Assessing the readiness of South Africa for Industry 4.0 – analysis of government policy, skills and education.

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Abstract

The Fourth Industrial Revolution (Industry 4.0) is imminent in the South African economy. Industry 4.0 is disruptive and challenges the status quo. This paper investigates the preparedness of South Africa for Industry 4.0 implementation. Government policies and initiatives on innovation and manufacturing are reviewed and presented to determine their position relative to Industry 4.0. Key statistics on education, skills and employment are presented and analysed to assess how well prepared the education system is to supply skills required in Industry 4.0. Based on the analysis and reviews of policy and key data recommendations are presented which highlight important actions to ensure optimal Industry 4.0 implementation.

Keywords
Industry 4.0, Policy, Education, Skills, Employment

1. Introduction

Industry 4.0 is defined as the convergence of cutting edge industrial, communication and information technologies to build synergistic manufacturing systems consisting of the Internet of Things (IoT), Cyber Physical Systems (CPS) and Smart Factories (Hermann, et al., 2016). As a result, this creates opportunities for swift and optimised decision making processes in manufacturing based on big data (Kang, et al., 2016). Industry 4.0 has direct implications on value creation, business models, work organisation and other supportive downstream processes (Kagermann, et al., 2013).

Research shows that Industry 4.0 will have major social and economic impact and will redefine the industrial workplace and skills required. New skills will be required and jobs will change or in some instances certain jobs will be obliterated. The net number of jobs has been shown to increase however the jobs will require different skill sets. Industry 4.0 is set to increase the need of new skills in fields such as information & communication technologies and data science (Lorenz, et al., 2015).

It follows that adopting an Industry 4.0 manufacturing approach requires deliberate actions at government level in preparing the workforce for the changing requirements as well as managing its possible impacts to yield an optimal result. Against this backdrop, this paper seeks to assess the readiness of South Africa for Industry 4.0 in terms of skills, government policies and education.

2. Literature Review

2.1 Industry 4.0

The term Industry 4.0 -4th Industrial Revolution- is used to describe the evolution of automated & computer controlled manufacturing facility (Industry 3.0) into a more advanced facility that gathers and analyses data to make intelligent decisions autonomously. Industry 4.0 is characteristic of decentralised production unlike centralised production in the earlier revolutions .The preceding industrial revolutions Industry 1.0 and Industry 2.0 were marked by elementary industrialisation which relied on steam powered machines and the advent of mass production enabled by hard automation respectively (Bunse, et al., 2014).

Figure 1 below summarises the industrial revolutions from past to present.

Figure 1: Summary of industrial revolutions from Industry 1.0 - Industry 4.0 (Bunse, et al., 2014)

A general consensus holds amongst researchers that industrial revolutions require development time (Qin, et al., 2016). Industry 4.0 covers four aspects which are considered to be manufacturing visions:

- Factory: the future factory will consist of intelligently networked processes and manufacturing resources (machines, robots, sensors etc.) and information exchange to yield autonomous factories. This kind of factory is capable of managing production and predictive maintenance. Processes such as product development, production planning will be controlled by decentralised systems interpedently. This future factory is called a Smart Factory (Lucke , et al., 2008)
- Business: As businesses will become interlinked in a massive communication network there will be exchange of data amongst different players i.e. companies, suppliers, factories, customers. This configuration points to an integrated business network, self-organised and capable of transmitting data in real-time (Kagermann, et al., 2013).

- Products: Industry 4.0 features smart products which are embedded with sensors and processors which transmit data back to manufacturing systems permitting a better understanding of product performance (Abramovici & Stark, 2013).
- Customers: In Industry 4.0 customers will design products to their preferences thus enabling mass-customisation of products (Schlechtendahl, et al., 2014).

Apart from the four aspects above, researchers and companies continue to work on other fields related to these aspects (Schalaepfer & Koch, 2015; Qin, et al., 2016).

2.2 Industry 4.0 Effects on Industrial Workforce

According to research conducted by the Boston Consulting Group, the industrial workplace will change in at least ten ways which have varying degrees of impact on the workplace and the extent to which new skills will be necessary to handle new tasks (Lorenz, et al., 2015).

Ten Use Cases were selected to describe the effects of Industry 4.0 in the industrial working environment (Lorenz, et al., 2015):

- Big data driven quality control – algorithms use big data to pick up quality issues and reduce defects.
- Robot-assisted production – robots perform repetitive operations such as assembly.
- Self-driving logistics vehicles – automated factory floor transport systems.
- Production line simulation – use of software to simulate and optimise manufacturing operations.
- Smart supply network – integrated entire supply chains that can be monitored.
- Predictive maintenance – remote condition monitoring of equipment to predict and prevent breakdowns.
- Machine as a service – instead of selling machines original equipment suppliers sell a service including maintenance.
- Self-organising production – integrated machines automatically manage and optimise output.
- Additive manufacturing of complex parts – 3D printing enables the manufacturing of complex parts in a single step, assembly becomes obsolete.
- Augmented work, maintenance and service – use of augmented reality to improve process efficiency work, remote assistance and operating guidance.

Based on the use cases above Industry 4.0 will result in replacement of human labour in physical and repetitive tasks as assistance systems take charge of those. This results in a positive qualitative effect on the workforce. It is projected that jobs which require competency in hard skills (in programming, data analytics etc.) to manage the automated systems and soft skills will be more important in Industry 4.0 setting (Lorenz, et al., 2015). Essentially, this a shift in the industrial employment landscape which calls for changes in government policy, skills development and education.

2.3 Background to the South African context

South Africa is grappling with high unemployment rate of 26.7% according to the labour force survey report for the first quarter of 2018. It is one of the highest unemployment rates in the world. The expanded definition of unemployment which includes non-searching (discouraged) unemployed labour sits at 36.7%. That is about 2.5 million discouraged job-seekers. Between Q4 2016 and Q4 2017 this number grew by 10.7% (StatsSA, 2018).Clearly these numbers narrate a case of a country with growing inequality as a direct result of high unemployment rate as one of the contributing factors. South Africa's Gini Coefficient is 0.68 based on per capita income. This puts South Africa on the map of one of the most unequal countries in the world (Stats SA, 2017).

This paper reviews government policies in the spheres of manufacturing, technology & innovation in light of the direct implications of Industry 4.0 socially and economically. Manufacturing creates 11.08% of total employment in the economy (StatsSA, 2018). It is therefore critical to study government policies to determine their direction relative to Industry 4.0. This is against the fact that developed countries such as USA and Germany have policies which feed directly into Industry 4.0 initiatives. It is noted that these countries treat advancement in technology as critical pillars of their economies. Research is prompted through government initiatives to understand the socio-economic impact of technology. A good example is a report released by U.S Government in 2016 entitled *Artificial Intelligence, Automation and the Economy* (USA Governement, 2016). The report is forward-looking and expresses in-depth cognisance of the impacts of advancements such as Industry 4.0 bring to society and the economy. The goal of such research initiatives is to outline policy responses to such inevitable changes.

In 2006 the German Government put in place a strategic framework called the High-Tech Strategy to drive innovation and technology. In 2012 the German Government rolled out High-Tech Strategy 2020 Action Plan which identifies Industry 4.0 as one of the critical projects in consolidating Germany's position as a technological leader in mechanical engineering. The action plan aims to advance digitalisation of traditional industry and expansion into Smart Service and Green IT sectors (Bunse, et al., 2014).

The South African Government has policies for industry and manufacturing to address economic challenges faced and position the economy for competitiveness and growth. These policies will be analysed later on in this paper to determine their positioning relative to Industry 4.0.

2.3.1 Education, skills and employment in South Africa

It is critical to understand the South African education system as it's the primary source of skills. This section describes the structure of the South African education system and some key high level numbers and performance statistics.

Education structure

The government has two departments which administer formal education and training in South Africa. The Department of Basic Education (DBE) is responsible for primary education from Grade R to Grade 12 (Department of Basic Education, 2018). Post-school education is administered by the Department of Higher Education and Training (DHET). Under its jurisdiction lies universities, colleges, and vocational training institutions. Vocational institutions impart Technical and Vocational and Education and Training (TVET) (Department of Higher Education and Training, 2018).

Education attainment in South Africa

According to United Nations Educational, Scientific and Cultural Organisation (UNESCO) education attainment refers to the highest education level that an individual has obtained (UNESCO, 2018). It is quite distinct from the highest level of education that an individual is currently attending. As such it is a good measure of how well the education system is supplying the required education and skills to the labour market.

Figure 2 below takes a look at this important statistic for South individuals between the ages of 25-64. StatsSA (2016) asserts that South African labour force is composed largely of this age group. It is therefore critical to understand how well educated and skilled the labour force is.

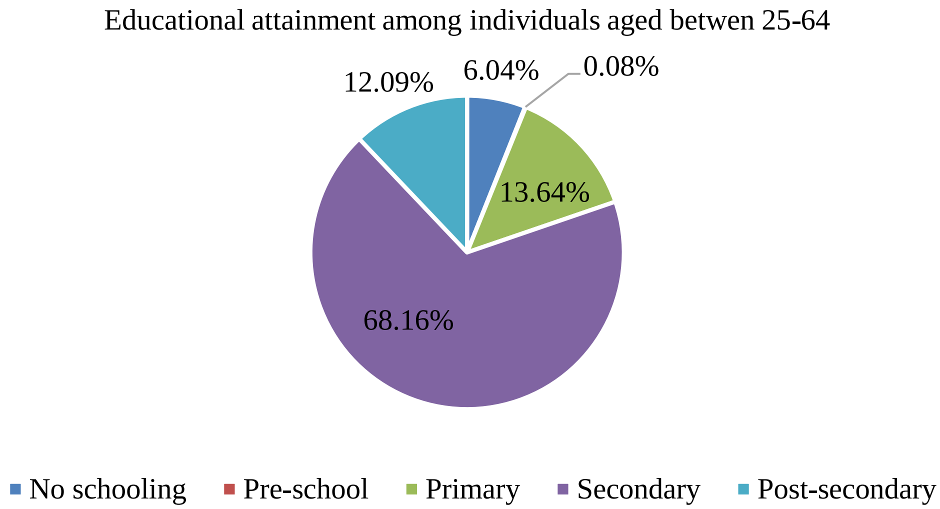

Figure 2: Educational attainment among individuals aged between 25-64 (StatsSA, 2016)

As depicted in Figure 2, the majority of South Africans between 25-64 years old (68%) have obtained secondary education as the highest level of education. Only 12% of the main labour force have obtained post-secondary education i.e. university degrees, diplomas, technical and vocational training.

In the Industry 4.0 scenario more skilled labour will be required and this flags a potential short fall of skills in general.

3. Framework for preparing for the changes

In order for South Africa to prepare for Industry 4.0, a strategic plan needs to be put in place. In Figure 3 below we propose a strategic framework with three major inputs.

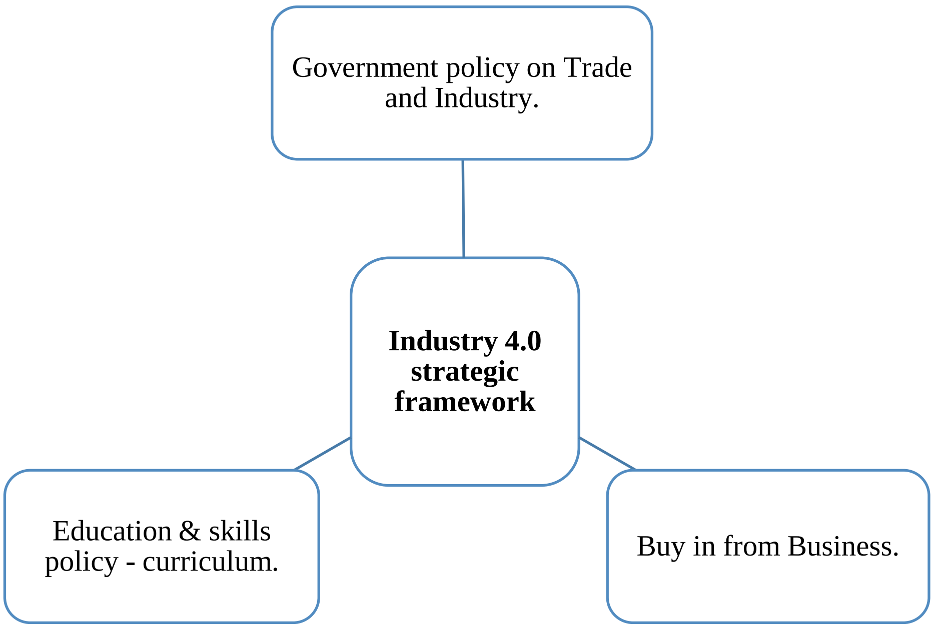

Figure 3 : Proposed inputs to an Industry 4.0 strategic framework.

In this paper we focus on reviewing the readiness of South Africa from an education and skills and government policy stand point. Buy in from the business fraternity is critical for industry 4.0 to yield optimal results. However, the business environment is mostly driven by government policies and hence we take a particular focus on that.

4. Research method

The research methodology entailed a desktop analysis of government policies on industry, science and innovation. Policies were analysed to determine if they address the Industry 4.0 agenda. Government department documents were retrieved from their official websites. Several government initiatives and programs focusing on technology and innovation were reviewed to determine any possible links to Industry 4.0.

Several data sets and periodical reports were retrieved from StatsSA which focus on education, employment and skills development. Data were summarised using descriptive statistics for analysis.

5. Data collection and Results

5.1. Policy and Government Initiative Review

Table 1: Government policies and initiatives on technology, innovation and manufacturing.

Government Policy/Initiative	Duties/Objectives	Comments
National Advisory Council on Innovation (NACI)	• Advises Ministry of Science and Technology on science and tech policy, innovation, international scientific liaison and stimulates National System of Innovation. • Develops National Advanced Manufacturing Technology Strategy (AMTS).	An initiative linked to two government departments – Science and Technology & Trade and Industry. Established based on the National Advisory Council on Innovation (NACI) Act- (Act No. 55 of 1997).A 2017 report by NACI shows awareness to the imminence of Industry 4.0.However, NACI is aware that there is no policy in place yet for Industry 4.0 as Department of Trade & Industry is yet to work on it (National Advisory Council on Innovation , 2017).
Advanced Manufacturing Technology Strategy (AMTS)	• Stimulating tech advancement in industry. • Building a conducive environment for innovation. • Identifying priority sectors which support job creation and equity. • Improving flow of tech resources to industry through knowledge networks to facilitate innovation.	AMTS is a 2002 policy which focuses on establishing innovation centres and projects e.g. ICT in Manufacturing Innovation Network, Automotive Industry Development Centre. The initiatives proposed are devoid of Industry 4.0 concept and focus.
Research and Development Tax Incentive - Department of Science and Tech	• Offered in terms Income Tax Act to promote R&D in the country • Aims to boost competitiveness and growth through promoting innovation • Ensure delivery of 150% deduction on taxable income to companies operating in scientific or technological R&D spaces.	Major government support for private sector R&D. Available to all businesses in all industry sectors. Opportunity for innovative entrepreneurial ventures in the Industry 4.0 space to grow.

Technology Innovation Agency	• Promote the development and exploitation of innovations, improvements and inventions. • Support the Government in stimulating technological innovation to improve inclusive economic growth. • Gathering intellectual capital on technology best practices. • Provides risk funding to assist innovators with idea commercialisation. • Provide advice on policy issues and frameworks to advance tech innovation (Technology Innovation Agency, 2018).	Established based on the provisions of the Technology Innovation Act of 2008.Focus areas include advanced manufacturing, agriculture, energy, health and ICT. Programs do not pay explicit attention to Industry 4.0 other than using the term *advanced manufacturing*.
Socio-economic Innovation Partnerships - Department of Science and Tech program	• Develop and sustain high-end science, innovation and technology capabilities in areas like aerospace, advanced manufacturing, ICT etc. • Inform and influence concerning the use of science and tech to promote inclusive development. • Introduce and monitor incentives to increase investments in private sector R&D and technological developments (Department of Science and Tech, 2017).	Part of the mandate is to support experimentation with innovations that do not have wide spread application as yet but have potential to can foster job creation, tackle unemployment and reduce inequality. No specific reference is made to Industry 4.0.

5.2. Skills, Education and Employment data

5.2.1 Primary and Secondary Education

Table 2 below tracks the pass rate and dropout rate of four cohorts tracked throughout primary and secondary education matriculating in 2014, 2015, 2016 and 2017.

Table 2: Pass rate and drop-out rate of four cohorts matriculating in 2014, 2015, 2016 and 2017.

Year	Gr 2 Cohort enrolment	Registered for matric exams	Wrote matric	Passed matric	Absolute dropout rate	Pass rate (broad)	Gr 2 Cohort pass rate
2014	1 109 201	549 239	532 860	403 874	52.0%	75.8%	36.4%
2015	1 118 690	667 925	644 536	455 825	42.4%	70.7%	40.7%
2016	1 081 652	674 652	610 178	442 672	43.6%	72.5%	40.9%
2017	1 022 853	629 155	534 484	401 435	47.7%	75.1%	39.2%

Source: Combination of author's calculations, Department of Basic Education (2018) and Mybroadband (2018).

5.2.2 Technical and vocational education

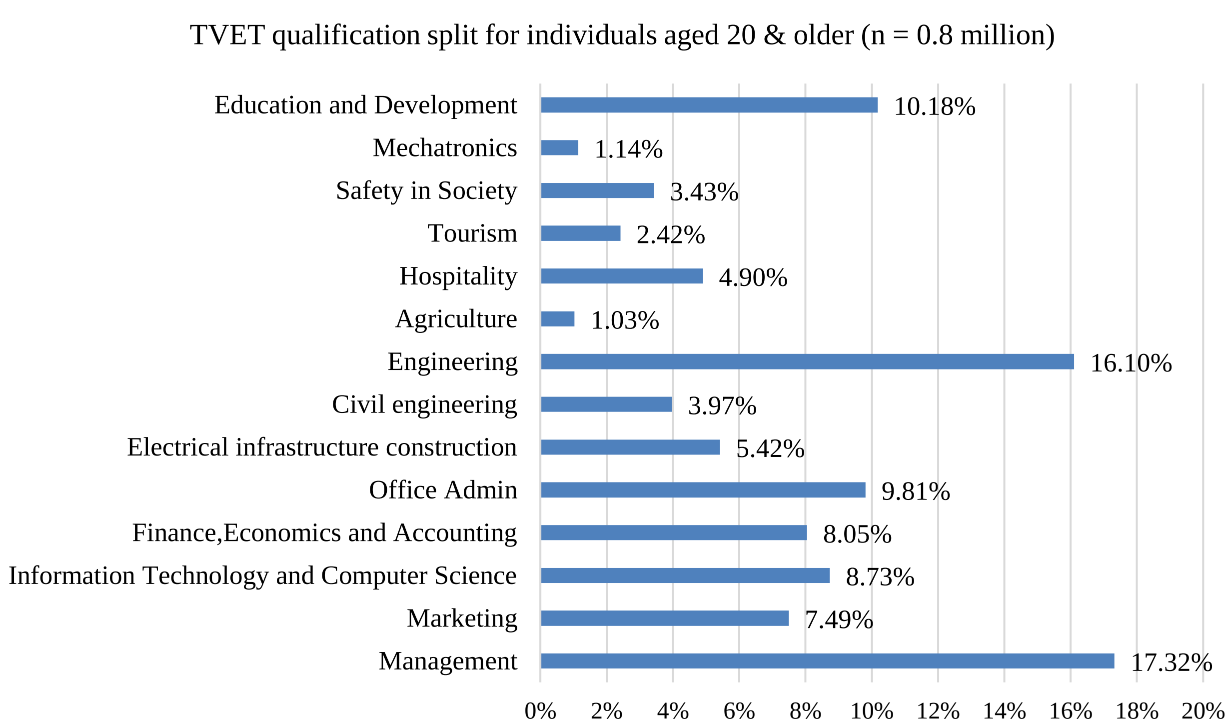

Figure 4: TVET qualification split for individuals aged 20 & older (StatsSA, 2016).

The most popular qualification is Management followed by Engineering. The least pursued qualifications are Mechatronics, Agriculture and Tourism.

5.2.3 University Education

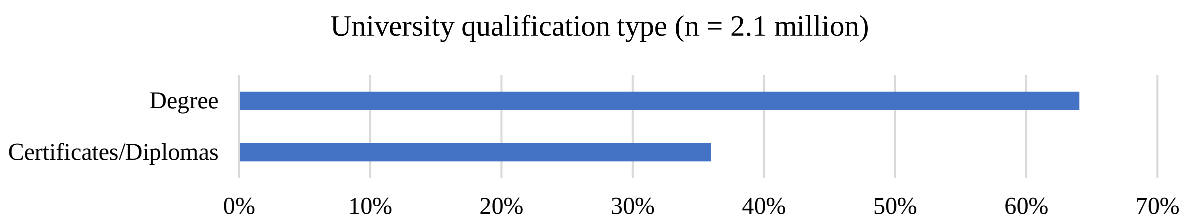

Figure 5: University qualification output split between degree and certificate/diploma qualifications (StatsSA, 2016).

It can be seen that degree qualifications are almost as twice as certificate/diploma qualifications, with degrees making up about 65% and certificates/diplomas making up about 35%. Although the current university education status shows that most of the qualifications are degrees, a closer look at the split by study program is critical which is shown in Figure 6 below.

5.2.4 University qualification split by programme

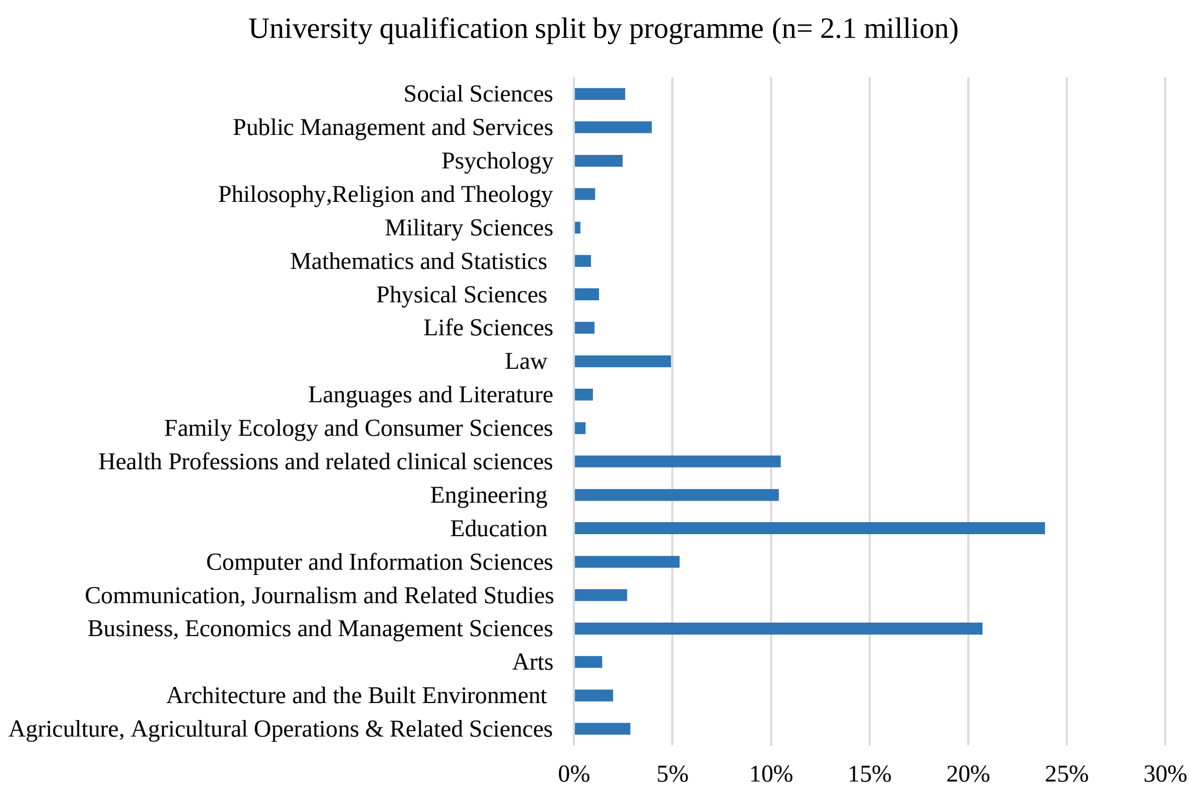

Figure 6: University qualification output split by programme inclusive of degrees and certificates/diplomas (StatsSA, 2016).

The university qualification most graduates obtain is Education closely followed by Business, Economics and Management Sciences. Physical Sciences and Engineering have much less graduates, with Physical Science being among the least obtained qualifications.

5.2.5 Unemployment rate and education attainment

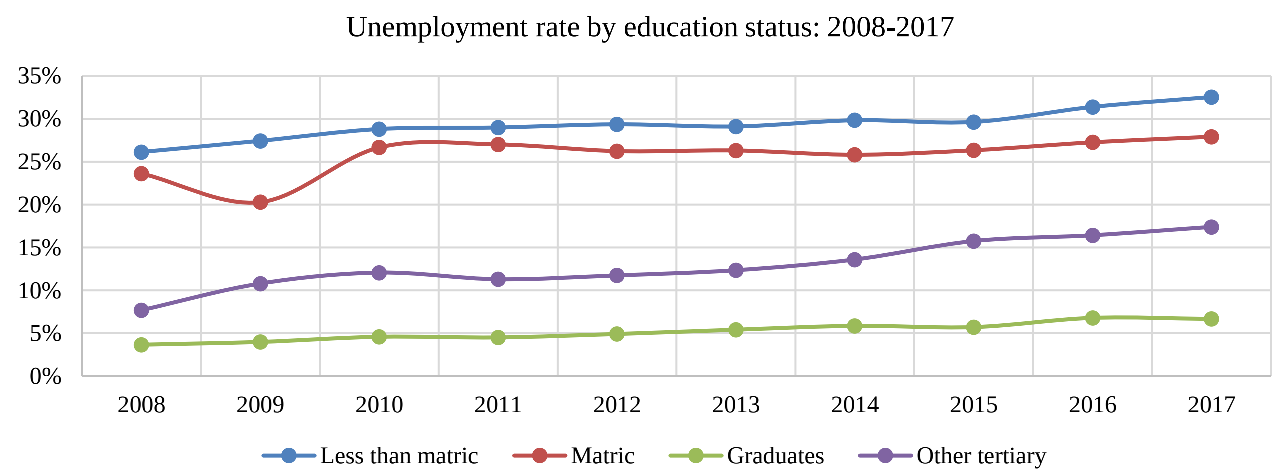

Figure 7: Unemployment rate by education attainment level from 2008 to 2017 (Source: (StatsSA, 2018) & authors' calculations).

The unemployment rate has been generally steady over the decade with no sign of reducing, and instead shows a slight increase at the latter stage of the decade. For all education levels, unemployment increased from 2008 to 2017.

5.2.6 Occupational structure in the labour market

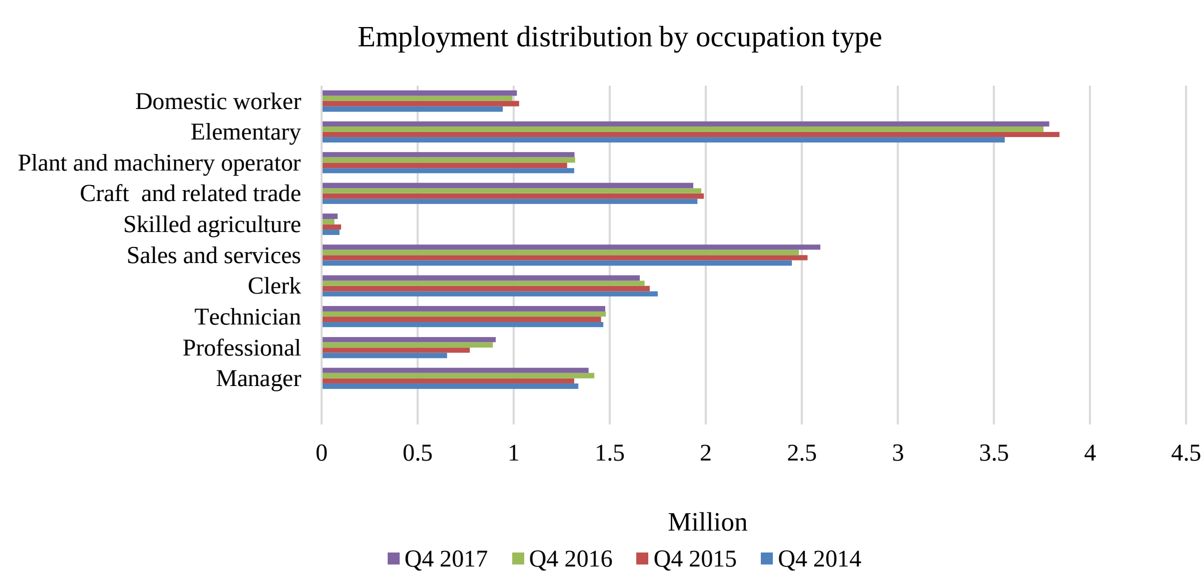

Figure 8: Employment distribution by occupation type between Q4 2014-Q4 2017 (StatsSA, 2018).

In Figure 8, each occupation has four bands each indicating four quarters. Most people are employed in elementary occupations. The occupation that employs the least number of people is skilled agriculture.

6. Discussion

6.1 Discussion of Government Policies and Initiatives

Interrogation of the available policies reveals an interesting finding. Although the South African Government has policies, programs and strategies developed by the Departments of Science and Technology and NACI which lean towards innovation and advanced manufacturing, there is no particular focus and drive targeting the imminent Industry 4.0. In the existing policies, technological advancements are discussed predominantly in the traditional Industry 3.0 sense without incorporating Industry 4.0 in any way. The AMTS does not even come close to spelling out a manufacturing vision that has Industry 4.0 at its core.

Furman (2016) cautions that advancements in technology can lead to *more* unemployment and inequality. Cognisant of this possibility, European countries are already preparing for Industry 4.0 by pitching their strategies to facilitate the structuring of roadmaps and areas of further research (Santos et al, 2017). Other related activities are also instructive, notably in the past 10 years, the global shipment of industrial robots has been steadily increasing generating inclination to heavy automation and towards Industry 4.0. Given this activity in global arena, it is telling that for 2018, it is estimated that about 1.85% of industrial robots will be shipped to Africa (International Federation of Robotics, 2017). This indicates a huge gap in terms of preparing technologically for Industry 4.0. According to World Economic Forum report released in 2016, South Africa needs to invest more in productivity improvement by creating technological readiness in the economy (World Economic Forum, 2016). Thus, government needs to properly plan for the eventuality of Industry 4.0 by increasing participation in technological advancements. The government is urged to urgently get involved with this subject matter and develop necessary policies which position the economy for accelerated growth. In particular, a mapped out national Industry 4.0 long term strategy is required.

Government action in setting up technology promoting initiatives and policies is plausible. However, the challenge now rests on re-focusing policies and effectively utilising such initiatives to prepare for Industry 4.0.

6.1.2 Policy proposals to facilitate and leverage on Industry 4.0

From Table 1, it is evident that the government has structures in place pushing for innovation in different facets. In this section we suggest how government can capitalise on the existing structures by driving a strong interest in Industry 4.0. Government should get the momentum going so that other stakeholders can accelerate their pace of progress with government support. Government ought to create an environment of strategic collaboration with industry and research institutions.

The following initiatives or adjustments are proposed:

- National Industry 4.0 strategic roadmap: The government should consider re-focusing its mandate on NACI to ensure that this establishment researches continuously on Industry 4.0, its impact and the latest trends, and advise on global best practises. Policy makers should then use recommendations provided by NACI to develop sound, forward-looking and actionable policies and a national Industry 4.0 roadmap for the manufacturing sector.
- Since NACI is composed of a multi-disciplinary mix at their council and executive committee levels, it makes good sense for NACI not only to advise Department of Science and Technology but also Departments of Education, Labour and, Trade and Industry. This is due to the fact that

Industry 4.0 will need to be supported by sound holistic policies from these government departments.

- Technology Innovation Agency should be mandated to research on Industry 4.0 as well as facilitate start-ups providing Industry 4.0 products and solutions. This entails Government taking consideration to increase the risk funding in the form of grants or other soft financing schemes (Boston Consulting Group., 2016).
- Government should extend the Research and Development Tax Incentive policy to companies working actively to achieve Industry 4.0 manufacturing standards and/or are upskilling current manpower to cope with the new highly digitised work environments.
- Government should put in place Industry 4.0 awareness campaigns through agencies like NICA and TIA. This initiative is meant to bring the academia and industry up to speed with the capabilities of Industry 4.0. These agencies could be equipped with tech demo centres which showcase Industry 4.0 technology in action to manufacturers-big and small-as a way of selling it. German has a similar initiative hosted by the Fraunhofer Society (Boston Consulting Group., 2016).
- Labour policy: Government should strengthen the Unemployment Insurance Fund (UIF) policy to ensure it covers workers who lose jobs due to Industry 4.0 to a reasonable extent. Currently it offers short term financial relief.
- Labour policy: Department of Labour should create programs that help workers who lose jobs due to Industry 4.0 to re-integrate into the foreseen highly digitised work environment. This can be set up as a job-search assistance initiative to assist the affected in finding advice on skills & education, and other related information on the labour-market. The goal is to help those displaced to find employment again in the new economy.

6.2. Education, skills and employment

6.2.1 Primary and Secondary education

Basic education is the gateway to the country's TVET institutions, colleges and universities where students are prepared for the labour market. Accessibility of basic education has improved significantly since 1994.However, a lot of hurdles still need to be overcome to provide quality education as this remains elusive (Reddy et al, 2016). Table 2 (see Data Collection and Results section) captures the performance at matric level of the local education system in the past 4 years in terms of drop-out and pass rates for cohorts tracked throughout primary and secondary.

Drop-out rate figures stand out. These figures are driven by many factors including poverty, inequality and inaccessibility of education particularly in impoverished and rural societies of the country (Spreen & Vally, 2006).

Pass rates reveal underperformance of the basic education system. This is mainly due to the poor quality of education received. Van der Berg *et al* (2011) argue that to improve the quality of education there is need to 'attract and retain the best teachers', improve school management leadership, improve accountability in policy implementation across all levels and improving early childhood development facilities to ensure high quality foundation before enrolling for primary education. This argument is cogent as it is critical to build a solid basic education to ensure that students sail through smoothly in later stages of education and skills development.

6.2.2 Technical Vocational Education and Training

Figure 4 in the Data Collection & Results section shows the profile of skills produced by TVET institutions across South Africa for individuals 20 years and older.

TVET institutions produce most of their skills in Management, Engineering, Education and Office admin. Computer Science and IT contributes 8.7% the qualifications. All engineering disciplines combined, inclusive of Mechatronics, contribute 21.2% of the qualifications awarded.

Industry 4.0 will demand more skills in computer science and IT as these skills are needed to run the highly automated systems (Lorenz, et al., 2015).With only 8.7 % of the qualifications produced falling under Information Technology and Computer Science, there is need to boost enrolment in this field.

6.2.3 University education

Figure 5 (see Data Collection and Results) shows the distribution of qualifications obtained by individuals 20 and older across the universities. Slightly more than 60% of the qualifications awarded are degrees and certificates or diplomas awarded are 36%. It is a good indication that the skills pool is advancing towards a more skilled workforce. However, what is critical for Industry 4.0 is the composition of these skills by study field.

In Figure 6 we examine the split of the qualifications (diploma, masters, doctoral etc.) awarded by programme type so as to understand the general skill composition available to the job market.

The distribution of university qualifications is heavily skewed towards Education and Business related qualifications. Combined these two study areas contribute 46% towards the number of qualifications awarded and released into the job market. Engineering and Computer & Information Sciences each constitute 10% and 5% respectively of the skills supplied by the universities. There is a serious deficit of Science, Technology, Engineering and Mathematics (STEM) related qualifications as they range between 1-10% by category.

Industry 4.0 will require more highly skilled personnel in Engineering and Computer and Information Sciences field. This calls for consideration of the enrolment split by study field at institutions of higher learning to boost STEM related qualifications.

6.2.4 Unemployment rate and education attainment

There is an inherent relationship between employability and education level. Figure 7 depicts yearly average unemployment by education attainment level since 2008 to 2017.

The graph shows that unemployment is more pronounced within the categories of lower education. This is due to the fact that low education equates to low or no skills to match to the available jobs which effectively renders an individual unemployable. Between 2008 and 2017, individuals with an education attainment of less than matric are more likely to be unemployed. For this category the unemployment reached a peak of 33% in 2017.This is consistent with what McGrath and Akojee (2007) posited that ‘even matric is no longer of much value in the labour market’. On the other hand, graduates are less likely to be unemployed with an average unemployment rate of 5% between 2008 and 2017.Across all categories there is a general gradual rise in unemployment rates since 2008.This situation is likely to be exacerbated in an Industry 4.0 setting and calls sound for policies.

6.2.5 Occupational structure in the labour market

This section presents data on the current distribution of skills in the labour market. It is necessary to understand the connection between education and the labour market including the occupational structure changes that are taking place in the economy.

Figure 8 in Data Collection and Results section shows high level skills distribution across all industries between Q4 2014 and Q4 2017.It is apparent that the majority of those employed do low skill jobs in the elementary, craft and sales & services jobs. These jobs are not only low skill but are also repetitive in nature which make them amenable to automation, hence, highly likely to be impacted by Industry 4.0. On the high skilled end (cognitive and non-routine jobs), manager and professional occupations occupy an average of 14% of the occupations. There is a gradual increase in the number of professionals employed in the economy as depicted in the graph. This is due to the changing occupation structure in the industry. Over the past four years the demand for other occupations does not change significantly.

The advent of Industry 4.0 will likely cause a heavy shift towards high skilled occupations in manufacturing. This will prompt an increased demand for highly skilled technicians, professionals and managers to run the highly digitised work environments (Lorenz, et al., 2015). A significant drop in plant and machinery operator occupations is expected in Industry 4.0 as well as in elementary jobs that fall under manufacturing.

This points out to an exacerbated shortage of skills and the need for government policy responses. There will be need for re-skilling employees in line with new job requirements. Training and education institutions need to introduce new relevant skills to curb the possibility of a skills shortage or forced unemployment in Industry 4.0.

6.2.6 Next steps government can take

Industry 4.0 will likely worsen unemployment across different categories of education attainment as it will require more highly skilled than unskilled personnel and general re-skilling. Given that causes of unemployment go beyond slow economic growth we propose the following initiatives to policymakers aimed at preparing the labour market and education for Industry 4.0 demands and employability:

- Increased access to quality primary and secondary particularly within the impoverished communities to ensure a solid base of basic education. Data have shown that the lower the level of education the higher the probability of being unemployed (see Figure 7). Particular focus should be placed on promoting digital and numerical literacy. Digital literacy is key in Industry 4.0 as part of basic generic skills. Government is urged to act swiftly to ensure broad access to computers and computer subjects. This digital literacy initiative needs to be compulsory to be effective.
- Restructuring and investing in post-school education and vocational training – Increasing digitisation will require government to focus on producing relevant skills to cater for a highly digitised industrial workplaces. Government should drive enrolment of students into STEM careers across the board as these are critical. Vocational training has proven to be critical in augmenting technological advancements in countries like Germany and Switzerland (Audino & Mason, 2018).

Universities and colleges can be pivotal in re-skilling professionals and managers to match them to Industry 4.0 skill demands. This is achievable through short courses accredited by these institutions. Vocational training institutions can do the same to re-skill artisans, technologists and technicians. In this case, government through DHET and Department of Labour are central to drive stakeholder buy- in to make it a success

7. Conclusions

Industry 4.0 is a disruptive revolution which needs adequate preparation prior to adoption. South Africa's policies are not positioned to drive Industry 4.0 and therefore there is need to create a holistic strategy that includes government policy on innovation, education and skills development. Unemployment is already of unprecedented levels which may be exacerbated if no significant preparation and policies are put in place to ensure optimal implementation for Industry 4.0. Policies should give support to the business community to accelerate the pace of adoption of Industry 4.0. There is need to improve access to education, adoption of STEM subjects and development of digital skills across the board from primary to tertiary. This will create a skills and occupational structure that is suited for Industry 4.0 environment and permits the economy to thrive creating opportunities for the skills pool.

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