FACTS AND FIGURES ON SKILLS IN MANUFACTURING

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the dti
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towards full-scale industrialisation and inclusive growth

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2030 NDP

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Introduction

South Africa has accomplished enormous social progress over the last two decades by giving millions of citizens access to key public services, most notably education, health, housing and electricity. About 90% of households have access to piped water and 84% to electricity (Statistics South Africa, 2016). The advanced banking system and deep financial markets have made South Africa a regional hub for financial services.

Nevertheless, growth has trended down markedly since 2011 owing to constraints on the supply side, in particular electricity shortages and falling commodity prices as well as policy uncertainty (OECD, 2017). Official unemployment rose from 25% to 27% (expanded rate was 36,8% in 2017). The youth are particularly hard hit by the economic slowdown, with an official unemployment rate of 52% in the third quarter of 2017.

Artisan training and development has been identified as a critical area to address the challenges of economic growth and redress, and provide an avenue to tackle the growing challenge of youth unemployment in South Africa (NSDS III).

This Information brief provides an overview of employment trends for artisans and technicians in the manufacturing sector in South Africa for 2002 to 2016. It examines the employment and value-added trends in the sector and provides detailed technical occupational trends as well as an overview of the skills levels and technical occupations by qualifications and sub-sectors. Finally, it analyses the relationship between enrolments and graduations of

engineering students at Universities of Technology and enrolments and competent artisans from the Department of Higher Education and Training.

Intermediate-level artisans remain crucial because multi-technical systems need maintenance, servicing and repairs (Rasool H, 2016). Technicians and artisans constitute the core of the technical workforce, ensuring innovation and efficiency of the production process through the optimal use, design and maintenance of materials, equipment, capital and personnel.

Highlights

- South Africa is ranked 61st globally (out of 137 countries) and third in Sub-Saharan Africa (SSA) in terms of competitiveness.
- BRICS (Brazil, Russia, India, China and South Africa) nations have low levels of industrial automation (robot density) and low numbers of Industry 4.0-related patent applications (robotics), with the exception of China.
- South Africa has one engineer per 3 200 people, compared to 1:130 in China, 1:270 in Europe and 1:450 in Australia.
- South African mining engineers get paid more than in other engineering fields.
- South Africa outperforms other BRICS nations, as well as many other countries, in terms of availability of the latest technologies.
- Mathematics and Physical Science are priority subjects in terms of the sector plan for

Medium Term Strategic Framework (MTSF) of the Department of Basic Education and the National Development Plan (NDP).

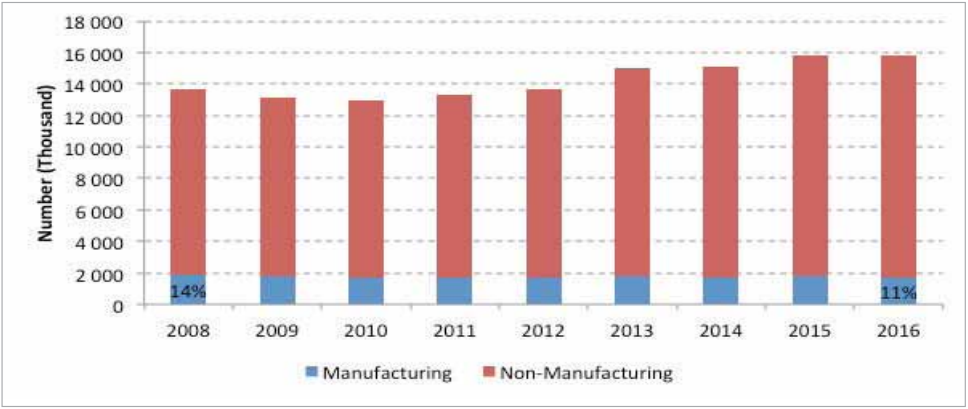
- General inequality in South African society has also had an uneven impact on the mathematics education system.
- South Africa has participated in the Trends in International Mathematics and Science Study (TIMSS) every four years from 1995, 1999, 2003, 2007, 2011 and 2015.
- South Africa showed the largest improvement from 2003 to 2015, as it improved its science and maths achievement, among grade 9s (TIMSS).
- The number of South African grade 9 Science learners scoring above 625 points declined more than half, from 215 in 2011 to 100 in 2015 (TIMSS).
- The international TIMSS results confirm that South Africa's Grade 9 learners have improved substantially in Mathematics and Science since 2002.
- Full-time grade 12 candidates achieving 60% in physical science was higher in 2016 than in any other year since 2008.
- Only 3,7% of physical science candidates achieved distinctions in 2016.
- Only 3,0% of mathematics candidates achieved distinctions in 2016.
- Only 18% of engineering students at Universities of Technology graduated in 2016.
- Most artisans are unqualified (60%), with one-third having Grade 12.
- Black engineers and technicians have the lowest share of registration with professional bodies.

- Most artisans are in the basic metals sector.
- Women constitute more than one-third of employed technicians, but only 24% of artisans in 2016.

Manufacturing employment, value-added and gross domestic product

This section considers growth trends in the manufacturing sector, its share of gross domestic product (GDP) and its impact on the trends in employment between 2002 and 2016. The research shows that the manufacturing sector is today 15% bigger (in terms of value addition) than it was 10 years ago, 51% bigger than 20 years ago, and 64% bigger than 30 years ago (Langenhoven H, 2016). The same research shows that employment numbers have declined alarmingly: 14% fewer people are employed today than in 2005 and 23% fewer than in 1995. Though the production of digital and changes in manufacturing technologies has led to the employment decline in the sector, there was still improvement and very strong linkages to the service sectors that still sustain jobs in the economy (the dti, 2017).

Figure 1: Manufacturing share of total employment, 2008-2016



Source: Statistics South Africa, QLFS: Q3

Manufacturing accounts for about 11% of the total South African workforce, down from 14% in 2008, as indicated in figure 1. Manufacturing constitutes a diminishing share of the economy simply because other sectors, primarily services, have been growing faster over the same period (Langenhoven H, 2016). According to the South African Reserve Bank, manufacturing's contribution to the economy declined from 19,7% in 1995 to 13,7% in 2015. In nominal values, manufacturing employment declined from 1,9 million in 2008 to 1,7 million in 2016. Manufacturing employment has been declining at an annual rate of 1,6%, while non-manufacturing employment has been increasing at an annual rate of 1,9% over the period 2008 to 2016. Manufacturing production was up 0,8% in January 2017, but is still below levels of production recorded before the global financial market crisis (StatsSA, 2017).

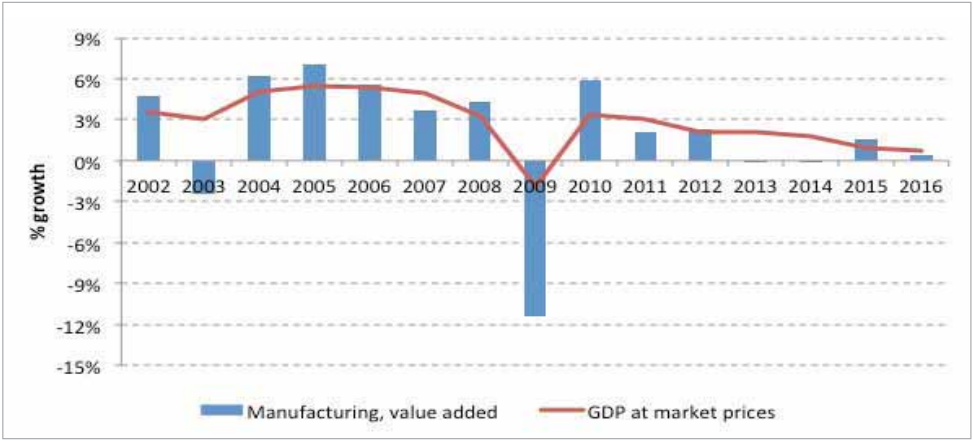
This might have been the cause of the declining employment figures in manufacturing.

The government, recognising that manufacturing can play a pivotal role in reducing unemployment, poverty and inequality, has highlighted the urgency of promoting increased labour-intensive forms of manufacturing in a number of government policy documents, including the New Development Plan (NDP) and Industrial Policy Action Plan (IPAP) (the dti, 2017).

Despite this recognition, the sector has continued to decline, both in terms of its contribution to economic growth and employment, as shown in figures 1 and 2. It is, however, doing a lot better than it would have been without the intervention of the dti over the last few years, particularly in the automotive, clothing and textiles, agro-processing, and film and business process outsourcing (BPO) sectors (the dti, 2017).

The declining share of manufacturing is not unusual and is also a feature of developed economies. For instance, the share of manufacturing in the United States (US) has been declining (Martin NB and Barry PB, 2014) for more than two decades now. Thus, the recent efforts by the Trump government aimed at “America First” is based on the idea of “reshoring”. Instead of offshoring manufacturing jobs to China, India or Indonesia, for instance, there is an effort to bring American manufacturing jobs back to the US. The success of this strategy is yet to be seen. The approach to “reshoring’ also has implications for developing economies such as South Africa, as we may also potentially lose manufacturing jobs, as they go back to their original economies.

Figure 2: Manufacturing and GDP growth rates at constant 2010 prices, 2002-2016



Source: Statistics South Africa GDP: Q3

GDP and manufacturing growth has disappointed in the last few years, as shown in figure 2. Weak consumer demand, persistently falling business investment, policy uncertainty and the prolonged drought weighed on activity (OECD, 2017). There is a strong positive link between growth of manufacturing and growth of GDP, as depicted in figure 2. Manufacturing has declined by about 20% since 2002 (StatsSA, 2017).

There has been a shift away from tradable sectors such as agriculture, mining and manufacturing towards non-tradable sectors and, in particular, financial services. Between 2002 and 2016, the size of the financial services increased by more than 24% (StatsSA,

2016), by far the biggest increase in any sector. Government services and retail and wholesale trade experienced more moderate growth.

Seventy percent of GDP is concentrated in only five sectors, namely trade, transport, financial, government and personal services (StatsSA, 2017) and it is fair to assume that this number will only increase in the future. South Africa's manufacturing is essentially made up of five large industrial groups, including agro-processing (24%), metals and engineering (23%), chemicals (22%), wood, paper and printing (13%) and the automotive sector (7%) (Langenhoven H, 2016). Weak GDP growth trends since 2008 further support the recommendations in the NDP that a broad programme of reform needs to be implemented, with skills development as one of its key features.

Industry 4.0

Industrial robots are machines that can be programmed to perform production-related tasks without the need of a human controller. An industrial robot is designed in such a way that it helps to move materials, parts and tools, and performs other tasks related to production and manufacturing. Industrial robots are a rescuer in situations that require high-quality production with consistent accuracy.

Manufacturing is a critical component of the South African economic policy and important in creating and ensuring jobs in the economy. The rapidly growing adoption of industrial robots in various industries has the potential to increase productivity and throughput, while

reducing labour costs, which is one of the major drivers for the growth of the industrial robotics market. The production of digital and changes in manufacturing technologies has led to the employment decline in the sector (the dti, Nov 2017).

Current status of adoption of industry 4.0 in BRICS

The world of work is changing, largely as a result of rapid advances in innovation and technology that have led countries to start using automation and robotics for production, particularly in the manufacturing sector. Figures from the International Federation of Robotics (IFR) show that sales of robots are increasing year-on-year, with a 15% increase in 2015 over the previous year (International Federation of Robotics, 2017). The speed in which the use of robots is increasing differs from country to another, and is largely dependent on whether the country is developed or emerging. Currently, each nation is working on improving its readiness for Industry 4.0 and driving quicker adoption.

Table 1: Comparison of South Africa, other BRICS nations and developed economies

	Robot Density[1]			Industry 4.0 related patents[2]	M2M Connection[3]	
	2002	2014	CAGR	2014	2014	**Global share**
Brazil	2	10	14%	19	10	4.0%
Russia	-	2	-	43	9	3.4%
India	0	2	-	35	3	1.2%
China	1	36	35%	2721	69	27.6%
South Africa	2	22	22%	10	5	2.0%
Korea	126	478	12%	476	3	1.2%
Japan	328	323	0%	1724	11	4.4%
Germany	172	282	4%	953	6	2.3%
USA	46	155	11%	3120	45	17.8%

Source: International Federation for Robotics; Ministry of Economy, Trade and Industry (Japan); WIPO; USPTO; GSMA Intelligence.

1 Robot density is defined as number of industrial robots per 10 000 employees

2 Industry 4.0 related patents have been assumed to be registered in 4 major patent categories – H04L (Transmission of Digital Information), B25J (Industrial Robotics), B29C (Shaping or Joining of Plastics) and G05B (Control and Monitoring Systems).

3 M2M Connections are defined as SIM connections that enable mobile data transmission between machines. It does not include SIMs used computing devices in consumer electronics such as smartphones, dongles, tablets, e-readers, routers or hotspots.

Table 1 shows the readiness and current status of adoption for Industry 4.0, for 2002 to 2014. The demand for industrial robots has accelerated considerably in recent years as a result of continued technological advancements in automation systems and artificial intelligence (ILO, 2016). With the expected reduction in cost arbitrage and increasing need for flexibility (e.g. mass customisation), it is important for BRICS nations to adopt advanced manufacturing technologies to remain competitive in the global market (BRICS Business Council, 2016). According to the latest World Economic Forum (WEF) Global Competitiveness Report 2017–2018, South Africa is ranked 61st globally (out of 137 countries) and third overall in Sub-Saharan Africa, behind Mauritius and Rwanda, which are ranked first and second respectively. This means that South Africa lost 14 places in the 2017/18 global competitiveness rankings, compared with its placing of 47 a year ago. The WEF report revealed that the top five most problematic factors hampering South Africa's competitiveness, particularly on doing business, include corruption, crime and theft, government instability/coup, tax rates and inefficient government bureaucracy.

South Africa trails its BRICS peers with respect to competitiveness, sitting in position four behind China (global rank: 27th – up from 28th place in 2016/17), Russia (global rank: 38th up from 43rd place in 2016/17) and India (global rank: 40th down from 39th place in 2016/17). Brazil is the lowest ranked BRICS economy, behind South Africa.

The adoption of robots in developed countries is occurring fast as those countries have high levels of industrial automation and Industry 4.0-related patent applications. Consequently, robot density in South Africa – measured as the number of industrial robots per 10 000

people employed, increased from two in 2002 to 22 in 2014 and Industry 4.0-related patents were 10 in 2014, as shown in table 1. South Africa (22) is in position two with respect to levels of industrial automation within the BRICS, behind China with 36 in 2014. South Africa is only better than India with respect to machine-to-machine connections within the BRICS, behind China (69), Brazil (10) and Russia (9). However, China has the highest growth rate (35%) per annum within the BRICS, followed by South Africa with 22%. BRICS nations, other than China, have low levels of industrial automation (robot density), Industry 4.0-related patent applications and machine-to-machine connections, as well as limited activities in robotics and additive manufacturing by companies, as shown in table 1. This is an indication of low levels of Industry 4.0 readiness. In South Africa, the public sector invests in research on additive manufacturing to support Industry 4.0.

The impact of robots and automation on skills and employment in South Africa

The manufacturing industry is a cornerstone for most economies, South Africa included. It has become increasingly important not only to produce high-quality products at affordable prices, but also to have the necessary highly trained labour force that will increase production and create much-needed jobs. Manufacturers rely on skilled people to operate advanced technology, which is a basic requirement of the sector.

Research shows that the future will be robots and humans working together, i.e. robots will complement and augment labour. Automation provides the opportunity for humans to focus on higher-skilled, higher-quality and higher-paid tasks. Meanwhile, there is ample evidence

that automation does not lead to job substitution, but rather to a reallocation of both jobs and tasks, in which robots complement and augment human labour by performing routine or dangerous tasks (IFR, 2017).

The rapidly growing adoption of industrial robots may shift skills requirements to higher skilled labour in the sectors in which automation has substituted for labour, but also may create new lower-skilled jobs in other sectors due to spillover effects. According to the BRICS White Paper on Skill Development for Industry 4.0, adoption of Industry 4.0 will result in the elimination of lower-skilled jobs through automation.

The manufacturing of robots requires high investment in hardware and software and introduces other ongoing expenses such as maintenance, which can hinder growth of the market. As a result, this will lead to the development of new forms of work, notably telework and ICT-mobile work. The focus will increasingly be placed on higher-end skills as technology will make the manufacturing environment a programmable system. There is a risk of job displacement through robotisation, which is particularly high in developing countries.

Many occupations involve a combination of tasks, and different manual and routine tasks have been mechanised for centuries. New technologies, including robots, predominantly replace labour in routine tasks (UNCTAD, 2017). A more recent study found that routine-based tasks dominate in manufacturing; as a result, some jobs will be replaced by robots and there will be development of new forms of work in the sector. The same study found that robots are not yet suitable for a range of labour-intensive industries, leaving the door

open for developing countries to enter industrialisation processes along traditional lines (UNCTAD, 2017).

South Africa has set itself the goals of eradicating poverty, reducing inequality, growing the economy by an average of 5,4% and cutting the unemployment rate to 6% by 2030. Education, training and innovation are critical to the attainment of these goals (NDP: 296-7).

Competitive rankings: Education and related indicators

The World Economic Forum's Global Competitiveness Report provides an overview of the competitiveness of 138 economies in 2016/17 and 137 in 2017/18, and is considered the most comprehensive assessment of its kind globally. It contains a detailed profile for each of the economies included in the study, as well as an extensive section of data tables with global rankings covering more than 100 indicators.

Table 2: Global ranking of indicators

	Year	Availability of latest technologies	Quality of the education system	Quality of math and science education	Availability of scientists and engineers
China	2016	81	43	50	30
	2017	81	29	50	29
South Africa	2016	44	134	138	112
	2017	45	114	128	100
Brazil	2016	85	128	129	111
	2017	78	125	131	90
India	2016	78	29	44	36
	2017	72	26	37	32
Russia	2016	83	69	52	58
	2017	84	64	51	50
Turkey	2016	62	104	107	49
	2017	57	101	104	49
Chile	2016	32	88	108	23
	2017	28	86	99	22

Source: Global Competitiveness Report 2016/17 and 2017/18

According to the Global Competitiveness data, South Africa is ranked 100 (less than 50% on average) out of 137 countries when looking at the availability of scientists and engineers in the country, an improvement on its ranking of 112 in 2016. South Africa has one engineer per 3 200 people, compared to 1:130 in China, 1:270 in Europe and 1:450 in Australia (Malan C, 2014). This means that South Africa does not have enough scientists and engineers, which could impact negatively on the country's levels of innovation and competitiveness.

The quality of mathematics and science education in South Africa is ranked 128, better than 10 countries that participated in 2017. The quality of the higher education system in South Africa is poor (ranked 114 out of 137 countries in 2017) and is second lowest within the Brazil-Russia-India-China-South Africa (BRICS) group of countries. South Africa is therefore languishing at the bottom of the competitiveness of economies in terms of its education system and the quality of mathematics and science education. If South Africa is to have any hopes of becoming competitive with other countries in BRICS, there needs to be a marked improvement in the quality of its maths and science education.

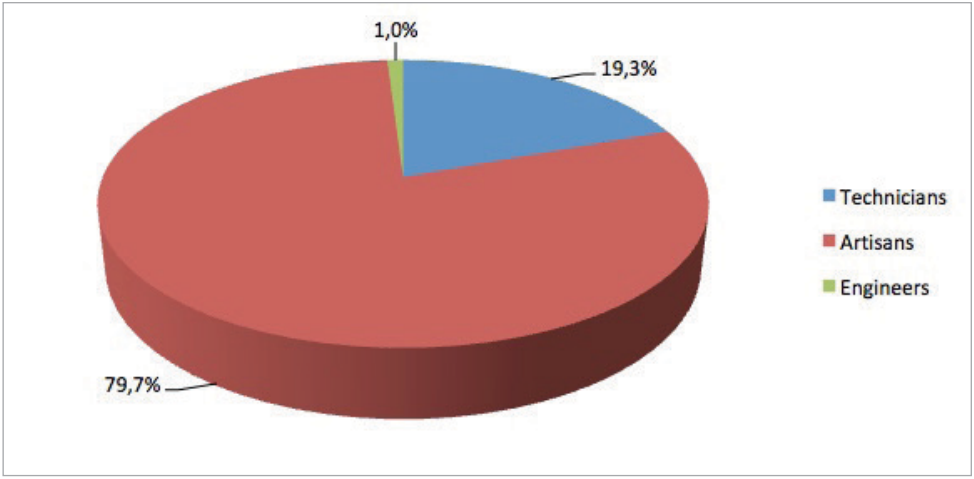
More optimistically, other indicators related to manufacturing show that South Africa has the potential to develop its industrial base. For instance, in terms of availability of the latest technology, South Africa ranked 45 out of 137 countries in 2017, which is better than the other BRICS countries, as indicated in table 2. Shortcomings in terms of the education system, however, is an indication of the inequality within the development process.

Competitiveness remains an important contributor to the broader goal of human-centric economic progress by creating the resources needed for increased well-being, including better education, health, security, and higher per capita income.

Demographic profile of artisan and technician employment in manufacturing

The overwhelming majority of the technical workforce in the manufacturing sector is represented by artisans (79,7%), followed by technicians (19,3%), while engineers and technologists constitute only 1,0%, as shown in figure 3.

Figure 3: Employment of technicians by age group ('000) (2002 and 2015)



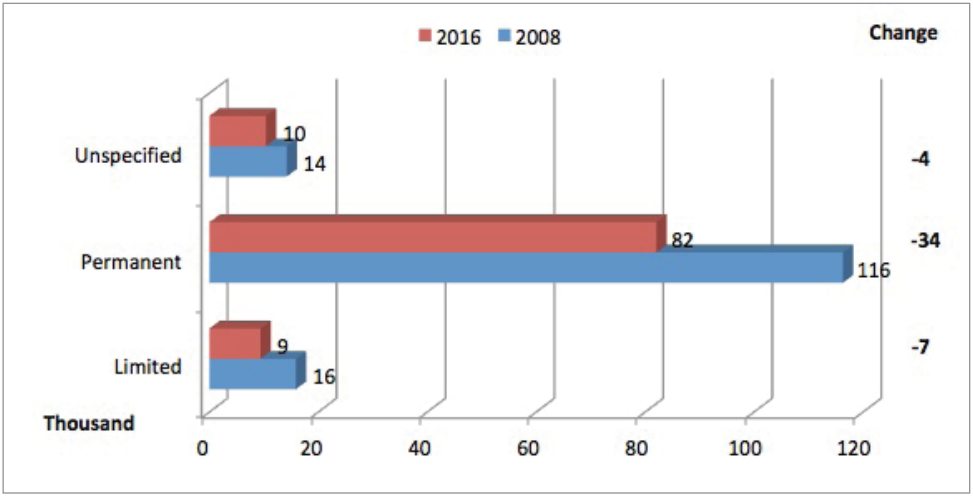
Source: Statistics SA, QLFS, 2016 and own calculations

Over the period, total manufacturing employment grew by about 0,2%, as compared to the annual growth of employment in the economy, which was 2,4%. By comparison, the compounded annual growth rate (CAGR) varied widely in technical occupations in manufacturing, ranging from -7,1% for engineers and technologists to -2,3% for technicians and -0,4% for artisans (2002 to 2016) (Annexure 1). Employment of technical workforce in manufacturing is therefore shrinking.

Without artisans, technicians and engineers, the economy cannot grow at the pace required (Sean J, 2016). South Africa has set itself the goals of eradicating poverty, reducing inequality, growing the economy by an average of 5,4% and cutting the unemployment rate to 6% by 2030. Education, training and innovation are critical to the attainment of these goals (NDP: 296-7).

Growth in the manufacturing sector as a whole depends on technical workforce. The Annual ManPower Talent Shortage Survey shows that trade skills are most needed in South Africa (Annual ManPower Talent Shortage Survey, 2016). The National Development Plan also highlighted that South Africa will require 30 000 artisans by 2030. According to the National Artisan Moderation Body (NAMB), there were 21 198 artisans who were competent in 2016/17, which means that the country is on track to meeting the target.

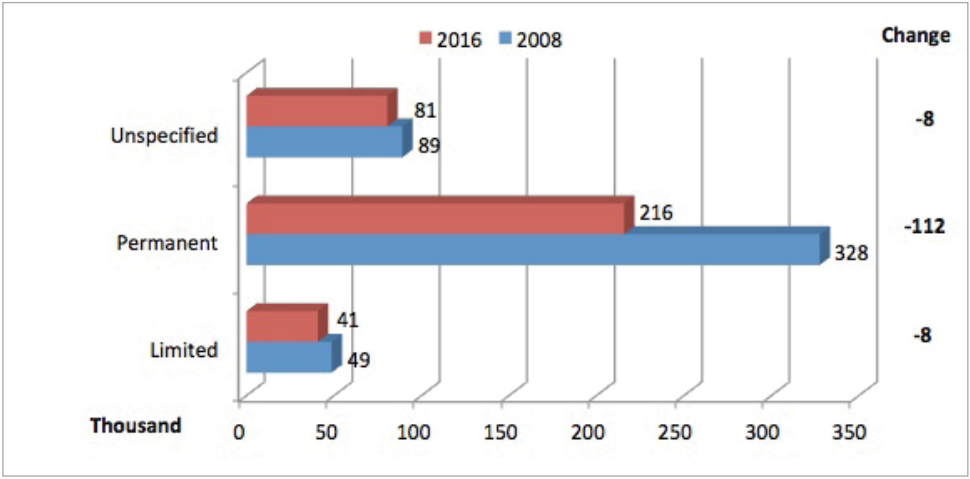
Figure 4: Year-on-year changes in nature of technician employment contract, 2008 and 2016



Source: Statistics SA, QLFS, 2016 and own calculations

The majority of technicians (82 000) in the manufacturing sector are employed on a permanent basis as compared to the 9 000 employed for a limited duration, as shown in figure 4. Limited-duration technicians declined by 6,9% per annum from 2008 to 2016, as compared to permanent technicians (-4,2%). Technicians with unspecified contracts declined by 4,1% per annum over the same period. The situation was the same for artisans, as shown in figure 5.

Figure 5: Year-on-year changes in nature of artisan employment contract, 2008 and 2016



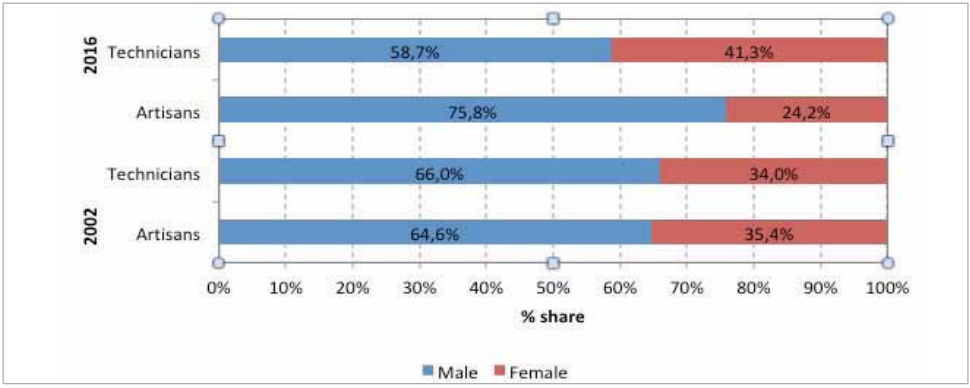
Source: Statistics SA, QLFS, 2016 and own calculations

Majority of the artisans in manufacturing sector are employed on a permanent basis (216 000), as compared to 41 000 who are employed on a limited duration, as shown in figure 5. Limited duration artisans declined by 2,2% per annum over the period 2008 to 2016, just below half of the annual growth of permanent artisans in manufacturing, which was -5,1%. The number of artisans with unspecified contracts declined by 1,2% per annum over the same period. The International Labour Organisation (ILO), in a survey of 180 countries, estimates that in 2015, stable, full-time employment represented less than one in four jobs.

In South Africa, it is estimated that between 25% and 50% of workers do not have permanent contracts. The trend is global, with about 90% of Chinese workers not having permanent contracts (Theron J, 2015). The ILO's research indicates that so-called advanced economies, such as the US and those in Europe, are experiencing the same trend, with standard employment less likely to be found.

There is no short answer to why permanent work is increasingly scarce, but the restructuring of the workplace to the benefit of the top echelons of society has eroded the base of organised labour, i.e. the permanent worker (Theron J, 2015). South Africa, however, is clearly doing better than other countries in that more artisans and technicians are employed on a permanent basis, and are more likely to receive training, which contributes to up skilling.

Figure 6: Employment of artisans and technicians by gender (%) 2002 and 2016

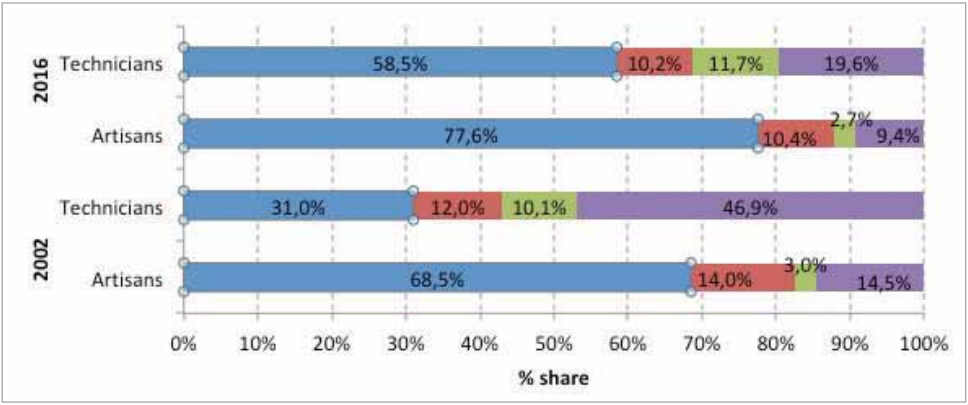


Source: Statistics SA, QLFS, 2016 and own calculations

In South Africa, women represent about 52% of the population, but only 24,2% are in craft and trade positions in the manufacturing sector, a decrease of 10% from 35,4% in 2002. The proportion of women employed as technicians increased from 34,0% in 2002 to 41,3% in 2016, a significant step towards closing the gender gap. TVET colleges are reporting an increase in female students in fitting and turning as well as electrical and motor trades. False Bay TVET College, for instance, has experienced a year-on-year average growth of 200% since 2014 in females studying for qualifications in motor trades, electrical and civil engineering (News24, 2016). And many of its top achievers in these subjects in 2015 were women. More women are graduating (20% in 2016) in engineering than men (18% in 2016) in universities of technology (DHET, 2017). In 2002 and 2016, women were far less likely than men to be working as artisans and technicians. A higher proportion of women (41,3%) are more likely to be technicians than artisans (24,2%), as shown in figure 6. According to NAMB, 23% (or 7 009) of enrolments were women, 54% of which completed their training in 2016/17.

With industries actively recruiting women for training as technicians, statistics are beginning to reflect that women are making inroads into formerly male occupations (News24, 23 August 2016). Considering the shortage of artisans in the country, the development of workers' skills, women in particular, through intensive training is a key part of the legacy that the Medupi Power Station project leaves behind. According to Eskom, the project's primary focus was to develop the skills of artisan women in South Africa; welders, pipefitters, boilermakers and riggers were a priority (OFM, 2016).

Figure 7: Artisans and technicians by population group (% share) (2002 and 2016)



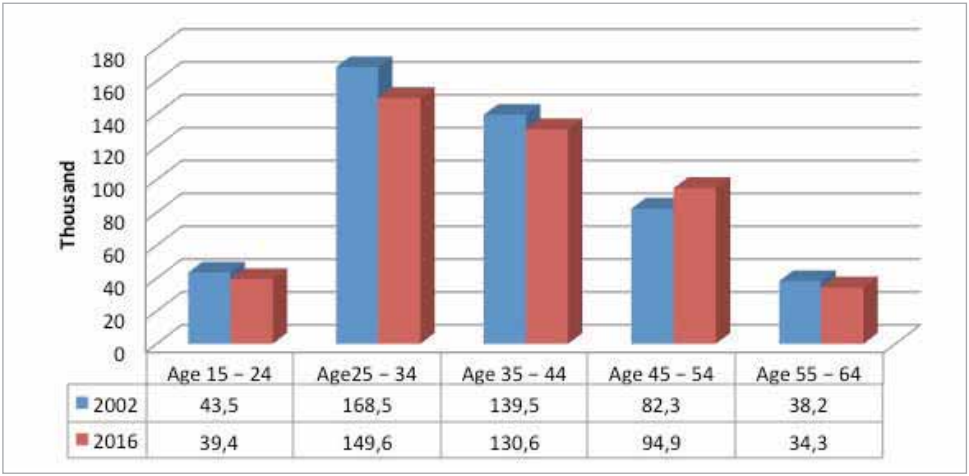
Source: Statistics SA, QLFS, 2016 and own calculations

Figure 7 shows employment of artisans and technicians by population group. Black African artisans outnumbered those from other racial categories, with about 69% of blacks working as artisans in 2002 and 78% in 2016. In 2002, about 47% of employed technicians were white, dropping to 20% in 2016. The number of black technicians increased the most, growing from 31% in 2002 to 59% in 2016. The percentage share of white artisans declined from 15% in 2002 to 9% in 2016.

The share of African artisans (albeit male) is reflective of the economically active population, contradicting the public perception that the average artisan is white and male (usually more than 50 years of age). The data shows that there has been a substantive turnaround

in the demographic profile of the employed artisan population, which closely mirrors the economically active population. The proportion of black African workers in the labour force has also increased since 2002 (StatsSA, 2016).

Figure 8: Employment of artisans by age group (thousand) (2002 and 2016)



	Age 15 – 24	Age25 – 34	Age 35 – 44	Age 45 – 54	Age 55 – 64
2002	43,5	168,5	139,5	82,3	38,2
2016	39,4	149,6	130,6	94,9	34,3

Source: Statistics SA, QLFS, 2016 and own calculations

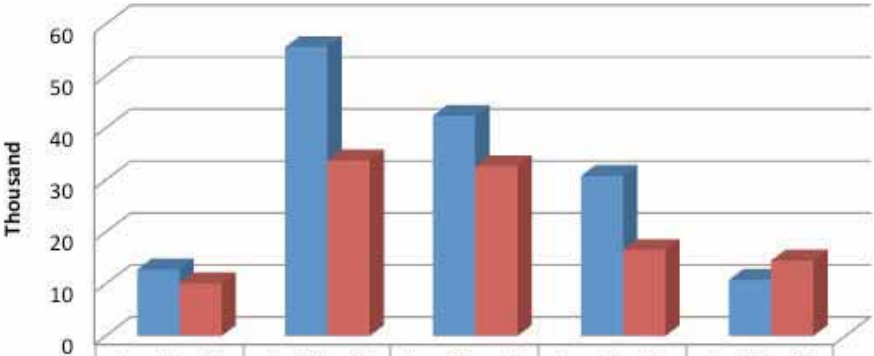
The age profile presented in figure 8 suggests that there is a balanced mix of youth and experienced artisans, with 42% in the age group 15 to 34 years, 29% between the ages of 35 and 44, and 29% aged 45 to 64. However, the decline in the number of artisans, from 168 000 to 150 000 (-0,8% per annum), in their prime productive years (25 to 34 years) is

worrying. The number of employed artisans in the age group 45 to 54 increased by 1,0% per annum over the period. There were much weaker gains in all age groups.

The relatively high share of artisans older than 35 suggests availability of experience. The relative growth in the number of artisans older than 45 years also bodes well for the sector, showing that more experienced artisans remain in the system. This may positively affect the transfer of skills from older to younger artisans and the availability of experienced mentors in manufacturing.

Artisan retention is particularly important, not only because the country is facing a critical shortage of artisans, but also because the average age of the artisan is 54 years (CDE, 2007). This means that 29% of the artisans who are currently employed will exit the labour force within the next seven to eight years, which will aggravate the current shortage of artisans and intensify the competition for talent.

Figure 9: Employment of technicians by age group (thousand) (2002 and 2016)



	Age 15 – 24	Age 25 – 34	Age 35 – 44	Age 45 – 54	Age 55 – 64
2002	12,8	55,6	42,4	30,8	10,8
2016	10,1	33,8	32,7	16,6	14,5

Source: Statistics SA, QLFS, 2016 and own calculations

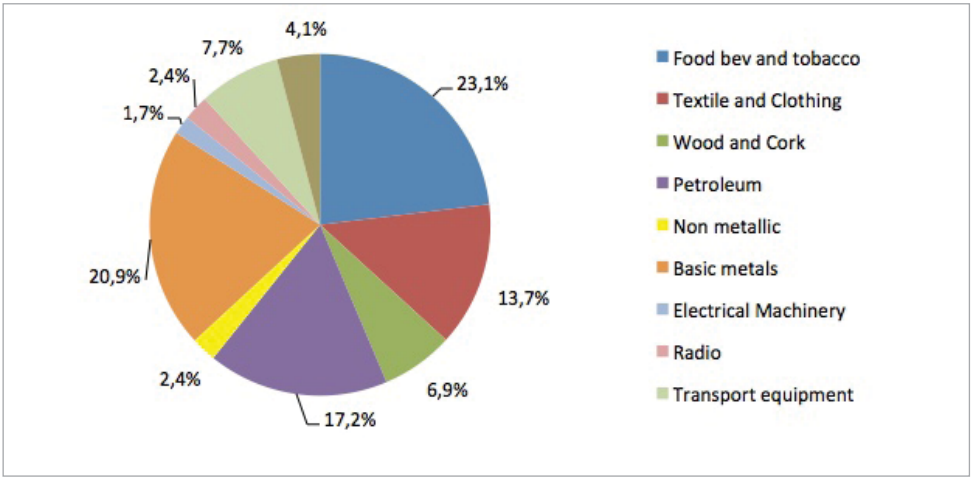
There appears to be a more balanced mix of youth and experience among technicians, compared to the age profile of artisans, with 40,8% in the age group 15 to 34 years; 30,3% in the age group 35 to 44 and 29,0% in the age group 45 to 64. However, the decline in the number of technicians in all age groups (except 55 to 64) is worrying, as shown in Figure 9. The decline in the number of entry-level technicians aged 15 to 24 suggests a slowdown of entry into the skills pipeline. The number of employed technicians in the age group 55 to 64 increased by 2,1% per annum over the period, as technicians of pensionable age exit the

system. Alternatively, they may also enter into business ventures, as research shows that owners of manufacturing enterprises generally have a technical qualification. Availability of experienced technicians older than 35 years may positively affect the transfer of skills from older to younger technicians.

Employment of artisans and technicians by sub-sector

Manufacturing covers a broad range of sub-sectors, each with its own set of unique challenges and opportunities.

Figure 10: Percentage share of technician employment by manufacturing sub-sector, 2016

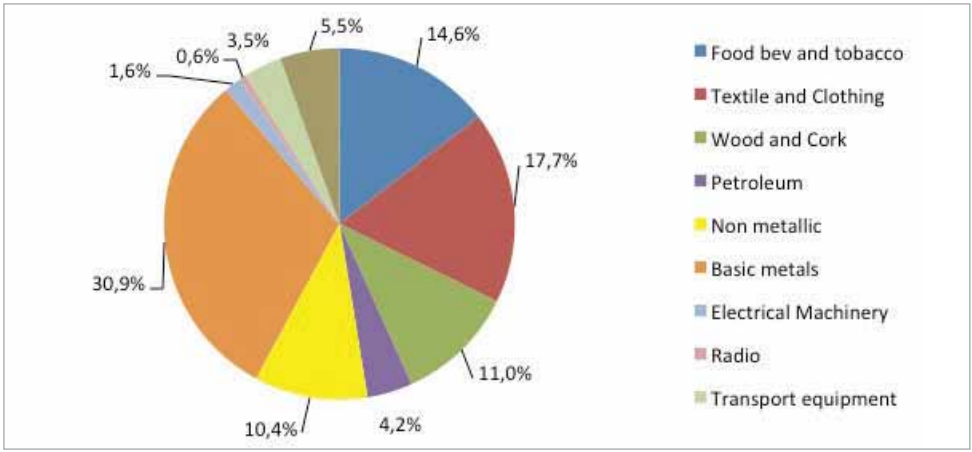


Source:Statistics SA, QLFS, 2016 and own calculations

The food, beverages and tobacco sector remains the largest employer of technicians in the manufacturing industry, followed by basic metals and petroleum.

The biggest challenge facing tobacco companies is the increasingly stringent regulations regarding the consumption, sale and advertising of tobacco products, while textiles, clothing and leather are dealing with strong competition from abroad, particularly from South-East Asia (Haroon B, 2017). Crucially, these challenges differ in their effect on GDP and the employment of artisans and technicians in various manufacturing sub-sectors, as shown in figure 10 and 11.

Figure 11: Percentage share of artisan employment by manufacturing sub- sector, 2016



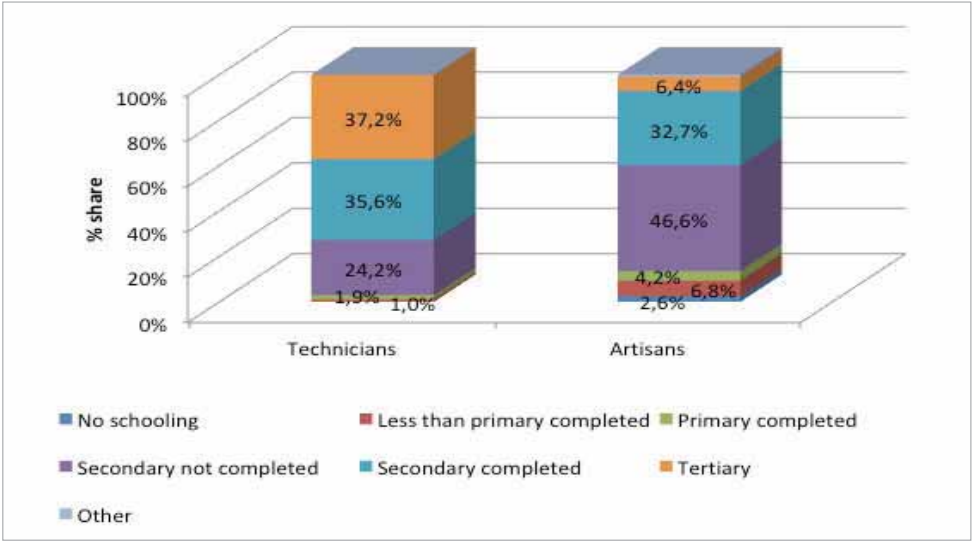
Source: Statistics SA, QLFS, 2016 and own calculations

Basic metals remains the largest employer of artisans in the manufacturing industry, followed by clothing and textiles, and food, beverages and tobacco..

Employment of technicians and artisans by education and skills level

A key constraint to economic growth is the mismatch between the demand and supply of skills. The extent to which workers are qualified in line with the requirements of the job is a key indicator of the skills mismatch. Historically, most artisans had less than grade 12 (at least grade 9) and a post-school qualification, NTC 1-3, attained at a TVET college. However, the oversupply of grade 12s means that recently trained artisans have a minimum of grade 12 plus a TVET engineering qualification.

Figure 12: Share of employed artisans and technicians by education, (Q3, 2016)



Source: Statistics SA, QLFS, 2016 and own calculations

Note: StatsSA does not include the trade test qualification in its survey, which is the only way to determine if an artisan is qualified or not. 'Tertiary' includes post-matric certificate and diploma, post-higher diploma, bachelor's degree, post-graduate diploma, honours degree and higher degree. Values for 'Other' are not shown on the graph.

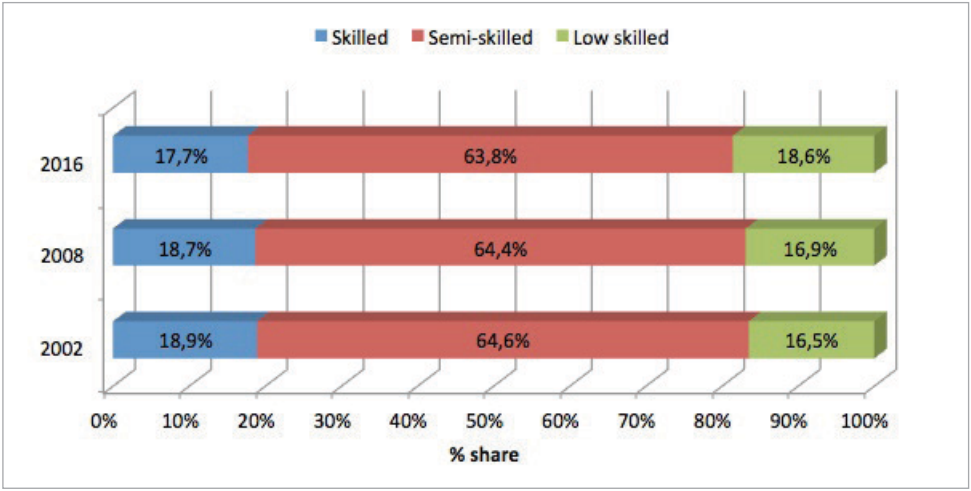
Figure 12 shows that the majority of artisans are unqualified, with 46,6% having less than grade 12 (with no additional qualification) and 32,7% having grade 12. Of concern is the

fact that only 6,4% had a tertiary qualification. The latter may be a result of the more recent phenomenon of grade 12 being the entry requirement. While those who are unqualified probably have significant experience, it is clear that not enough effort is being made to provide a form of certification through Recognition of Prior Learning (RPL).

The share of employed persons with tertiary qualifications (graduates and other tertiary) was higher among technicians than artisans.

In terms of employed technicians, there is a dissonance between the baseline qualification required (National Diploma from a University of Technology) and the actual qualifications attained. This is worrying. As a result, only 37,2% of technicians in the manufacturing sector had tertiary qualifications, implying that the majority did not have the right qualifications. The findings suggest that 62,7% of employed technicians have either a Grade 12 (35,6%) or less (27,1%). These results echo similar findings for the period 1996 to 2005 (Du Toit and Roodt, 2008). The authors argued that the lack of experiential training in the workplace, as required by the National Diploma qualification, may be a contributory factor to the degree of under-qualification. According to the CEO of the Artisan Training Institute (ATI), artisan training has seen a sharp decline over the last 24 months as a result of contractions in the mining, engineering and agricultural sectors due to companies experiencing cash flow and budget constraints (Fin24, March 2016).

Figure 13: Share of employed persons by occupation in manufacturing, 2002 to 2016



Source: Statistics SA, QLFS, 2016 and own calculations

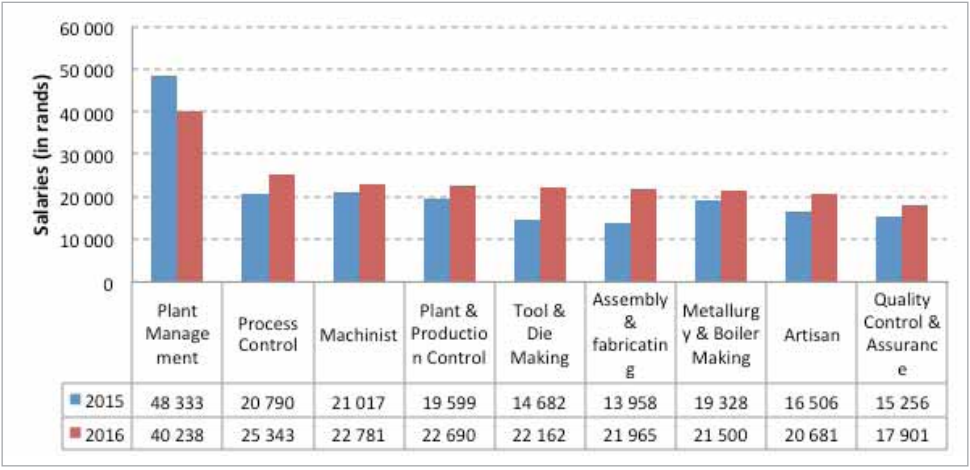
The share of low skilled employment was stable over the period, while that of skilled employment declined by 1,2 percentage points to 17,7% in 2016, and semi-skilled by 0,8 percentage points to 63,8% in 2016, as shown in figure 13. The majority of manufacturing employment are semi-skilled occupations (63,8%), followed by low skilled (18,6%) and skilled (17,7%).

The manufacturing sector faces a low growth environment, characterised by a poor skills profile and weak competition for goods and services (StatsSA, 2015).

Salaries and wages of artisans and engineers in South Africa

This section analyses trends in income (salaries and wages) in the manufacturing sector.

Figure 14: Manufacturing and assembly salaries in South Africa



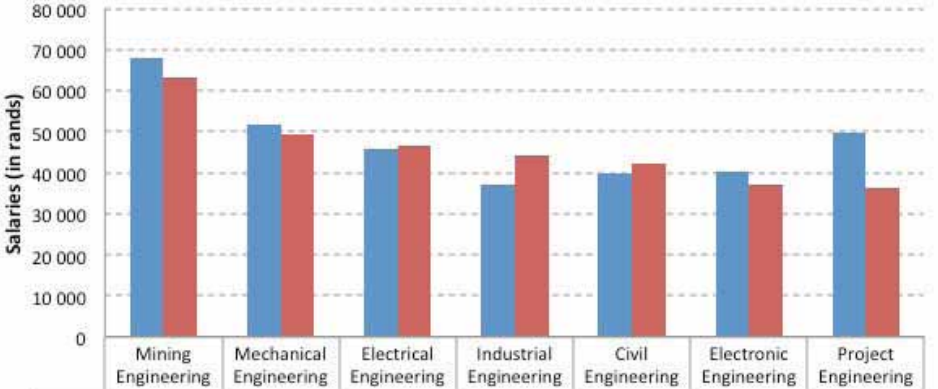
	Plant Management	Process Control	Machinist	Plant & Production Control	Tool & Die Making	Assembly & fabricating	Metallurgy & Boiler Making	Artisan	Quality Control & Assurance
2015	48 333	20 790	21 017	19 599	14 682	13 958	19 328	16 506	15 256
2016	40 238	25 343	22 781	22 690	22 162	21 965	21 500	20 681	17 901

Source: Career Junction's salary index 2016

Figure 14 shows the average manufacturing and assembly salaries in South Africa, as published by Career Junction. Plant managers earn the most in the manufacturing and assembly fields, followed by process controllers and machinists. Average salaries for artisans are far better than in 2015, possibly due supply and demand. Salaries may also be determined by qualifications and work experience in a particular field.

According to Sean Jones, CEO of the Artisan Training Institute (ATI), artisans are almost guaranteed formal employment and, upon graduation, can earn between R20 000 and R25 000 a month, more than most university graduates will earn (Sean J, 2016).

Figure 15: Engineering salaries in South Africa



	Mining Engineering	Mechanical Engineering	Electrical Engineering	Industrial Engineering	Civil Engineering	Electronic Engineering	Project Engineering
2015	68 125	51 606	45 697	36 968	39 918	40 056	49 890
2016	63 095	49 439	46 446	44 024	42 153	37 007	36 105

Source: Career Junction's salary index 2016

Figure 15 shows the average salaries of engineers in South Africa as published by Career Junction. Engineers in the mining sector earn the most, followed by mechanical engineers. Data on average salaries, after tax, within the major engineering fields – mechanical, electrical, chemical and civil – show that engineers in South Africa ultimately earn more than

their counterparts in the traditional South African immigration meccas: Australia (Auks), the United Kingdom (aUKs), and the United States (aUkS) – or AUKS countries (News24, 22 February 2016).

Project engineers earn less than those employed in other engineering fields, with the average salary dropping from R49 890.00 in 2015 to R36 105.00 in 2016. Pay-scale trends show that South Africa and the US are the top two countries in terms of earning potential for engineers, with South Africa marginally beating the US. Australia comes in a distant third and the UK is by far the worst country for engineers to generate wealth (News24, 22 February 2016).

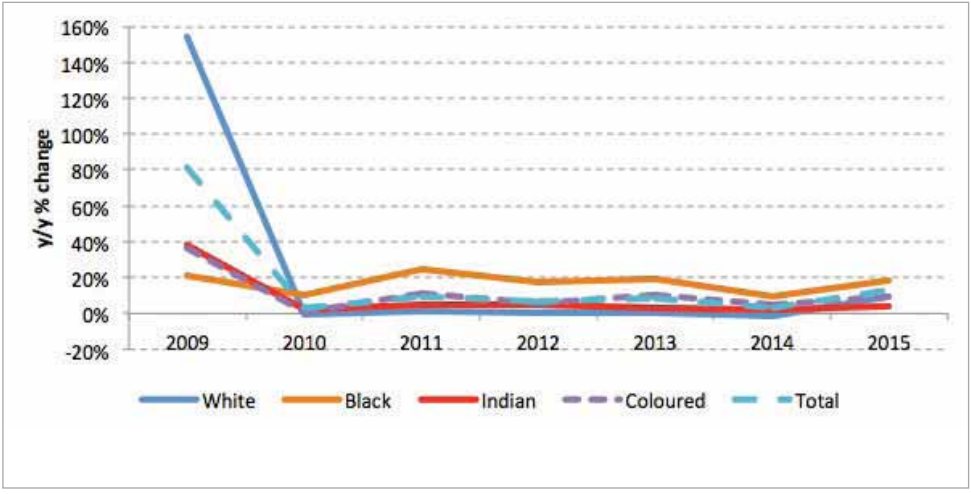
South Africa and the US have high relative engineering salaries because the demand for engineers far outweighs the supply, as indicated by their unemployment rates of less than 1% and 3% respectively (News24, 2016). Meanwhile, the unemployment rate for engineers in Australia is 5,5% and the UK 8,6%, explaining why the earning potential for engineers in those countries is so low – employers aren't interested in hiring any new engineers (News24, 2016). The unemployment figure for South African engineers might seem contradictory in a country that has one of the highest national unemployment rates in the world at 27%, but what tends to be forgotten is that mostly it is the unskilled labour force that is unable to find work.

Even though engineers in South Africa earn much more than their counterparts, more than 300 qualified engineers leave the country every year (News24, Salary offerings on the Career Junction website, 2016).

Registration of professional engineering technicians with ECSA

Persons applying for registration as professionals must have demonstrated their competence, as measured against standards determined by the Engineering Council of South Africa (ECSA) for the relevant category of registration, and have passed any additional examinations determined by the council.

Figure 16: Registration of professional engineering technicians with ECSA, 2009 − 2015



Source: ECSA, 2016

The number of registered engineering professionals stood at 27 342 in the 2014/15 financial year and 28 307 in 2015/16, showing an incremental trajectory of 3,5% in the database. The percentage share of professional engineering technicians was 18,4% for 2015/16. This continued growth trajectory can be a result of many factors, including awareness campaigns on the benefits of registration presented by ECSA to industry and higher education institutions (ECSA, 2016).

Figure 16 provides an analysis of the annual growth trends of registered technician professionals. Black Africans represent the overwhelming share registered in 2015/16, with a 46,7% growth in registration, the fastest compared to other population groups. In 2009 whites represented the overwhelming share of professional engineering technicians, but constituted 44,1% of registrations in 2015/16. Indian registrations showed the slowest growth in 2015.

Supply of artisans and technicians

The supply of artisans and technicians in this paper will be analysed using the following data sources:

- Artisans trade test results – number of people enrolled and those who passed the artisan trade test as released by Indlela, based on SETA data; and
- HEMIS data – this dataset has the number of engineering (including technician) enrolments and graduations from universities of technology. Engineering technicians generally hold a National Diploma (NDip) from a university of technology.

SETAs have been established to manage the skills development needs in South Africa. Each SETA coordinates skills development in its particular sector. For the purposes of planning and managing the delivery of training, the economy has been divided into 23 sectors, each of which has its own SETA.

Table 3: Artisan enrolments and completion by manufacturing SETAs, 2016 − 2017

Manufacturing SETAs	Actual Enrolled Learners			Actual Certificated Learners		
	2015/16	2016/17	y/y growth rate	2015/16	2016/17	y/y growth rate
CHIETA	3 359	4 263	27%	743	936	26%
FOODBEV	45	178	296%	0	13	-
FP & M	454	419	-8%	101	124	23%
MERSETA	8 121	8 038	-1%	8 352	9 661	16%
Total Manufacturing	11 979	12 898	8%	9 196	10 734	**17%**

Source: DHET, 2017

Table 3 shows the number of enrolled and certificated artisan learners in manufacturing SETAs, i.e. Chieta, Merseta, Food Bev and FP&M) for the 2015/16 and 2016/17 financial years. The number of artisan enrolments in manufacturing SETAs stood at 12 898 in 2016/17, up from 11 979 in the previous year. The number of artisans who passed the trade test in manufacturing SETAs also increased by 17% over the same period. The actual certificated

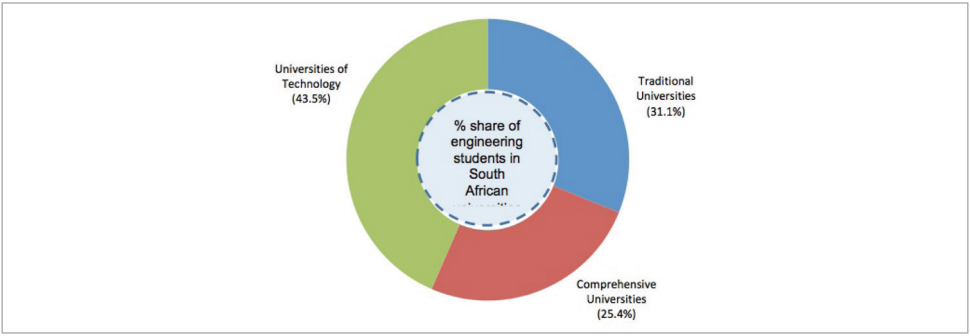
artisan learners at merSETA increased by 16%, while Chieta rose 26%. This is in support of the National Skills Development Strategy (NSDS), which highlights the need to increase the numbers of artisans in South Africa. For more details, see Annexure 2.

Enrolment and graduation of engineers, technologists and technicians

The ratio of enrolment to graduation of engineering students provides insight into the profession's skills pipeline. There are three types of universities in South Africa: traditional, comprehensive and technological. The country's 25 public higher education institutions offer a range of study and research options for local and international students.

Figure 17 shows that the overwhelming majority of students are at universities of technology (43,5%), followed by traditional (31,1%) and comprehensive universities (25,4%).

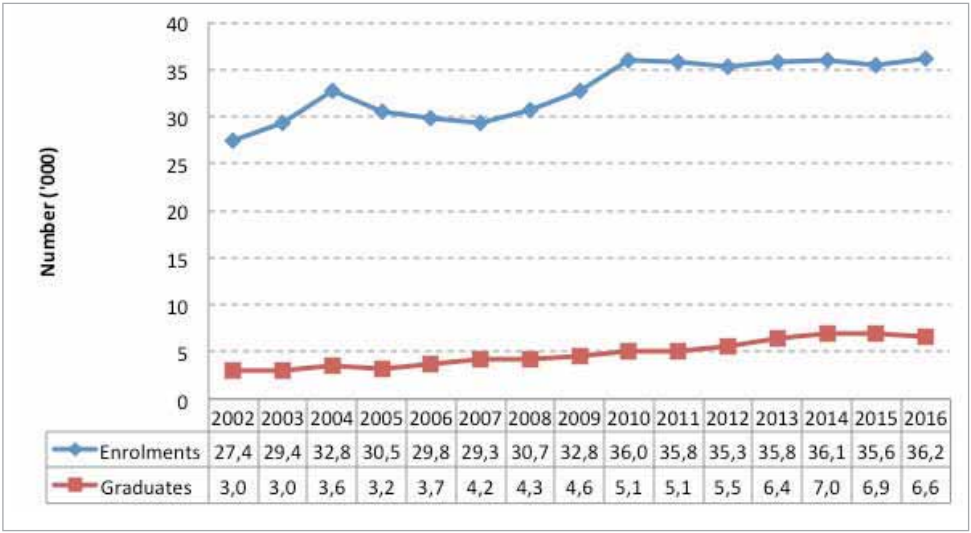
Figure 17: Engineering students by types of universities in South Africa, 2016



Source: DHET, 2016

The number of university of technology enrolments improved incrementally over the period after a dip from 2005 to 2007. Figure 18 shows that while there was steady growth in university enrolments in 2016, graduation rates declined by 4% from a low base. There is a big gap between the number of enrolments and the number of graduates.

Figure 18: Trends in universities of technology engineering enrolments and graduates (2002 – 2016)



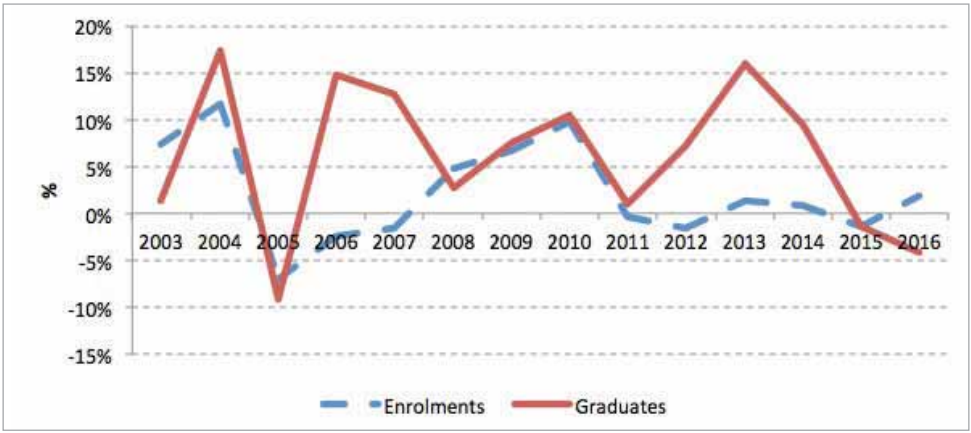
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Enrolments	27,4	29,4	32,8	30,5	29,8	29,3	30,7	32,8	36,0	35,8	35,3	35,8	36,1	35,6	36,2
Graduates	3,0	3,0	3,6	3,2	3,7	4,2	4,3	4,6	5,1	5,1	5,5	6,4	7,0	6,9	6,6

Source: DHET, 2016

There is a positive relationship between enrolments and graduates at universities of technology. Figure 19 suggests that in 2005, the number of engineering enrolments at these

institutions decreased by almost 8% and the number of graduates by 9%. Despite some significant fluctuations over the period, the ratio of enrolments to graduates was almost 1:1 between 2008 and 2011. The number of graduates began to far outweigh the number of enrolments, starting from 2012 to 2014.

Figure 19: Annual growth in the universities of technology engineering enrolments and graduates (2003 – 2016)



Source: DHET, 2016

South Africa began restructuring its higher education system in 2003 to widen access to tertiary education. Smaller universities and technikons (polytechnics) were incorporated into larger institutions to form comprehensive universities.

A comparative analysis suggests there may have been a substitution effect (crossover of students from one kind of institution to the other) at play between the comprehensive, traditional and technology universities in 2005. In 2006, however, the number of graduates at universities of technology increased by 14,8%, but slowly decreased to align with enrolments, and then grew at 10% per year until 2011. In 2016, graduates at these universities declined by 4%, while enrolments increased 2%, as depicted in figure 19.

Table 4: Gender distribution of engineering enrolments and graduates at universities of technology (2016)

	Enrolments	Graduates	% share of graduates
Male	26 303 (73%)	4 618 (70%)	18%
Female	9 903 (27%)	2 000 (30%)	20%
Total	36 206 (100%)	6 618 (100%)	18%

Source: DHET, 2016

According to the DHET-HEMIS data, engineering is one of the areas with the greatest gender imbalance in the universities of technology, with only 27% of students being women. Engineering enrolments are still dominated by men (73%), as depicted in table 4. Government statistics (HEMIS) show that in 2016 the percentage of women engineering students who graduated (20%) from universities of technology was higher than that of men (18%). According to the CEO of the Artisan Training Institute (ATI), more women are graduating as electricians, fitters and turners, and measurement, control and instrumentation technicians (Fin24, March 2016).

Conclusion

Manufacturing is a critical component of South African economic policy and in creating and ensuring that there are jobs in the economy. It is a driver of tertiary education. There is a continuous decline in quality and a misalignment of qualifications for artisans and technicians in the manufacturing industry. A shortage of technical skills is one of the key problems undermining the competitiveness of the South African manufacturing sector. Competitiveness remains an important contributor to the broader goal of human-centric economic progress. In South Africa, the public sector invests in research on additive manufacturing to support Industry 4.0, but still has low levels of Industry 4.0 readiness. The adoption of industrial robots has the potential to increase the productivity and throughput and reduce labour costs, which is one of the major drivers for the growth of the industrial robotics market. The low throughput and pass rates for qualifications are also an issue, which has implications for the manufacturing industry and continued growth in the economy.

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Annexures

Annexure 1

Comparison of employment trends in artisans, technicians and manufacturing in South Africa (2002 to 2016)

Year	Artisans and technicians employment in manufacturing				Total manufacturing employment '000
	Technicians '000	Y/Y % change	Artisans '000	Y/Y % change	
2002	153		481		1647
2003	141	-7.9%	453	-5.8%	1560
2004	120	-14.6%	464	2.4%	1724
2005	110	-8.1%	545	17.5%	1742
2006	120	8.4%	547	0.4%	1757
2007	109	-9.1%	525	-4.0%	1776
2008	158	45.1%	546	4.0%	1917
2009	168	6.5%	458	-16.1%	1771
2010	163	-2.9%	445	-2.8%	1713
2011	135	-17.6%	471	5.8%	1737
2012	143	5.9%	430	-8.7%	1727
2013	166	16.3%	404	-6.1%	1667
2014	145	-12.5%	441	9.2%	1741
2015	137	-5.4%	475	7.7%	1774
2016	110	-19.7%	455	-4.2%	1683
CAGR	-2.3%		-0.4%		0.2%

Annexure 2

Registered and competent artisan trade test learners, 2015/16 – 2016/17

IPAP Clusters	2015/16		2016/17		y/y growth rates	
	Registered	Competent	Registered	Competent	Registered	Competent
Plastics, pharmaceuticals and chemicals	3 372	743	4 263	936	26%	26%
Clothing, textiles, footwear and leather	459	101	419	124	-9%	23%
Green and energy-saving industries	1 378	470	1 287	697	-7%	48%
Agro-processing	45	0	178	13	296%	-
Tourism, arts and culture, hospitality, sports	514	0	683	0	33%	-
Metal fabrication, capital and transport equipment	8 130	8 352	8 038	9 661	-1%	16%
Business processing services	1 127	550	1 416	1 247	26%	127%
Non-SETA candidates (INDLELA)	5 734	2 952	7 311	3 224	28%	9%
Not in IPAP	7 881	2 946	7 222	5 296	-8%	80%
Total	28 640	16 114	30 817	21 198	8%	32%

Source: DHET, 2017

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