarily an umbrella organization for a number of sector-specific employers' organizations within the metal and engineering industry. This suggests that many employers' organizations are too small and scattered to bear the burden of maintaining offices and the operational costs of running an organization. It was stated that the collection and dissemination of firm-level information by SEIFSA, in order to coordinate and develop a more systematic response to economic challenges, was extremely difficult because firms were reluctant to provide information. However, while reluctant to disclose information, firms all wanted to obtain sectoral and industry-level information from SEIFSA. It seems that some firms will even supply incorrect or incomplete information concerning their own business activities. When these firms get sector and industry information they will correct or complete their own contribution, thereby hoping to have the right information. But given that a number of firms are doing this it ends up that everybody has incorrect information. The information is therefore of no strategic value to any firm.

NAACM, on the other hand, was making an attempt to address networking and clustering. It had started to initiate the formation of Local Area Groups in an attempt to strengthen collaboration around information exchange and support among component manufacturers in a given geographical region of the country. NAACM had also established a web site at which automotive component manufacturers could register and obtain relevant sector and industry-level information.

Within SEIFSA, there was only one association, the South African Iron and Steel Institute (SAISI), that had initiated a similar associational venture to that of NAACM. The Institute has only six members, all very large: Cape Gate, Cape Town Iron and Steel Works (CISCO), Columbus Steel, Highveld Steel and Vandium Corporation, Mittal Steel, and the Scaw Metals Group. There is evidence that quite a lot of discussion takes place between these firms, including between their human resources managers. One area where discussions have taken place is with respect to plant shut downs, so as to coordinate the demand for the limited pool of repair and maintenance artisans. A second issue that had been discussed was the salaries that are being offered to certain scarce skilled occupations, especially artisans.

There have been no initiatives along these lines in the power transformer or industrial boiler sectors. However, in the latter sector the very large capital investments that are envisaged by ESKOM have created the opportunity for the three or four large firms that dominate the sector to enter into partnerships. Although large, none of these firms is big enough to take on the ESKOM projects on their own. They can only do these projects by developing consortia. However, at this point such a collaborative association is nothing more than a possibility.

METAL AND ENGINEERING FIRMS AND SECTOR EDUCATION AND TRAINING AUTHORITIES

According to one training manager, the initiative to organize the new skills development system at first included participation from mostly technical people (e.g. artisan instructors and mentors to technicians and engineers) as well as people that were directly involved in firm-level training. The initial meetings drew up to 150 such people from firms within the sector in Gauteng. However, as the process unfolded more and more outsiders, such as people with a knowledge or interest in curricula, education policy makers and so forth, were drawn into these deliberations. Eventually the meetings attracted more non-technical people than technical people. The technical people became discouraged by the increasingly unrealistic proposals that came to dominate the discussions and their attendance and participation dropped off. Many technical people thus felt distanced from the decisions that informed the design of the new system.

In the past, there were two contrasting perceptions amongst employers of the new system and, in particular, SETAs. The first was that the skills levy was nothing more than an additional tax on employers and it was being used to sustain a bureaucratic system. Employers found that the red tape that had to be worked through to retrieve returns for skills development at the workplace was extremely frustrating and a disincentive to firms. The most efficient firms accepted this fact and sought to avoid putting energy and effort into recouping the expenses that they had incurred for training. By treating the levy as a tax they either did not train or carried on doing the training they wanted to do without reference to the new skills development system.

The second perception was one of enthusiasm for the new skills development system and the opportunity it gives progressive employers to transform the South African skills development landscape. The reality, however, is more complex. Firms relate in quite a diverse manner to government policy and, in particular, the skills development system. Some make use of the skills development machinery and yet remain vehemently critical of its outcomes. Often in one breath they will praise the old Industrial Training Boards in comparison to the SETAs and in another they will celebrate the opportunities that the qualifications progression opens up for learners starting at the bottom of the ladder. One needs to interrogate these stances and go beyond their ideological underpinnings to establish what the situation is with regard to utilization of the new system.

Employers were unanimous in condemning the amount of administrative red tape and bureaucracy that they have to comply with when engaging with the Merseta. One employer went as far as proposing that the local FET be roped in to assume some of this administrative burden, particular with regard to aptitude testing, candidate selection and career guidance. One employer described the performance of the administrative mechanisms to obtain refunds for training costs as 'shocking'. However, even when they are critical of the SETA not all employers have the same difficulty in retrieving funds expended on workplace training.

The interviews suggest significant differentiation in the ability of firms to obtain tangible benefits from the skills development system. One argument was that far more resources needed to go along with the delivery of training. Small firms simply could not conduct training because they were not able to assign capital equipment for training purposes and neither did they have dedicated personnel with the pedagogical skills to conduct the training. To get training taking place at these firms one needs a publicly supported FET system that can provide most of the theoretical instruction and some of the elementary practical training for the workforce. Such theoretical instruction is generally available through existing FET institutions in a region. Programmes for learners to undergo the practical skills training in trades is also available at these institutions, although learners are encouraged to gain placement with an employer for at least six months after undergoing such practical skills training. Thereafter employees normally return to the FET institution and undergo final preparation in order to complete an assessment that would give them a certificate of competence or award them artisan status.

In general, large firms have the resources and capacities to run their own company-specific training schools. These can provide training even if the publicly supported training system fails to deliver on training. Not surprisingly, such firms tend to be vociferous about perceived failures in training delivery and the role of SETAs. The implication, which is supported by the interviews, is that the failures of training delivery have been borne in the main by small firms. The interviews provide evidence that the problems in the new training system have also impacted on medium to large firms but that they began to put contingency systems into place to deal with this problem.

Part of the reason for the failure of training delivery impacting so severely on small firms is that such firms have limited powers in the governing board of the Merseta. This is also the case with regard to certain regions. Employers in the Western Cape complained of being marginalized. The problem is exacerbated in a region such as the Western Cape because it is made up of mainly small and medium sized firms.

These concerns do not emerge at the large iron and steel milling firms, although some are disparaging of the new system. The reason that the large iron and steel mills have a different perception is that they are not dependent on the new system because they all operate a firm-specific training school or centre. However, there are instances of participation by these firms in the new system. One steel mill has developed a good relationship with the regional office of the Merseta. The firm also referred to the success of a pilot project that it ran for section 18.1 and 18.2 learners.

The large machine building firms have a perception that this new skills system is a failure. This has resulted in them giving greater importance to training in their own training schools. One such firm has decided to write off the skills levy and pursue its own training initiatives. The firm is however involved with the Cape Town branch of Merseta, where it has tried to contribute by playing more of a leadership role. The other firm does not rely on the Merseta at all. It contends that the SETAs are bureaucratic and are usually staffed by non-technical people who do not understand the needs of the industry. To illustrate this, it was maintained that the establishment of the SETAs has meant that administrative requirements take up a lot of the time and resources that formerly would have been devoted directly to training: it now takes the manager and a staff member four weeks to prepare and collate information in order to produce an annual training report on the firm for the SETA. Because the firm's computer and technology systems are not compatible with the SETA's reporting system, all the information has to be collected manually. Previously all this time and energy would have gone into actual training. The training manager at the firm suggested that the Merseta should put more effort into developing regional training centres, to which employers can send employees to undergo training.

CURRICULUM CHANGES AT THE FET LEVEL AND THE CONFLICT WITH THE DEPARTMENT OF EDUCATION

A constant theme which permeates discussions with different stakeholders in the educational and training arena in South Africa is the nature of the transition from one system of educational and industrial training to another. The discussion and debate constantly raises issues of incorporation and inclusiveness as the old system is adapted to the new, but it also highlights issues of capacity, quality and implementation as the new system is erected and becomes operational. This theme broaches multiple dimensions of the educational and training landscape and usually pits diverse institutional groupings and interests against one another.

At present there is quite a vigorous dispute concerning the new further education and training curriculum that is being implemented by the National Department of Education, with resistance coming mainly from employers who feel that their concerns have not been adequately addressed in the process of adopting the new FET curriculum. The argument that employers have advanced, emanating especially from the educational and training managers within firms, is that the new curriculum does not adequately cater for the technical trades that the old NATED curriculum embodies. The new FET curriculum consolidates the theoretical content of a diverse range of trade and occupational learning areas into a narrower band of learning streams. In doing this, the specificity of these learning areas is sacrificed for the generality of streams that have larger interchange between qualifications. Thus, qualifications that had traditionally been organized on a trimester basis are expanded for delivery over a whole year. The Department has put into motion what employers consider a too rigid time-frame that displaces the older NATED qualification, which can be done on a trimester system up to level six, with whole-year qualifications for the FET band. Critics among the education and training lobby within firms consider the time-frame to be insufficient to allow individuals who have already embarked on their NATED qualification to complete it. Employers as a whole are also disconcerted about the full year which trainees in their employ are required to be at a FET institution to obtain theoretical instruction in their field of training. The new system is seen to impose an additional cost burden on employers and to keep their trainees away from employment for an unusually long period.

An official in the Western Cape Department of Education (WCED) concedes to some of the points that employers have generally raised but balanced this with a more nuanced set of explanations[46]. The new National Certificate (Vocational) is designed to replace the NATED N1 to N3 courses at all FET colleges. It is built on a completely new curriculum platform. The existing NATED curriculum, which spans N1 to N6, was developed in 1981 and has never had major revisions. From the onset the NATED curriculum was more theoretically orientated and the alignment between theory and practice tended to be a shortcoming. It generally had a poor reputation, particularly among employers. The latter's criticisms were taken into consideration in the design of the new curriculum. Hence the new curriculum gives learners a wider repertoire of skills in which decision-making, information processing and communication are important components.

Our research found that, with the exception of the award of the artisan status through the successful completion of a trade test, the NATED programme was insufficiently articated with HE engineering programmes offered at Universities and Technikons. It is hard to imagine what the situation would have been had the National Department of Education not enforced a level of equivalence between matric and the N3 level, which learners from a FET college use to bridge and gain entry into the HE system. This remains the only bridge that establishes a definite articulation between the FET curriculum and the HE curriculum.

Probably the most contentious issue regarding the new curriculum is that the duration (one year) of the programme will impose an unnecessary burden on employers, who must release employees to attend courses at a FET college. An informant from the WCED recognized this to be a problem but maintained that it can be resolved by making provision for specific courses to have a parallel sandwich or block-release structure. In this way both full-time and part-time students can be accommodated on the programmes offered through the new FET curriculum.

[46] Interview: Danita Welgemoed, Western Cape Department of Education, 19 November 2007.

CONCLUSION

The diversity of enterprises within the three broad organizational forms identified for the metal and engineering sector (i.e. iron and steel mills, engineering or machine shops, and machine building firms) requires a nuanced strategy to be formulated with respect to enterprise growth in which the skills intensity of the enterprise is maximized.

The quality of public school education is considered to be a major stumbling block for firms that are seeking to build a wider repertoire of skills within the labour force. Firms see this level of education as a vital foundation for the generation and reproduction of occupational and trade skills which are more firm-specific or require firm-specific experiences to develop more fully. Furthermore, firms across the spectrum view the institutions designed to support the delivery of workplace skills formation as cumbersome and slow to generate results. This is due to the level of bureaucracy that is necessary to make the system operate. Despite the criticisms, though, some firms appear to effectively negotiate the skills development system by working with Merseta and delivering on its planned training outcomes.

There are, however, signs of hope and innovation. One is the gradual resurrection of artisanal training. The Department of Labour signaled this when it reiterated that the regulations in the old Manpower Training Act governing apprenticeship training had not been repealed and replaced by learnership regulations, and that the two training programmes can exist side by side. Furthermore, the Department of Labour has explored the skills development of higher numbers of learners/trainees on a regional and SETA level using lead employers as the key agency to carry out the training. The model is referred to as ESDL (Education Skills Development Lead Employer) and it is in the process of evolving into the ESDA (Education Skills Development Agency) model. The model makes provision for a system in which an agency can accelerate skills development by performing a developmental and brokerage function in the delivery of education, skills development and work experience.

Not all of the innovative institutional vehicles for skills development are new. ATRAMI, which was designed as a form of recognition of prior learning that would convey experienced skilled operators into the artisan ranks, is a prime example of an existing training scheme that has lots to offer. The problem is that it is not being utilized to the extent that it should be utilized.

This chapter has used interview and case material to provide a picture of enterprise level training within the metal and engineering industries. The evidence was used to construct an argument that identifies and maps systemic and institutional factors for the generation and delivery of high and intermediate level technical and organizational skills. The first part of the argument differentiates the formation of firm or enterprise level skills through an analysis of the production value chains within the sector. Thus the argument is that the value chain in which firm level production is organized, coupled with enterprise size and capital concentration and intensity (which we are saying has a strong structural association), ultimately has an impact on the degree and capacity of enterprise or firm level training that can be embarked upon.

In Chapter Three we showed that the deficiencies in the contribution of public FET institutions to the supply of skilled labour to the metal and engineering industries were quite serious. In the present chapter, using the above typology of firms in relation to their location within upstream (milling firms) or downstream (engineering fabricators or machine shops, and machine building firms), has enabled us to get a qualitative understanding of the extent to which these firms are either limited by or can overcome the deficiencies of a public education and training system. Generally only the milling firms have collectively succeeded in making up for these deficiencies. They have done this by operating internal firm level training schools for specific categories of skilled workers, such as apprenticeships and learnerships.

There are of course a number of engineering fabricators or machine shops and machine building firms that have embarked on similar internal training ventures. However, the majority of firms within these sectors cannot do this without an expanded public education and training provision, one that alleviates them of the burden of investing in machinery and infrastructure that is dedicated for staff training.

This chapter has therefore provided a detailed analysis of segmentation among metal and engineering firms that takes account of their location within the value chain, their capital intensities, their enterprise size, their involvement in enterprise level training, and their gravitation or orientation towards embracing an educational and training system that matches their needs and resources.

Chapter 5

Conclusion

This study of the industrial structure and skill embodiments within the metal and engineering sector of South Africa contains a wide spectrum of empirical evidence that is woven through with qualitative insights and theoretical arguments. In order to advance an argument linked to specific practical policy recommendations it is pertinent to highlight the most salient features of the evidence that has been put forward.

The Shape of Outputs in Qualifications and the Challenge of Quality in Education

A major theme which permeates our research is the challenge to correct the poor quality of public schooling. The impact of the educational crisis was emphasized by interviewees. They used a diversity of approaches to mitigate for problems within the schooling system. These ranged from devising more stringent aptitude measures, especially for work involving mathematical calculations and accurate measures, to the setting of higher entry requirements for potential recruits. In addition, the absence adequately prepared entrants from the school leaving population, has led to some firms realizing the importance of training the lower occupational levels of the labour force. In analyzing the educational supply data, we were keen to examine the extent to which the higher education system and the further education system was able to close the gap left by the schooling system.

Overall, while there was a noticeable growth in the number of candidates enrolled for qualifications at both the further education and higher education levels, there was a gradual decline in educational outputs. Although the evidence covers only a ten-year period, it is clear that enrolment growth corresponded to a decline in throughputs. Contemporary education policy has been concerned to expand enrolments in further education institutions beyond the traditional trade test occupations. This calls for a greater diversity of teaching programmes accompanied by increases in student enrolments. Hence it has meant attracting new learners from outside the artisan or traditional trade test occupational trajectory to the FET system.

The pattern of enrolments within the metal and engineering fields within the FET system is strongly influenced by the minimum theoretical entrance requirements that exist for engineering artisans. This means that enrolments are disproportionately bunched at the N1 and N2 levels, followed by a drop-off in enrolments and throughputs at the N3 and N4 levels. This is followed by a substantial increase in enrolments at the N5 level and another drop-off at the N6 level. This pattern of enrolments for different levels within the FET curriculum is consistent across the ten-year period.

Furthermore, when outputs across the FET levels are viewed over time (i.e. 1996 to 2005) the increase in outputs is significantly lower when compared with the increase in enrolments. One reason for such a problem relates to institutional efficiency and can be solved by increasing as well as improving the learning and teaching resources of institutions. The quality of learners that enter the system can only be corrected by better teaching programmes or by organizing teaching programmes in a manner that allows for effective remediation.

A similar trend of enrolment growth exceeding graduation or output growth can be observed in the data for higher education supply. Outputs as a percentage of enrolments over the period 1996 to 2005 have declined respectively for National Diploma graduates from 11.4% to 8.3%, for B Tech graduates from 44.1% to 19.1%, and for graduates holding professional engineering degrees from 17% to 13.1%. Overall, all qualifications awarded in the engineering fields within the higher education system witnessed a shift in the ratio of enrolment to graduation from 15.4% in 1996 to 11.8% in 2005. This means that the higher education system has become less efficient in producing engineering qualifications.

Limited Beneficiation and a decline in Employment

The above focuses on problems related to the supply of skilled human resources. We attempted to align these to challenges on the demand side. The most serious challenge on the demand side relates to the poor development of the downstream, higher value-adding branches of the metal and engineering sector. The incidence of investment expenditure within the basic iron and steel industries, compared to downstream industries such as metal fabrication and product manufacture, provides a useful indicator of the limited beneficiation taking place in the sector. As was shown in Chapter One, investment in the basic iron and steel industry amounted to roughly 50% of value added in the late 1990s compared to 18% for metal products. Basic iron and steels was furthermore characterized by a high export orientation with roughly three-quarters of outputs designated for exports. In contrast, downstream production in metal products and machine building is largely oriented to the domestic market.

Although the general decline in employment within the metal and engineering sector was associated with higher employment declines in the basic iron and steel and non-ferrous metals industries than in the rest of the sector, this was not matched by an equivalent reduction in output in these industries. In fact, the reduction in employment was accompanied by increased technological investments resulting in the level of outputs increasing. Our interviews confirm that the iron and steel mills have undergone a significant labour force reduction over the last few years but in many instances this had gone along with increased output. In the industries outside of this (i.e. metal products and machinery) this trend towards employment reduction was also evident. There was also a decline in the number of enterprises within specific industries. For instance, as indicated in Chapter One, the number of foundries in South Africa shrunk from about 450 in the 1980s to just over 200 in 2003. The challenge that policy makers need to confront in a sector in which employment and the number of enterprises has contracted, and where the process of beneficiation has been weak, is to find ways to grow the downstream, higher value-adding industries. Only through measures to increase beneficiation can there be a reversal of the gradual decline of the metal and engineering sector as a whole.

The Impact of Firm Size and Globalisation on the Incidence of Firm-based Artisan Schools

The case studies confirm that large capital intensive firms in the metal and engineering sector have been pace-setters with regard to workplace-based training, particularly artisan training. While there has been a decline in the number of small and medium-sized firms doing artisan training, most large firms that had trained artisans in the past still continue to do so, although on a reduced scale.

The precedent was set years ago with the establishment of ISCOR as a state-owned company. ISCOR was the largest iron and steel firm in South Africa and was reputed to account for roughly one-third of all apprentices inducted into the metal and engineering trades in the country. ISCOR's core operations were however concentrated in basic iron and steel (i.e. the milling processes). Other state-owned firms and parastatals were also instrumental in maintaining large internal training schools out of which trained artisans and other skilled workers emerged. These included ESKOM, South African Transport Services (incorporating Roads, Railways and Harbours), and the works divisions of the major municipalities and divisional councils in South Africa. The famed Railway Workshops that was to be found in large South African cities (e.g. Salt River, Germiston etc) trained artisans to perform important service and maintenance tasks that could be classified within the metal products and machinery and equipment industries (engineering and machine shops and machine building operations). Recruiting from this constant supply of artisans by firms in the metal and engineering sector meant that the above organizations were effectively training for the industry as well as the wider economy.

This was to change with the demise of apartheid and the inclusion of South Africa in the global economy. These developments meant that state-owned companies such as ISCOR came under pressure to demonstrate their commercial viability. The ostensible subsidization of the firm's training activities was thus put under greater pressure. Similar pressures were being felt by the large private milling firms that had emulated the internal artisan training school model established by ISCOR and others. This meant that the many firms that had relied on poaching qualified artisans from ISCOR and the big milling firms began to experience a decline in the stream of labour supplies that they could access.

The internationalization of the South African milling firms (Mittal, Columbus and Highveld Steel) through foreign acquisition suggests the generation of skills and talent will largely be synchronized to the internal requirements of each firm. Even participation by such firms in accelerated artisan training initiatives, which seek to utilize the training capacity of these firms to produce artisans surplus to their own needs, is not likely to significantly increase the flow of excess labour supplies to a wider network of firms in the economy. Accelerated artisan training by the handful of milling firms will have only a limited impact on the availability of skilled labour and particularly artisan labour. While the accelerate artisans training programmes are a step in the right direction, more is required to solve the skills problems. The solution needs to encompass the provision of training by firms that are engaged in engineering and machine shop operations and machine building firms.

The Location of Public Sector Intervention in the Skills Development Imperative

The reduction of the state's ownership stake in large parastatal concerns such as ISCOR in the milling industry coincided with a more commercial focus being imposed on public sector firms that were involved in general engineering and machine shop operations. The most visible example was the significant operational and staff reduction experienced by the workshops of the South African Railways. The broad array of skills within the labour force that were embedded within such entities was consistent with what was sought throughout the metal and engineering sector. These included skills at the lower, middle and top end of the occupational chain.

It is critical for skills development in the metal and engineering industries that the gap left by the significantly reduced role of the state in the industries is filled. Given that the absorption capacity for lower skilled elementary workers into employment was higher in firms located within the engineering and machine shop and machine building industries, we argue that training initiatives should focus on these industries in the sector. We expand on this argument in the section below.

Shifting the Paradigm to Address the Problem

The argument put forward in this paper is that the skills crisis in the metal and engineering sector is rooted in three areas:
first, in the low quality of public education and training, particularly at the general education or schooling level; second, in the outdated equipment and curriculum on the part of FET institutions resulting in inferior quality education (Fisher et al, 2003:340 and 347); and third, in an enterprise training orientation that is unable to align enterprise training for a new millennium.

Significant improvements are thus required in public general education and public FET education, especially in educational endowments in mathematics, science and communication. Such improvements will enable learners to embrace a growing and advancing technological society. Most importantly the efficiency of post-schooling system at the FET and HE level must be improved.

However, our argument focuses primarily on the enterprise level training system that prevails in the metal and engineering sector. Given the pattern of training in the past – training predominantly done in the (low beneficiating) milling sector – the current enterprise training system can be characterised as a low beneficiation system. By this we mean training that focuses on the needs of the early stages of metal beneficiation such as milling. The public technical college system largely developed to fuel the apprenticeship training initiatives that arose in these large state-owned and private enterprises. Under the low beneficiation training system that was in place, the aggregation of engineering and machine shops could only manage to sustain very modest internal training. Those that did so put a high premium on having a credible public technical college system that could provide a sufficient level of theoretical and basic workshop training to the apprentices they indentured. Small engineering and machine shops not able to do this depended on recruiting or poaching staff from larger firms that did undertake staff training.

The process of adapting and shifting the training system to one of high beneficiation has been tardy at a policy level and at the level of the education and training institutions such as FET colleges. It is only in the new millennium that a modest recapitalisation of FET institutions has been initiated by the state. However, to be successful an appropriate industrial policy has to be implemented in tandem with the FET recapitalization programme in order to supply better technical trained labour to enterprises that grow and expand, that is, to enterprises in the downstream industries of the metal and engineering sector. While laudable, interventions such as the accelerated artisan programme will not on their own propel the enterprise training from a relatively low to a high beneficiation training system because they are premised on the training outputs of large firms, many of which are in the milling process industries.

The convergence of a developmental industrial policy and an across the board quality education and training policy is pivotal to the supply of adequate skilled workers to the metal and engineering sector. But convergence will only take place if there is an expansion of the high beneficiation segments of the metal and engineering industries, that is engineering and machine shops and machine building firms. While the process of convergence is likely to be gradual at the beginning, it will increasingly depend on the FET system. This is because many new enterprises will be constrained in terms of enterprise size and flexibility from instituting more than basic provision for internal firm level training. Thus such an emerging enterprise level system will place a massive reliance on the public FET system to perform an important skills provision function. Only when this outcome gradually materialises will we be able to celebrate the birth of a high beneficiation training system in South Africa.

Opportunities to Close Gaps

Our research points to a number measures that need to be taken to improve the skills development system in the metal and engineering sector.

1. The endorsement by key institutions in the sector of accelerated artisan training to expand the corps of artisan and skilled workers must be followed up by concrete steps that will ensure that young people are encouraged to pursue careers in the engineering field. It will also be important to communicate information to firms about the incentives that are open to them if they participate in such accelerated skills development programmes (e.g. tax incentives etc.)

2. The short-term focus on programmes such as accelerated artisan training should not detract from parallel industrial policy measures to create an expansive and competitive enterprise system, particularly for engineering and machine shops and for machine building. These policy measures have to function in tandem with measures to build a high beneficiation training system in South Africa in which the mandate of the FET and HE system to provide quality human resources in the science, technology and engineering fields is radically enhanced.

3. The paradigmatic shift which embraces a high beneficiation training system necessitates more institutional flexibility and less bureaucracy and regulatory red-tape. Building a high beneficiation training system cannot be done overnight and therefore the existing institutional architecture has to be used to the fullest. Thus all the statutory instruments (e.g. ATRAMI), and institutional vehicles (e.g. SETAs, FETs, independent training centres) have to play a role in the acceleration of education and training outputs. Similarly, new institutional vehicles that are already in the legislative pipeline, such as the Employment Skills Development Agency, must be supported. Important lessons can be derived from these instruments and vehicles. Where the results are positive the lessons can be used to inform the construction and shape of a high beneficiation education and training system.

4. The Merseta should establish and fund Regional Training Centres that it can operate on its own or in a joint venture with specific employers or an employers association, for example SEIFSA's FUNDI Training Centre and Solidarity's SOL-TECH training initiative.

5. Employer associations should be encouraged to convince their membership that there are long term economic and growth benefits from deepening inter-firm level collaboration, particularly in the area of skills development.

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