# AUTOMATION AND THE FUTURE OF LABOR IN THE SOUTH AFRICAN MANUFACTURING SECTOR

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## ABSTRACT

*For decades, the assumption underlying various development initiatives has been that economic growth and social prosperity can be achieved through the growth of labor-intensive industry, such as manufacturing, thus resulting in the employment of otherwise unemployed individuals. In South Africa, government agencies seem to surmise this same assumption and derive their development plans from it. This thesis challenges this assumption and explores the relationship between the future of labor in South African manufacturing and the integration of automation technology into the manufacturing sector. This thesis finds that automating process chains in the manufacturing sector may displace labor by implementing labor-saving technologies in South African firms, but also by placing the competitive advantage in manufacturing to countries more prepared for technological change. In this thesis, I find the South African demographic most susceptible to job displacement in this sector is low or semi-skilled, young, black males. I suggest a number of policy responses, including skills-upgrading initiatives and a redistribution of some gains achieved through automating processes to those displaced, as a part of an enhanced social net.*

## BIOGRAPHICAL SKETCH

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# DEDICATION

To my students in Emanyiseni.

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I would like to thank my advisor, Professor Lori Leonard, for her enthusiastic support throughout the process of writing this thesis.  I would also like to thank Professors Jim Lassoie and Terry Tucker for their strong support through this academic year.

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# CHAPTER ONE

## INTRODUCTION

Inherent in a range of development philosophies, projects, and scholarship is the notion that tapping into Africa's abundant supply of labor is a viable path out of poverty for the continent. In an effort to create jobs and leverage this abundance of labor, scholars and politicians alike have endorsed policies to promote growth in labor-intensive industries such as manufacturing. Development economists such as Söderbom and Teal (2003), for example, argue that the labor-intensive nature of manufacturing provides Africa an opportunity to increase exports, create jobs, and reduce poverty simultaneously. Bhorat et al. (2016) stated that, "No country, to date, has managed to transition out of a middle-income to a high-income country status, without the dynamism of a vibrant, labour-intensive [sic] manufacturing industry." In the public sphere, the government of South Africa, for example, sees future manufacturing jobs as an integral component of its economic and social development (Department of Trade and Industry, 2015; Department of Trade and Industry, 2017). These noble aspirations share the assumption that the future of labor-intensive industry runs hand-in-hand with future jobs. In the face of continuously improving automation technologies, however, these assumptions are suspect, and such suspicions should behoove the international development community to examine the relationship between the future of industry and labor.

South Africa is a paragon example of an African country that should consider this relationship. Its government has consistently pointed to manufacturing as an important source of new jobs for the country. In 2015, for example, the Department of Trade and Industry (DTI) enshrined the position of manufacturing as a job-creator into its Industrial Policy Action Plan (IPAP). Two years later, the DTI's 2017 annual report states as one of its strategic objectives: "Grow the manufacturing sector to promote industrial development, job creation, investment and export." And in addition to the push for future jobs in manufacturing, the industry in South Africa is already crucial to its labor force and economy. In June 2017, approximately 1,799,000 people were employed in the manufacturing sector, constituting just under 11.2 percent of the country's total employment[1] (Statistics South Africa b, 2017).

Labor in the manufacturing sector is clearly of great importance to South Africa. But the nation's job-creation plans, when viewed in the context of automation, expose potentially serious problems with the country's development strategy. In its current state, automation technology has the capacity to automate aspects of sundry manufacturing jobs that already exist, and this capacity continues to grow (Maynika et al., 2017). For example, Volkswagen assembly lines in South Africa have already automated processes to assemble doors, panels, bumpers, wheels, and batteries (Gorlach & Wessel, 2007). Looking forward, developments in the capability and availability of 3-D printing technology allow for decentralized and streamlined manufacturing with fewer production components (World Economic Forum, 2017). It is thus evident that the security of both current and future jobs in South African manufacturing should be examined in depth, along with the policies necessary to address the findings.

In this thesis I will explore the relationship between automation and the future of labor in the South African manufacturing industry, and the policies relevant to this relationship. This thesis has been designed to sequentially move toward suggesting policies that contribute to the welfare of South Africans employed in the manufacturing sector. The thesis has four main

[1] This estimate includes both formal and informal labor.

sections.  The first section is a literature review.  The next section will make approximations for the potential for integration of automation technologies into existing production lines in South African manufacturing, and the likelihood that these advances will result in job displacement.  It will then explore the socio-demographic characteristics of those employed in the industry, and will lastly leverage this information, in the context of the potential for job displacement, in order to suggest policies aimed at facilitating advances in South African manufacturing which both promote the nation's competitiveness and protect the welfare of its laborers.

# CHAPTER TWO

## LITERATURE REVIEW

Job-content change and job displacement due to technological innovation are nothing new. As early as 1930, John Maynard Keynes (1930) introduced the term technological unemployment: unemployment due to technological improvements economizing labor faster than new jobs can be created. In 1955, the United States Congress held a hearing on automation and technological change where Ford [2] discussed the machinery used in automobile manufacturing plants to automate assembly lines. Ford defined automation as "the automatic handling of parts between progressive production processes." A more modernized definition came in 1997, when Parasuraman and Riley defined automation as the execution by a machine agent of a function previously carried out by a human. He noted, unlike many others preceding him, that this process usually involves a computer. This thesis will adopt Parasuraman and Riley's definition of automation.

Job displacement due to technological change is a recurrent theme from the industrial revolution to the present day. The Luddite Movement is often referenced as an example of what can go wrong when jobs are displaced by machines. In the early 19$^{th}$ century, groups of disgruntled handicraftsman, who came to be called the Luddites, rioted across parts of England in defiance of the textile machinery that replaced their labor, resulting in the Luddites destroying many of these machines ("Luddite," 2013). Now, certain textile manufacturers are using robotic sewing machines that stitch fabrics together and dexterously move fabric between machines for further stitching, which some predict will lead to substantial job losses in this industry (Chang &

[2] The automobile manufacturer

Huynh, 2016). But job displacement does not mean unemployment. At the beginning of the 20th century, for example, agriculture accounted for 40 percent of the jobs in the United States. Just over a century later, in 2010, agriculture employed only 2 percent of American workers (Autor, 2014), yet over the course of the year, the unemployment rate never exceeded 10 percent (Bureau of Labor Statistics, 2017). The recurrence of job displacement due to technological change throughout history, however, does not necessarily mean that the future will follow the same trends as the past. In theory, job duties can evolve within existing job categories in coordination with technological change. Whether or not the effect of technological change on employment will manifest in this fashion is subject to debate, and will be considered by this thesis.

In the present day, the range of tasks that automated robots and computer programs can perform is growing. In their seminal work, Frey and Osbourne (2017) showed how more sensitive sensors and greater dexterity allow industrial robots to not only complete routine, iterative movements, but non-routine manual tasks that require a broadening spectrum of actions. Some of this broadening can reduce the need for human employment. A McKinsey & Company analysis found that with existing technologies, at least 5 percent of occupations worldwide are fully automatable (Manyika et al., 2017). Computer capabilities in complex communication and pattern recognition, for example, can cause companies to hire fewer employees because computers can perform tasks previously carried out by humans (Brynjolfsson & McAfee, 2012). Furthermore, the current state of automation technology is not static. Scholars such as Jämsä-Jounela (2007) have argued that trends in the development and use of automation technology point to a continued expansion of applications and will become increasingly more important in process chains.

Automation plays a role in the type of labor demanded. Autor et al. (2003) have argued that the changes in job content that favor educated labor have been prompted by technological change. They noted that the correlation between labor demand shifts and technological innovation is clear, albeit not explicitly causal. After a rigorous analysis, however, Autor et al. maintain that technological change can be considered a causal factor in shifts in labor demand toward educated labor. Earlier, in their formative work, Autor et al. (1998) have argued that the growing need for educated labor is greater as companies utilize computers more, which also creates a labor demand shift toward educated labor. This trend has been recognized by governments as well. For example, the U.S. Bureau of Labor Statistics' December 2015 monthly review stated that, "the jobs in manufacturing tend to be computer based," and that there is a need for employees who can program computers rather than work assembly lines. The trailing question is whether or not the same laborers who previously worked the assembly lines will become the computer programmers. And if not, what will be their means of livelihood in the intuitively likely scenario that they, instead of becoming the programmers, are left jobless when automation progressively, or perhaps from the laborer's perspective, insidiously, replaces their job duties.

The 2016 World Economic Forum (WEF) publication "The Future of Jobs" also made a strong case that technological change will necessitate investments in upgrading employee skills and emphasized a general trend on the demand side of the labor market toward high-skilled and technical labor. The report stated that this trend is expected to lead to a "transformation of manufacturing into a highly sophisticated sector where high-skilled engineers are in strong demand." The report published the results of a 2015 WEF survey of chief human resources officers and other company leadership from firms across nine industry sectors in fifteen developed and developing countries. The respondents represented 13,549,000 employees worldwide. The survey asked a series of questions pertaining to technological change and the future of work.

The survey results reflect some of the investigations explored earlier. Of the respondents, nine percent reported that robotics and autonomous transport were the biggest drivers of technological change, and seven percent chose artificial intelligence (AI). When asked to choose the most significant barriers to change, 37 percent of respondents said that workforce strategies were not aligned with innovation strategies. Further, 65 percent of respondents noted that their companies are currently pursuing strategies that invest in reskilling employees. The WEF echoed these themes in a 2017 white paper "Technology and Innovation for the Future of Production: Accelerating Value Creation."

As the landscape of the labor market continues to change in the face of computing and automation, new challenges require further analysis. It is apparent that not only can automation open new job categories, but that it has the potential to displace a significant portion of the existing labor force. Some estimates put at least 47 percent of US jobs at high risk of automation over the next two decades (Frey & Osbourne, 2017) and 49 percent worldwide (Manyika et at., 2017). More conservative estimates put 9 percent of all jobs in OECD countries at risk of automation (Arntz et al., 2016). On a global scale, McKinsey & Company estimates that 1.1 billion employees could have their jobs automated by adapting currently existing technologies, and that manufacturing jobs are especially vulnerable (Manyika et al., 2017).

This does not imply, however, that these jobs cannot or will not be replaced in some other capacity. For example, Autor and Dorn (2013) have linked the growth of low-skilled service jobs to the decline of easily automatable jobs such as those in manufacturing. Autor (2015) later maintained that some middle-skill jobs will continue to exist despite the automation of many of their tasks. Further, some scholars have argued that increased productivity in manufacturing has led to higher demand, lower prices, and increased overall employment within the manufacturing industry (Nordhaus, 2005). Others have contended that following a recession, job losses from technological change in routine-based jobs have seldom been replaced even as productivity recovers (Jaimovich & Siu, 2012).

Moreover, there is no consensus on whether current trends in job losses in the manufacturing sector are primarily due to improvements in technology, offshoring, or a combination of these and other factors. (Katz & Autor, 1999; Goos et al., 2009; Blinder, 2006; Rowthorn & Ramaswamy, 1997; Williams et al., 2014; Nordhaus, 2015). In his recent but influential work, Rodrik (2015), for example, argues that the shrinking size of global manufacturing employment has a different set of causes in advanced and developing countries. He maintains that technology is a more prominent factor in advanced economies, and that globalization and trade are the main culprits of job losses since the 1970s in developing countries. The extent to which automation is responsible for previous net job losses in manufacturing is unclear. But the aim of this thesis is not to determine the cause of job losses in manufacturing where they have already occurred, but to analyze policies that can mitigate the deleterious effects of future job losses due to automation in South African manufacturing. To do so, it will be necessary to explore automation in the context of the South African manufacturing industry.

## Automation in South Africa

The population of South Africa in 2016 was roughly 55.6 million (Statistics South Africa f, 2016). In the second Quarter of 2017, a total of 16,100,000 South Africans were employed, including both formal and informal employment (Statistics South Africa b, 2017). Of those employed, approximately 1,799,000 were employed in manufacturing, both formal and informal, which accounts for nearly 11.2 percent of the total workforce (Statistics South Africa b, 2017).

The South African Government sees its manufacturing sector as an integral component of both its economy and employment structure (Department of Trade and Industry, 2015; Department of Trade and Industry, 2017; Kaplan, 2004). The government's recognition of this importance dates as far back as the Tariff Act of 1925, which, in an effort to create a market for domestically manufactured products through import substitution, placed tariffs ranging from 20 to 25 percent on foreign goods (Schneider, 2000). More recently, in 2015, the DTI released its International Policy Action Plan (IPAP), setting the agenda for the future of manufacturing in the country. Among its objectives are increasing exports in "labour-intensive" [sic] manufacturing and job creation. Simultaneously, the plan places a heavy emphasis on technological innovation across the industry. In its 2008 to 2018 ten-year plan to move South Africa toward a knowledge-based economy, the Department of Science and Technology reiterates the theme of technological innovation. Put in the context of automation, this clearly raises questions about the parallel objectives of increasing labor-intensive manufacturing and investing in technological innovation.

In Bhorat and Rooney's paper "State of Manufacturing in South Africa" (2017), the authors found that from 2001 to 2014, South African management jobs in the manufacturing industry grew at a rate four times the overall employment in the industry. The same period saw the net creation of 59,000 highly-skilled manufacturing jobs, while losing 82,728 jobs in total employment across the industry. This trend appears to be consistent with global industry trends toward high-skilled and away from semi-skilled labor discussed earlier. Bhorat and Rooney (2017) also found that approximately 9,000 unskilled manufacturing jobs were created over this period. This is consistent with the findings of Goos et al. (2009), who observed the same “job polarization” trends in Europe, where high-skilled and low-skilled jobs were disproportionately created relative to jobs in manufacturing and clerical work involved in routine tasks, which, in fact, has been experiencing losses since the 1970s. Goos et al. argued that that the evidence pointed to technological change as the primary cause, consistent with the findings of Autor et al. (2003).

A four-month study in a South African manufacturing plant provides further evidence for the existence of this trend. Hagedorn-Hansen et al. (2017) conducted a study comparing two manufacturing cells that produced an aluminum anti-vibration dampener component of vehicle suspension arms. One cell was fitted with additional machinery to automate the process chain, and was considered an automated cell. The other was considered semi-automated. The study found that not only was the automated cell more productive and that it yielded higher profit margins, but that only one unskilled laborer was needed to operate five automated cells. In the semi-automated cell, one semi-skilled laborer was required per cell, and the cell could not continue to operate during breaks. At least for this particular process chain, automation resulted in higher profit margins and the need for one unskilled laborer at the expense of five semi-skilled laborers.

Another study analyzed the automation levels of three Volkswagen assembly lines in Germany and South Africa (Gorlach & Wessel, 2007). It found that although automation can in many cases be more costly than labor per assembly unit, a low automation level is the primary reason for poor product quality. The study found that relatively high levels of automation are optimal when low skill levels and lack of motivation are present. Out of the three assembly lines the study examined, the authors suggested higher levels of automation in the South African assembly line than the two in Germany, stating low skill levels and high margins for error as reasons.

Automation is also expanding vertically in South Africa, from the manufacturing of products to the exportation of those products at the port. Automated straddle carriers are large, self-driving container transports that both move freight containers between locations and stack them vertically. In the Durban Container Terminal, these machines are replacing human-operated container transports. The benefits to the terminal have been savings in labor costs, increased efficiency, fewer collisions, and longer equipment lifespans (Nakker, 2015). Automation has to some extent impacted and will continue to impact South Africa, and this thesis will later explore the nature and degree of that impact in Chapter Four.

## The Social Impact of Automation

In the 1958 article "Of Things to Come, Automation and Counseling," Hart and Lifton warn of the coming need for psycho-therapy counselors to deal with the dissatisfaction, alcoholism, drug use, and other social ills caused by job displacement due to automation. Whether or not their fears came to fruition is a matter of debate, but what is clear is that automation has the potential to cause social changes, both positive and negative. The literature points to a number of these positive changes. Among them are rising wages, increased participation of women in the workforce, more leisure time and the development of meaningful leisure activities, and an abundance of material goods (Badishkanian et al., 2016; Black & Spitz-Oener, 2007; Autor a, 2015). One study in Germany, for example, found that women's participation in non-routine jobs has increased as a result of technological developments, and the authors argue that this observation applies to other countries (Black & Spitz-Oener, 2007).

But there is another side to the social impact of automation. As explicated earlier, automation can lead to job displacement, which has been linked to a range of social tribulations (Brand, 2015). Burgard et al. (2007) observed that job displacement has a statistically significant effect on depression. Further, Sullivan and Water (2009) found that not only do mortality rates sharply increase among the recently displaced, but that the risk of death hazards among job-displaced individuals persists as far as twenty years after displacement. Put in the context of recent findings that there has been an increase in mortality rates for white, non-Hispanic men in the United States (Case & Deaton, 2015) labeled by some as "deaths by despair" (Scutchfield & Keck, 2017), these trends should be concerning. Further, the economic effects of job displacement can be long lasting. Eliason and Storrie (2006) found that job losses resulted in lower long-term earnings in Europe and the United States. Clearly job displacement, caused by automation or otherwise, has potential be detrimental to individuals if their welfare is derived by no other means than the occupation in which they were previously employed.

As discussed earlier, some scholars argue that under certain circumstances, job displacement due to technological change leads to unemployment (Jaimovich & Siu, 2012). Although job displacement is neither a necessary nor sufficient condition for unemployment, the link is intuitive. The social issues associated with unemployment in a country have been studied in depth. Because automation may well lead to unemployment among those displaced, unemployment's effects on society at large should be examined as well.

Unemployment has been linked to higher rates of certain types of crimes (Raphael & Winter-Ebmer, 1999). In South Africa specifically, Demombynes and Özler (2005) have shown that crimes such as armed robbery and murder have been significantly correlated with unemployment. The World Bank's 2011 World Development Report also noted a clear link not only between unemployment and crime, but youth unemployment and likeliness to join gangs, rebellions, or participate in social upheavals. In South Africa, in the second quarter of 2017, the country's unemployment rate was 27.7 percent[3] (Statistics South Africa b, 2017). Surely, already high levels of unemployment compounded by potential job losses due to automation of the manufacturing sector pose a considerable risk to the social welfare of the country.

Inequality can also be exacerbated by automation. This can be a result of the job displacement discussed earlier, but also a result of one of the benefits of automation: rising wages. The increasing demand for high-skilled labor can lead to income inequality by contributing to wage polarization (Hemous & Olsen, 2016). In the broader picture, inequality can grow between regions and generations. Cities with higher incomes are generally less susceptible to the automation of human labor than cities with pervasive low or semi-skilled, labor-intensive industry (Badishkanian et al., 2016). This can lead to agglomerations of high-skilled labor in regional hubs, while cities with traditionally labor-intensive industries, such as Detroit or Dhaka, lose out. Furthermore, Sachs and Kotlikoff (2012) found that low-skilled labor is generally concentrated in younger generations, and that these demographics are less likely to benefit from automation and AI. These trends were investigated in depth by Benzell et al. (2015), who drew similar conclusions.

[3] This estimate was calculated by Statistics South Africa by conducting 30,000 private household surveys, with households weighted for extrapolation. An unemployed person is an individual capable of work that at some point in the preceding four weeks, from the time of the survey, has actively sought work, but has not worked during that time (Wilkinson, 2017).

In 2014, Pew Research Center conducted a poll of 1,896 experts in AI and robotics. Although there was no consensus among the respondents, the number of experts close to these technologies who expressed fears of a "breakdown of social order" is staggering. Of the respondents, 48 percent said that by 2025, robots will displace more jobs than are created. One respondent, NASA Program Manager Mark Nall, predicted that the coming changes in automation technology will be unlike previous technological developments, stating, "Due to their versatility and growing capabilities, not just a few economic sectors will be affected, but whole swaths will be. This is already being seen now in areas from robocalls to lights-out manufacturing.[4] Economic efficiency will be the driver. The social consequence is that good-paying jobs will be increasingly scarce."

But what does the potential for social disruptions due to automation mean for South Africa? According to some metrics, South Africa already suffers from some of the highest levels of inequality in the world (The World Bank, 2017). In 2015, the income per capita Gini coefficient was 0.68 (Statistics South Africa c, 2017). South Africa's DTI acknowledges the gravity of the inequality in the country, stating in its 2015 IPAP, "This is very significant because growing inequality is not only a threat to social wellbeing, stability and cohesion, but also undermines domestic demand and therefore the possibilities for expanded economic growth."

## Policy Responses to Automation

In a 2016 policy brief, "Robots and Industrialization in Developing Countries," the United Nations Conference on Trade and Development (UNCTAD) warned that the robotic

[4] Manufacturing facilities operating at 100 percent automation, where lights are, literally or hyperbolically, turned off because human labor is not present.

substitution of human labor may cause the appeal of offshoring to developing countries to wane, and that some re-shoring to developed countries has already occurred in manufacturing activities where automation is a key factor. The brief makes a number of policy suggestions for developing countries, including a sustained increase in the share of wages, redesigning the education system to reflect the needs of industry, and fostering interdependency in domestic production by advantaging intra-sectoral and cross-sectoral industry, making re-shoring more difficult.

The international public sector consistently reiterates these policy suggestions for developing countries. The World Bank's 2016 Flagship Report, "Digital Dividends," discussed the growth of digital, computer, and automation technologies as both a challenge and opportunity for developing countries. It provided a number of policy suggestions to emerging economies. It advised that policies should aim to improve educational environments, encourage research and development, strengthen cooperation between private sector, government, and educational institutions, and teach digital skills such as coding. Further, a 2015 OECD policy brief on South Africa stated in reference to the South African labor market, "With low quality, low status and low labour [sic] market relevance, the system is ill-prepared to address the needs of the country's burgeoning youth population." In a list of suggestions to policy makers, the brief recommends expanding early childhood education, enhancing the equity and efficiency of resource use in the education system, improving labor market relevance, and developing vocational and work-based learning systems.

These policy recommendations are also common in academic spheres. One study in Turkey (Srour et al., 2013) examined the skill gap in the Turkish manufacturing sector from 1980 to 2001. The authors found that domestic and imported technologies caused a rise in demand for skilled labor five to six times higher than the demand for unskilled labor. They recommended that developing countries couple trade liberalization with policies that increase the supply of domestic skilled labor. Autor (b, 2015), as well, points out the importance of human capital investments and educating labor forces on the skills that complement technological changes. Even the South African DTI's 2016/2017 Annual Report places a strong emphasis on skills development. But is the reskilling of the entire labor force displaced by automation a realistic expectation, especially in a country already struggling to meet its educational objectives? Surely, policies that recognize the effect of technological change on the labor force should not only aim to raise the skill levels of employees, but to mitigate the potential harm to those who could be left behind.

In addition to discussing the policies necessary to reskill employees, Autor (a, 2015) breaks down the "paradox of abundance." He cautions that the reassurances of some economists are losing their effect, and that subsets of the labor force will see sharp falls in participation. He argues that the challenge won't be employment, but how to distribute the abundance that results from the increased production capacities due to automation. The nature of that distribution will be determined by policy, and some scholars have provided policy options that will leverage the wealth created by higher efficiencies to promote the wellbeing of those not directly benefitting from that wealth. Sachs and Kotlikoff (2012), for example, argue that wealth gains due to automation will generally end up in the hands of older generations whose skill sets are advantaged by the changing labor market. They propose a tax-and-transfer policy that taxes the gains of older generations and uses them to advance the welfare of younger generations. This intergenerational wealth-transfer policy does not specify how tax revenue will be used to promote the welfare of the youth, but one can infer that revenues might be used to execute some of the education-based policy initiatives recommended by the international public sector.

As Sachs and Kotlikoff suggested, a tax on those who benefit from automation may be necessary. The social net that absorbs the impact of labor market shocks, however, may have to be strengthened in more than one dimension. One possible policy solution is a universal basic income (UBI). A UBI is an unconditional, guaranteed grant provided to each citizen of a country on an individual basis (Parijs, 2004). This idea has been proposed by figures as far to the right as Milton Freidman, in the form of a “negative income tax” (Friedman & Friedman, 1982), and likewise by traditionally left-leaning economists such as Robert Reich (Reich, 2017).

In the paper, “Basic Income: A Simple and Powerful Idea for the Twenty-first Century,” Parijs (2004) provides a detailed account of what a UBI is, and what it is not. This thesis will understand UBI in the context of the parameters set by Parijs. To summarize, a UBI is paid by a government, to a set of specified individuals, on a consistent, regular basis. The set of individuals to which a UBI is paid is a subject of debate, as children, refugees, migrants, inmates, etc. add considerations. Generally, however, all law-abiding citizens of a country should be eligible, and considerations should be taken to accommodate for individuals providing for children[5]. The methods by which a UBI pools funds to redistribute are variable, and it is unclear how such funds would be gathered or created in South Africa in particular.

The concept of UBI in South Africa has some political support already, (Matisonn & Seekings, 2002), and the nation has a social welfare grant (SWG) program that has strong conceptual overlaps with a UBI. Makino (2004) argues that the combination of structural

[5] This will be explored in depth in Chapter ___ in the context of South African society.

unemployment and a well-established system of SWGs make UBI, or in her terms, a Basic Income Grant (BIG), an ideal policy fit for South Africa. Some scholars argue, however, that such an approach is too broad and conceptual (Wispelaere & Stirton, 2004), and that there would likely be serious issues with implementation (Wispelaere & Stirton, 2012).

Despite criticisms, often from the right, research on South Africa's existing SWG program provides support for Makino's argument. One qualitative study (Surender et al., 2010) that conducted 39 focus groups with 386 individuals found that, contrary to the observations of opponents of SWGs in South Africa, lack of motivation did not appear to be a significant factor driving joblessness. Structural conditions in the labor market were considered the primary reason. Another mixed method study (Neves et al., 2009) found that in addition to alleviating poverty, social grants galvanize the informal labor market, enable households to invest in productive assets, and allow recipients to save. Because SWGs in South Africa could be a model for policies that absorb the social impact of automation, or even the foundation for an augmented SWG scheme, they will be further examined in Chapter Six.

The *potential* for automation in the South African manufacturing sector to bring forth or exacerbate serious social problems does not entail the actualization of these problems. By carefully considering the industries and demographics within the manufacturing sector that are likely to be affected and responding with well-fitting policies, the improvements in productivity from automation may actually provide a major net positive for the welfare of the nation. But it cannot be ignored that South Africa has historically been plagued with its fair share of social upheavals, and they have often resulted in unrest or worse. Surely, automation in the South African manufacturing sector has the potential to ferment new social turbulence, and informed policymakers would be wise to consider the country's transition into an automated age. After all, whether this transition will follow the peaceful path of the nation's extolled leader Nelson Mandela, or take the incendiary route of the Luddites of the $19^{th}$ century, may in the end, be a matter of policy.

# CHAPTER THREE

## RESEARCH METHODS

In order to suggest relevant policies, it was first necessary to develop a clearer picture of the South African manufacturing sector. In Chapter Four, I have drawn from a variety of academic papers, consulting reports, industry documents, case studies, and government data in order to better understand the potential for automation across the activities with which the South African manufacturing sector is engaged. I broke the sector into ten sub-sectors and gave rankings of high, medium, or low to each sub-sector's priority level to the industry, and to each sub-sector's potential to be affected by automation technologies. These rankings are intentionally vague enough to avoid making specific and unscientific claims, but potent enough to inform policy recommendations and draw general conclusions about the sector at large.

I determined the ranking for priority level by first considering the size of each sub-sector in terms of its percent contribution to the sector's total labor force. Because this thesis is concerned with the manufacturing sector with respect to its impact on its laborers, the number of laborers employed in each sector is of great concern. An industry with a substantially greater number of laborers employed should thus be considered a higher priority industry. Second, in determining priority rankings, I considered the total income produced by each sub-sector. This metric is also necessary for analysis because it clearly has import to policy makers. I have assigned priority rankings to be relative between sub-sectors; they do not adhere to absolute numerical thresholds.

The rankings for automation potential were determined by a holistic analysis of the size of each sub-sector, industry trends, salaries within each sub-sector, and existing technology. The process of arriving at these rankings was less straightforward and required a level of subjectivity which renders these rankings useful insofar as they are used to rank the automation potential of sub-sectors relative to one another, but not against other industries or with respect to any absolute determination of automation potential. Further, the timeline is not specified, nor should it be. These rankings attempt to characterize the *potential* for processes within sub-sectors to be automated.

This analysis primarily leveraged case studies and academic papers in order to assess automation potential. The primary factor I considered and a necessary condition upon which all other factors are contingent is the technological feasibility of automating processes in each sub-sector. For any given sub-sector to have any level of automation potential, it must be possible to automate at least some aspects of production. By seeking examples from case studies and academic studies, I determined whether or not technologies relevant to each sub-sector are currently available that have the capability of replacing or displacing human labor. I also considered industry trends within each sub-sector; because competitive forces encourage the growth of new labor-saving technologies in some industries more than in others, this factor was necessary to consider. I also analyzed the size of each sub-sector in terms of total labor force and total income; I considered the size of the sub-sector and thus the access to capital and specialization a possible influence on the potential to automate processes. In addition, I considered the salaries within each sub-sector, as low wages are one factor that inhibits both adoption and research of some automated production technologies.

Certainly, the high, medium, and low rankings are subject to political, economic, social, and technological vicissitudes not addressed in this thesis. The purpose of these rankings is to achieve a level of accuracy adequate enough to draw conclusions about the manufacturing sector in South Africa, only to the extent that the level of accuracy will facilitate drawing those conclusions. To use a fictitious example, if sub-sector A demonstrates, according to the criteria discussed above, a markedly high automation potential, and sub-sector B is markedly low, and these two sub-sector account for the majority of the labor force, it follows that policy suggestions would reflect this difference and would be tailored to the different properties of the two sub-sectors. A different scenario might be such that sub-sectors A and B account for the stark majority of the labor force and both have a ranking of high automation potential, and thus a single policy could address both sub-sectors.

It should be emphasized that this thesis will recognize only a general assessment, and that these trends are subject to fluctuations as technology changes. It should also be noted that this classification is concerned with a broad potential for automation, and that whether this potential is actualized is dependent on a host economic, political, and social factors. This thesis does not intend to make projections, or provide a timeline to which labor market changes will adhere.

In Chapter Five, I compiled data on the socio-demographic composition of the South African labor force, and specifically labor in the manufacturing sector. This data comes primarily from Statistics South Africa's Quarterly Labor Force Survey (QLFS). I then analyzed this data, surmising the implications of the literature review, particularly that some skill levels have a higher susceptibility to job displacement due to automation than others. This analysis allowed for the determination of demographics most vulnerable to automation, thus informing the policy suggestions of Chapter Six.

# CHAPTER FOUR

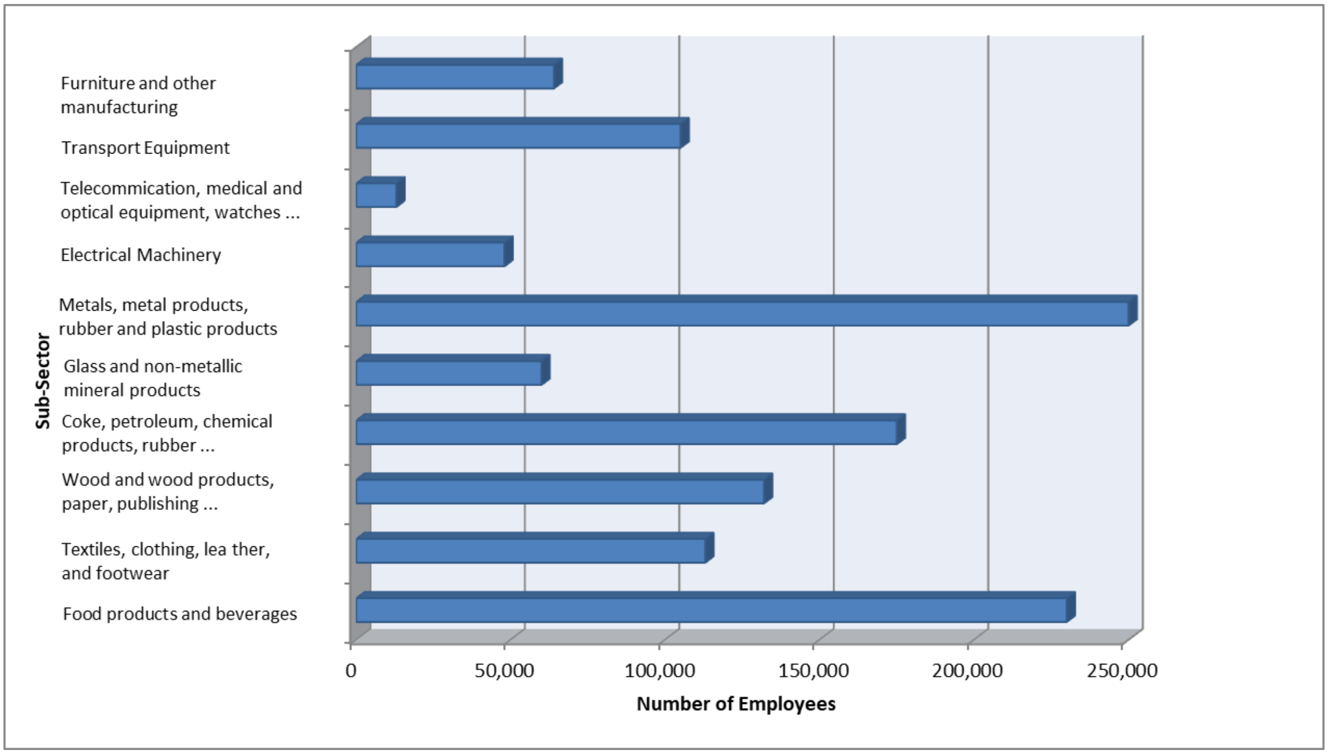
# THE SOUTH AFRICAN MANUFACTURING SECTOR

## Sector Breakdown

In order to explore the future of labor in the manufacturing sector and recommend policies well-positioned to calibrate for the potential changes in the labor market, it will be necessary to break down the manufacturing sector by sub-sector. This chapter will separate the manufacturing sector into ten, separate sub-sectors.

Figure one displays the ten areas within the South African manufacturing sector that this thesis will consider its sub-sectors. This breakdown is consistent with Statistics South Africa's manufacturing divisions (Statistics South Africa e, 2017). Figure one also displays the number of employees working in each sub-sector in 2014.

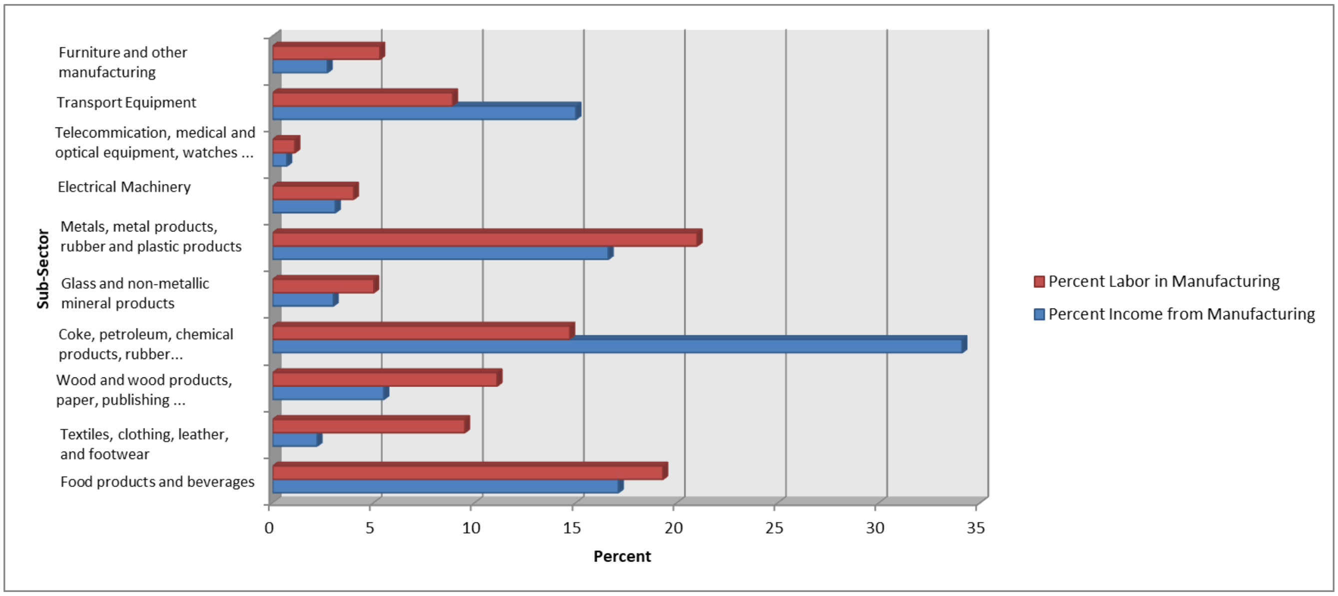
**Figure One: South African Manufacturing Sector Sub-Sectors and Total Employment**




Data compiled from Statistics South Africa i, 2016

Figure two below also displays each of the ten sub-sectors within the manufacturing sector. In addition, it displays the percent of labor in the manufacturing sector that each sub-sector represents (in red), and the percent of total manufacturing income that each sub-sector represents (in blue). This graph should put into perspective the need for labor in relation to the income from each sub-sector.

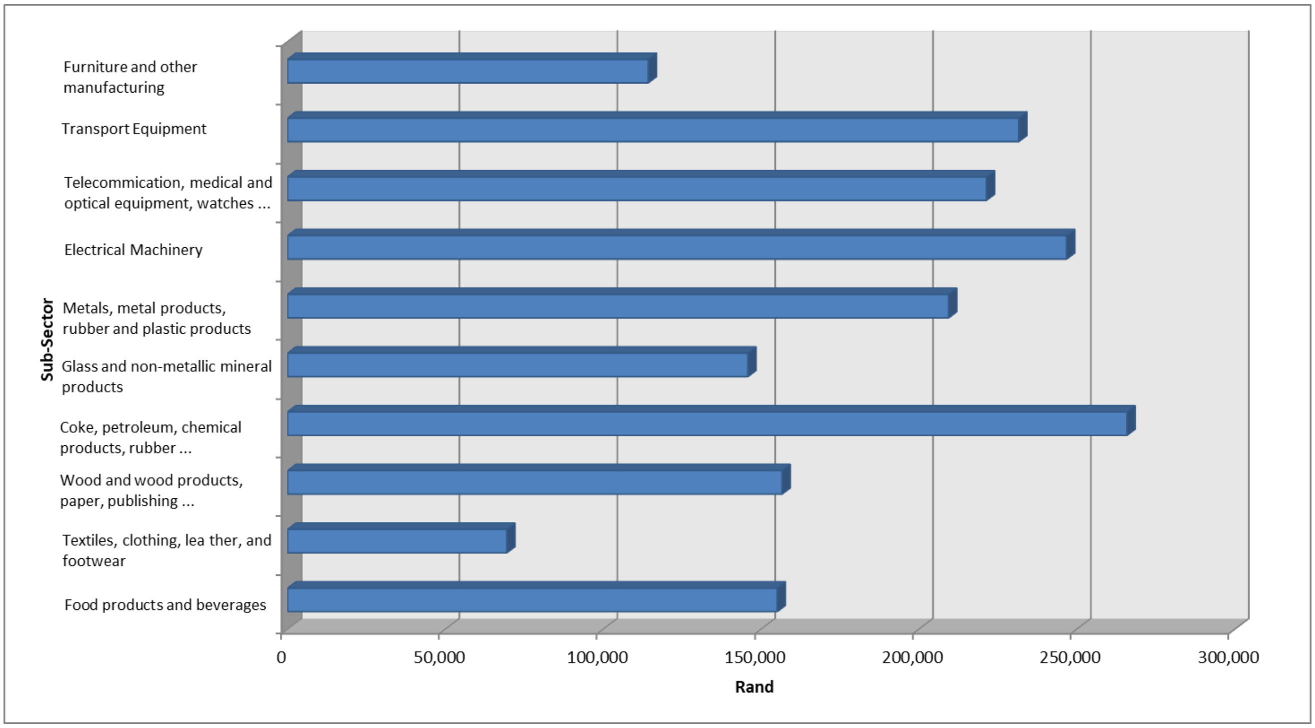
**Figure Two: Sub-Sectors by Percent Share of Labor and Total Income**




Data compiled from Statistics South Africa i, 2016

Figure three below displays the average yearly employee salary in each sub-sector. This will be an important consideration when determining the potential for automation within each sub-sector. An industry such as textiles, clothing, leather, and footwear, for example, has a relatively low average yearly salary. The low average salary in this sub-sector is one factor likely to make human labor more competitive with automation.

**Figure Three: Average Salaries in Each Sub-Sector**




Data compiled from Statistics South Africa i, 2016

Although the objective of this thesis is not to predict job losses, some sub-sectors within the manufacturing sector are more susceptible to job displacement due to automation than others. For this reason, the capacity to automate production within each sub-sector will be explored. This thesis will draw upon case studies, academic inquiries, consulting reports, and industry documents to assess the general automation capacity of each manufacturing sub-sector in which South Africa is engaged. In this chapter, I will classify each sub-sector's automation potential as high, medium, or low. I will also classify each sub-sector's priority level, based on the size and income of the sub-sector.

This chapter will also reference Frey and Osbourne's (2017) widely-cited study on the susceptibility of labor to automation and "computerization." Frey and Osbourne developed what they consider a novel methodology to determine the probability of job displacement in 702 specific job fields.  The study analyzes each occupation by the activities with which employees are engaged, and ranks the probability of each occupation being automated from zero (not computerizable) to one (computerizable).  Most of the sub-sectors have at least one class of occupation that Frey and Osbourne have analyzed, and will be included to assist in the approximation of potential for automation in South Africa.

**Furniture and Other Manufacturing**

The first South African sub-sector this thesis will explore is "furniture and other manufacturing."  In 2014, the sub-sector employed 64,000 individuals, which comprised 5.3 percent of the total manufacturing labor force.  This sub-sector accounted for 2.7 percent of the total income from the manufacturing sector, with an average salary of 114,240 Rand per year, the second-lowest average salary of the manufacturing sector sub-sectors (Statistics South Africa i, 2016).  Because of the relatively low percentage of total labor and income in the sector, it will be considered a medium priority industry.  Examining a number of studies and industry sources in coordination with industry statistics will help to estimate the automation potential of furniture and other manufacturing.

As early as 1986, Sander, in the paper "New Automation Trends in the Furniture Industry," explicated the trends with which this thesis is now concerned.  Sander showed that automation can improve various assembly processes in the furniture industry both yielding higher productivity and resulting in fewer errors.  Moreover, in a more recent and specific study, Barbosa et al. (2015) examined the process chains executed by completely automated manufacturing cells which produced airplane furniture, such as seating.  From the assembly of physical components, to the application of resin, to the curing of the product in an oven, the process continued exclusively under the control of automated machinery. The study cited the following as "tangible gains" from automating processes as opposed to production using manual labor:

- Increase of productivity (reduction of manpower): gain of roughly $500 K per year;
- Reduction of roughly 30% in wastes related to consumable materials;
- Elimination of costs with non-conformity related with defects detected in final assemblies: gain of roughly $ 330 K per year;
- Reduction with training costs and turnover of the workmanship;
- Flexibility to meet the demands of production's volume;
- Payback of investment in a short period of time.

Although this study does not represent the potential for all types of furniture, nor are the advantages from automating processes in this particular case generalizable, it does provide a sense of the high-end potential for the automation of furniture; total automation appears physically feasible with existing technology.

In another paper, Hunter (2008) observed the reengineering of a furniture manufacturing cell at the Franklin Corporation, a Mississippi-based furniture company that builds reclining chairs and upholstered furniture. The Franklin Corporation reengineered its cells to emulate the Toyota Production System (TPS). The TPS is a manufacturing strategy that streamlines processes, minimizes human labor, automates certain processes, and reduces the risk of error (Hunter, 2008). Hunter observed that, although the strategy was not developed for furniture, its adoption yielded an 11.2 percent increase in productivity. Further, the manufacturing cell preceding reengineering required 11 workers, while only seven workers were required for the TPS cell.

Yet another case study by Elamvazuthi et al. (2009) examined the manufacturing of leather furniture, which requires a process called nesting. Nesting typically requires manual laborers to fit irregular-shaped pieces of material onto a surface without the pieces overlapping, and without trimming the pieces. The process of nesting is integral to many furniture manufacturers. The case study found that manual labor had relatively low productivity and high material loss. The automated alternative, however, which was comprised of two, computer-operated cutting stations, yielded higher productivity with substantially less loss of material.

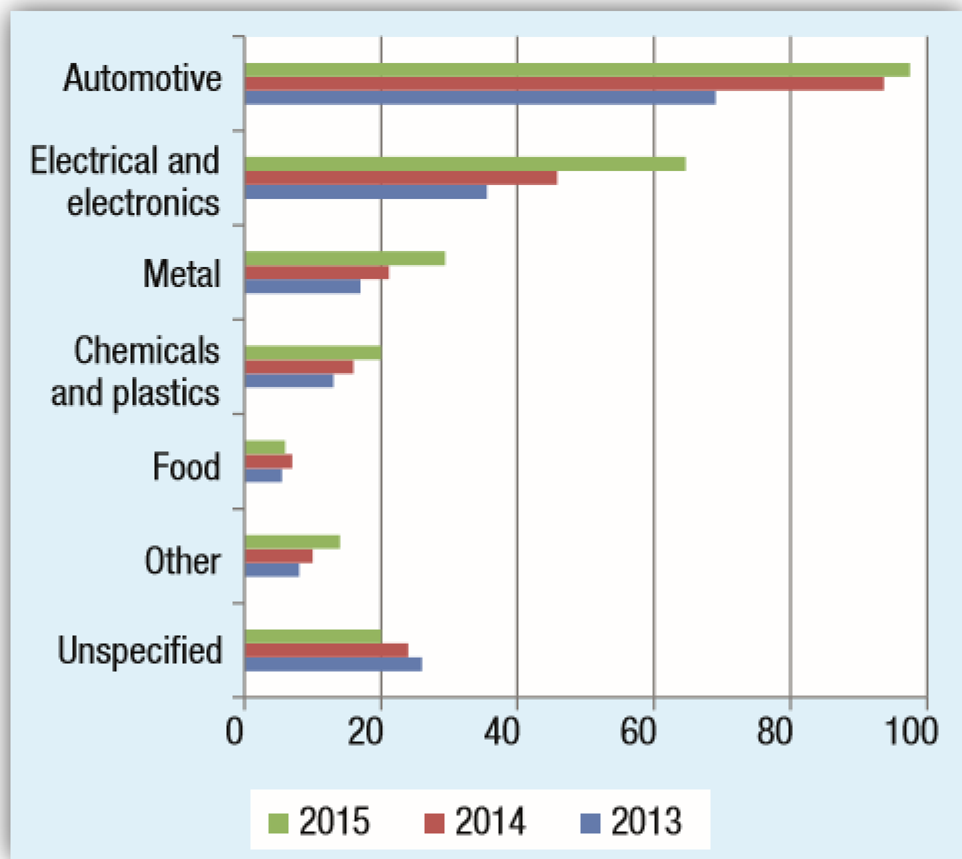
The above studies indicate a high potential for automation in the furniture industry at large. This is consistent with Frey and Osbourne's (2017) analysis of furniture finishers, an occupation they gave a 0.87 probability ranking for computerization. To put this into context, Frey and Osbourne assign the following probabilities of computerization for each respective occupation: 0.0031 for mental health and substance abuse social workers, 0.0064 for speech language pathologists, 0.011 for mechanical engineers, and 0.013 for sales managers. Furthermore, the 5.3 percent of South African manufacturing sector labor that comes from this sub-sector is almost twice as high as the 2.7 percent of the sub-sector's contribution to the sector's total income. This suggests that the work is labor-intensive, relative to the other sub-sectors.

## Transport Equipment

The second sub-sector is transport equipment. In 2014, the sub-sector employed 105,000 individuals, composing 8.9 percent of the entire manufacturing sector's labor, and 15 percent of its income. The average salary was 231,607 Rand per year, the third highest of the sub-sectors (Statistics South Africa i, 2016). Because of transport equipment manufacturing's significant percentage of the sector's labor force and income, it will be considered a high-priority sub-sector.

Global industrial robotics usage is highly concentrated in three manufacturing sub-sectors: vehicles and transport equipment, electronics and electrical equipment, and machinery (Change & Huynh, 2016; Badishkanian, 2016). This is also evident in from figure four below, which comes from UNCTAD's 2016 policy brief, "Robots and Industrialization in Developing Countries." It is clear that not only is the use of industrial robots in the automotive industry high relative to other industries, but that in most industries represented, industrial robot supply is on the rise.

**Figure Four: Annual Industrial Robot Supply by Industry (Thousands of Units)**




Source: UNCTAD, 2016

The case study expounded in the literature review comparing Volkswagen automobile assembly lines in Germany and South Africa made a clear case for automation in this South African industry as well. It concluded that the South African assembly line's optimal automation levels had not yet been reached. And furthermore, in South Africa, the average yearly salary in this sub-sector is relatively high, creating an incentive to reduce labor costs. These are all strongly suggestive of a high potential for automation in South African transport equipment manufacturing. Frey and Osbourne did not analyze any relevant job category.

### Telecommunications, Medical and Optical Equipment, and Watches and Clocks

The next sub-sector is "telecommunications, medical and optical equipment and watches and clocks" manufacturing. This seemingly gerrymandered combination of goods is loosely consistent with the United Nations' manufacturing sub-sector category, "medical, precision and optical instruments, watches and clocks" (United Nations Statistics Division, 2017). The miscellaneous nature of these goods, however, render their production's automation potential somewhat of a quagmire. For this reason, this thesis will look to the industry statistics in South Africa for clarity.

First, with only 13,000 employees and comprising 1.1 percent of the manufacturing sector labor force, this sub-sector is notably small. Further, it only accounts for 0.7 percent of the entire sector's income. The average yearly salary is 221,362 Rand, the fourth largest of the sub-sectors (Statistics South Africa i, 2016). The diversity of goods within telecommunications, medical and optical equipment, and watches and clocks manufacturing along with its dismal size and low employment figures should render its potential for automation low. Firms benefit most from automation in manufacturing at scale, and the lack of prominence of this sub-sector suggest that there is less incentive to automate productions. Further, because it only employs 13,000 workers, the weight of this group's influence on policy is low relative to more populated sub-sectors. For the purposes of this thesis, the potential for automation in telecommunications, medical and optical equipment, and watches and clocks manufacturing will be considered low, as will its priority. Frey an Osbourne did not analyze any relevant job category.

## Electrical Machinery

The fourth sub-sector is electrical machinery. In 2014, electrical machinery manufacturing employed 48,000 individuals, accounting for 4 percent of manufacturing labor and 3.1 percent of the sector's total income. The average yearly salary was 246,760 Rand (Statistics South Africa i, 2016). This sub-sector will be considered low priority because of its relatively small percentage of the sector's total employment and income.

As stated earlier, electronics and machinery are two of the three manufacturing areas with the highest concentration of industrial robotics (Change & Huynh, 2016; Badishkanian, 2016; UNCTAD, 2017). This sub-sector overlaps with both of them and has a high average yearly salary, suggesting that there is a high automation potential. To buttress this classification, this section will expound two case studies that assess the effect of automation and technological change in electronics machinery production.

Vitkova and Hajek (2016) developed a case study investigating the optimization of costs in the production of small electronic machinery. First, they established the costs of the components involved in the production of small electronic machinery. They then explored the technological improvements to the equipment's manufacturing life cycle. Among these improvements were automation of production and automation of testing, but they also included additional non-automated hardware. Based on Vitkova and Hajek's calculations, the cost reductions after upgrading production were approximated as the following:

- Material – 3.42 percent reduction
- Personnel cost – 0.50 percent reduction
- Energy cost – 0.45 percent reduction
- Other cost – 2.45 percent reduction

This case study illustrates that there are considerable cost-reduction incentives to automating aspects of production in the electrical machinery sub-sector.

The second case study (Suzuki, 1993) investigates research and development spillovers and their effect on electrical machinery manufacturing in Japan. Although Japan's economy and social structure is starkly different than South Africa's, there are two key takeaways. First, the study found that research and development has substantial spillovers even to competing firms. Second, the study found that these spillovers have a labor-substituting effect, suggesting that technological advances in this manufacturing sub-sector may displace labor. This sub-sector appears to have a high potential for automation, which is consistent with Frey and Osbourne's (2017) findings of a 0.95 percent probability of computerization for electrical and electronic equipment assemblers.

## Metals, Metal Products, Machinery, and Equipment

The fifth sub-sector is metals, metal products, machinery, and equipment. In 2014, it employed 250,000 individuals, accounting for 21 percent of labor in the manufacturing sector and 16.6 percent of the sector's total income. The average salary was 209,405 Rand per year (Statistics South Africa i, 2016). From the start, the sub-sector's high percentage of employment and income in the sector makes it a high priority. In order to determine the potential for automation in this sub-sector, an industry document and a case study will be expounded.

An Emerson Industrial Automation (2015) report provides an in-depth overview of metal, metal product, and machinery manufacturing and explicates the applications and benefits of automating processes. The report lists the following as processes which are optimized when automated:

- Degreasing lines
- Coating lines
- Bonding lines
- Slitters and cutting lines
- Cut-to-length machines
- Aluminum cold rolling mills
- Copper cold rolling mills
- Metal presses
- Wiredraw lines

Further, the report lists the following benefits to automating the above processes:

- Manufacturing consistently high quality finished metals
- Providing precision and repeatability in terms of performance, control and long term reliability from machinery
- Maximizing productivity and throughput
- Saving energy
- Reducing operation costs
- Providing the support and technology to exactly meet your production requirements
- Enhancing safety and providing environmentally sound solutions

The report continues to explain the far-reaching capacity of automation within this industry, making a clear case that many of the processes in this area of manufacturing can be automated, and that there are incentives for doing so.

A case study by ABB Robotics (2010) investigated an Ontario-based manufacturing firm, Azimuth Three Enterprises, and its recent investment in industrial robot integration into its metal fabrication production facilities. Notably, one of the driving factors behind this investment was reportedly the lack of skilled laborers. The study found that the use of robotics addressed this issue for the firm and resulted in increased speed and accuracy and a reduction in cost and maintenance. Because of the capacity to automate processes in this sub-sector and the strong apparent incentives to do so, metals, metal products, machinery, and equipment manufacturing will be considered to have a high automation potential. This is consistent with the findings of Frey and Osbourne (2017), who gave a 0.82 probability of computerization to sheet metal workers, and a 0.88 probability to metal-refining furnace operators and tenders.

### Glass and Non-Metallic Mineral Products

The sixth sub-sector is glass and non-metallic mineral products. In 2014, it employed 60,000 individuals, constituting five percent of total manufacturing labor and three percent of total manufacturing income. The average salary was the third lowest of the sub-sectors, at 145,822 Rand per year (Statistics South Africa i, 2016). Because of the small size of the sub-sector, it will be considered a low-priority industry. To estimate the automation potential of this sub-sector, this section will reference a comprehensive report involved with the industry.

In 2004, Siemens, a large, industrial manufacturing company, published an analysis of industry trends in glass manufacturing along with a series of case studies analyzing various firms (Siemens, 2004). The report made a compelling case for very momentous trends towards robotic automation in industrial automation and the integration of computer-based management in almost all aspects of production. The analysis was supported by a number of case studies, including the two following.

The first case study, “Transparency and Reliability (Siemens, 2004), examined the recent upgraded float glass production line of Europe’s largest glass manufacturer, Saint-Gobain. It integrated both hardware and software into the existing line to bring to fruition the industry’s

"Totally Integrated Automation" concept. The study notes enhanced ability to measure pressure, flow, and temperature and overall economic benefits. Further, one computer control system controls the production lines in the entire plant, keeping real-time records of measurements in order to reduce waste.

The second case study, "Perfect Premiere" (Siemens, 2004), examined the automation of a hydraulic press in a plant that produces TV pressed glass. The hydraulic press is one of the most integral machines in the production of TV pressed glass, which is produced at the plant 24 hours a day. The automation system integrated a series of computer-controlled software systems which, after their integration, was reported to have met the complete satisfaction of the firm.

From these two cases studies, it is evident that automating critical aspects of the glass production process is possible. Frey and Osbourne's (2017) findings indicate a high level of automation potential in this industry as well, giving a 0.88 probability of computerization to extruding and forming machine setters, operators, and tenders of synthetic and glass fibers. The average yearly salary of employees in this industry in South Africa, however, is relatively low. Further, the industry accounts for only a dismal percentage of the sector's labor and total income. For these reasons, in the South African context the automation potential will be considered medium.

### Coke, Petroleum, Chemical Products, Rubber, and Plastic Products

The seventh sub-sector is coke[6], petroleum, chemical products, rubber, and plastic products. In 2014, it employed 175,000 individuals, making up 14.7 percent of manufacturing labor and 34.1 percent of its income. The average employee salary was 265,871 Rand (Statistics

[6] Coke is a solid, coal-based fuel. This does not reference the beverage coke.

South Africa i, 2016). This industry provides the highest percentage of total income, the third-highest percentage of labor, and the highest average employee salary. It is clearly a high priority industry within the South Africa manufacturing sector. Only a small percentage of activities within this sub-sector were from rubber and plastic production and most were engaged in fuel production (Statistics South Africa e, 2017). This section will discuss two case studies in order to approximate the automation potential of this sub-sector.

The first case study comes from the industry itself and is titled, "Major Petroleum Refinery Converts to New Digital Automation System" (Maverick Technologies, 2008). The refinery in this study completely revamped its production facilities, automating and upgrading flow, temperature, and pressure measurements, eliminating "midnight workarounds," and allowing for more computer-based control of combustion. Although it is unclear to what extent the changes in this case did or did not displace labor, or perhaps increased the demand for labor, this industry example illustrates the capacity to automate and digitize aspects of petroleum production.

The second study comes from the energy and fuel technology journal, Koks i Khimiya and is titled "Trends in the Automation of Coke Production" (Rudyka et al., 2009). The coke manufacturing process requires closely-monitored furnace temperatures. The automation process examined in this study streamlined system-wide operations and monitored temperatures and other conditions important to the manufacturing process. The study explicitly stated that the automation of production "reduces the workload of the staff." This does not necessarily imply job displacement, but does raise questions about the demand for existing numbers of staff. Further, the study stated that, "the presence of an operator at a local operator point is increasingly rare," insinuating a trend towards fewer of such staff. The conclusion of the study was that human error is reduced and that "completely automatic control" can be achieved.

Extrapolating from these two case studies, in concert with the high percentage of income and labor from this sub-sector, and that its average employee yearly salary is the highest of all sub-sectors in manufacturing, this industry will be considered to have a high potential for automation. This is consistent with the findings of Frey and Osbourne (2017), who assigned chemical plant and systems operators a 0.85 probability of computerization, and petroleum pump system, refinery operators, and gaugers a 0.71 probability.

### Wood and Wood Products, Paper, Publishing, and Printing

The eighth sub-sector is wood and wood products, paper, publishing, and printing. In 2014, this sub-sector employed 132,000 individuals, accounting for 11.1 percent of labor in manufacturing and 5.5 percent of total manufacturing income. The average employee salary was 156,616 Rand per year (Statistics South Africa i, 2016). Because this industry comprises 11.1 percent of the manufacturing labor force, it will be considered a high priority sub-sector. To get a sense of the potential for automation, this section will explore one case study and one industry analysis.

In the paper, "Opportunities for robotic automation in wood product industries: The supplier and system integrators´ perspective," Landscheidt et al. (2017) explored the demand for automation solutions in the wood product production industry from the side of the suppliers. They found that there was substantial demand among current and potential customers, but often little knowledge of the available technologies. Some of the main issues hindering firms from automating aspects of production, the case study reasons, are a result of managerial and workforce fears, incompetence, or lack of understanding.

In the seminal book, *Springer Handbook of Automation*, Vogel-Heuser (2009) analyzes the technical capacity of automation in the wood and paper industry in the chapter “Automation in the Wood and Paper Industry.” The chapter details the complex machinery and computing systems pervasive throughout existing wood and paper production automation, and concludes with a discussion of trends and future developments. What is clear from this 2009 chapter is that the wood and paper industry still has major advances to come throughout the entire engineering life cycle.

Both the case study on the wood product industry and Vogel-Heuser’s analysis suggest future potential for automation. The case study finds that it is not due to a lack of relevance or benefits that hinder adoption of automation technologies, but ignorance of benefits, suggesting areas where existing technologies have potential to be integrated. The industry analysis portends future developments in the automation of manufacturing that competitive firms may integrate. Further, because in South Africa this sub-sector comprises a significant percentage of the manufacturing sector’s labor force, this sub-sector will be considered to have a high automation potential. This is consistent with Frey and Osbourne’s (2017) findings, with the following probabilities of computerization: 0.91 for wood patternmakers, 0.97 for woodworking machine setters, operators, and tenders (excluding sawing), and 0.86 for wood sawing machine setters, operators, and tenders.

**Textiles, Clothing, Leather, and Footwear**

Sub-sector number nine is textiles, clothing, leather, and footwear, and in 2014, it employed 113,000 individuals. This constitutes 9.5 percent of the country's manufacturing labor force, and 2.2 percent of the sector's total income. The average salary was 69,443 Rand per year (Statistics South Africa i, 2016). This is the lowest average yearly salary of the sub-sectors as they are defined. Because nearly ten percent of the manufacturing labor force is employed in this industry but only accounts for a small fraction of total income, it will be considered a medium priority industry. This section will explicate two academic papers and one United Nations International Labor Organization (ILO) paper to provide insights into the automation potential in textiles, clothing, leather, and footwear.

In the first paper, the authors Parker et al. (1983) tested a small robotic arm specifically designed to pick up a fabric square from a stack, an iterative physical process common in the garment manufacturing industry. The paper makes numerous references to automated processes in garment manufacturing replacing human labor, but the technologies in this domain are still limited. The paper notes that no robotic component to date can compete with the human finger when it comes to various aspects of sewing and cutting fabrics. The robotic arm tested was successful in its particular task 95 percent of the time, which may be a distinguished feat of engineering, but not be reliable enough for factory-wide integration.

The second investigation (Torgerson & Paul, 1988) runs an experiment with machine-vision for robotic apparel manufacturing. The paper first explains how international competition in the textile industry drives innovation in robotic manufacturing, but that there are still technological gaps in the robotic handling of fabrics as opposed to solid materials. The authors conducted experiments with a concept called path analysis, a process in which robotic systems to use visual inputs on fabric size and shape to inform robotic motion. They found great utility in the vision-guided robotics systems, which were used in the experiment to cut fabrics, but emphasized the need for research on technologies that can join pieces of fabric robotically and autonomously.

The preceding papers were published in 1983 and 1988, respectively. The technology and its lapses that papers discuss have since been subject to significant changes. A more recent paper from the ILO on the potential for job displacement due to automation among ASEAN countries[7] discusses garment manufacturing in the Asian context, providing another point on the trajectory of industry trends through time, and thus delivering insights into the potential for automation in the industry. The paper (Chang & Huynh, 2016) consistently referred to the industry as being at high risk of automation, stating that the "large share" of garment workers is at risk. The paper also cited US textile manufacturers that were successful in "developing robots and materials-handling systems that can stitch pieces of fabric together, pick them up and move them to another machine." This clearly demonstrates important technological advances since the Torgerson and Paul's 1988 paper.

From these three papers, it appears that the textile, clothing, leather, and footwear sub-sectors display demonstrable potential for automation. This is also reflected in Frey and Osbourne's (2017) findings, with a 0.73 probability for computerization of textile knitting and weaving machine setters, operators, and tenders, and a 0.81 probability for pressers of textiles, garments, and related materials. The factor that differentiates this sub-sector from others in South Africa, however, is the notably low salaries of workers employed in it. Although South African manufacturing salaries are on the rise (Statistics South Africa i, 2016), the relatively lower salaries in this sub-sector render it at a medium level of automation potential.

[7] Thailand, Vietnam, Indonesia, Malaysia, Philippines, Singapore, Myanmar, Cambodia, Laos, and Brunei

## Food Products and Beverages

The final sub-sector is food products and beverages. In 2014, it employed 230,000 individuals, comprising 19.3 percent of the manufacturing sector's total labor force and 17.1 percent of its income. The average yearly employee salary was 155,094 (Statistics South Africa i, 2016). Because 19.3 percent of the manufacturing labor force work in this industry, it will be considered high priority. In order to estimate automation potential, this section will explore two papers on the topic.

The first paper comes from an Institute of Electrical and Electronics Engineers conference (Schleipen & Drath, 2009). The paper examines a data format that facilitates the storage and exchange of engineering data, called Automation Markup Language (AutomationML). The paper focuses on an assembly line in the food and beverage industry to explain a model for understanding AutomationML. More specifically, the paper details the use of automation technologies on the portion of an assembly line that fills containers with infant formula. Although the paper is primarily concerned with the technical details of AutomationML's application on the assembly line, the investigation very clearly illustrates a complex, highly automated assembly line with little if any human labor involved directly with the product.

The second paper, "Trends in Food Packing and Manufacturing Systems Technology" (Mahalik & Nambiar, 2010), studies manufacturing in the industry more holistically. It notes challenges specific to the industry, especially regarding health regulations. Moreover, the short shelf life of food products, unlike other industries, forces upon manufacturers the need for speedy manufacturing processes. Concerning human employment, the paper takes a clear position that automation in the industry reduces the need for human employment and that continued adoption of automation in production lines is necessarily an industry trend.

Both of these examples point to a high level of existing technology, and the second of them points to continued expansion of production automation in this industry. Further, this sub-sector in South Africa boasts a high percentage of both manufacturing labor and total income; maintaining a competitive edge will therefore be essential. For these reasons, this thesis will consider the automation potential of this food products and beverages manufacturing to be high. This is consistent with Frey and Osbourne's findings, who give machine operators of food and tobacco roasting, baking, and drying a 0.91 probability for computerization.

## Re-Shoring of the Manufacturing Sector

Not only does the high potential for automation clearly affect South African manufacturing firms, it affects firms in other countries as well. This leads to a phenomenon called re-shoring: the return of manufacturing production to the developed countries that previously outsourced production. The appeal of low wages that once gave developing countries a competitive advantage in labor-intensive industry may be fading.

The re-shoring phenomenon is closely linked with automation in the manufacturing sector. One of the incentives driving the re-shoring of manufacturing production comes from the deluge of benefits associated with automating production. In developed countries, where physical infrastructure is generally more developed, the political climate is comparatively more stable, capital is easier to acquire, and the availability of skilled labor is greater, the comparative advantage for automation is clear.

The re-shoring of production to developed countries implicitly results in job displacement in the countries where goods were previously produced. This means that when firms in developed countries automate processes at home and cease production activities in countries where labor is cheap, the laborers in developing countries lose their jobs. Firms in developed countries, however, can only re-shore the activities that have already been offshored. In the case of the South African manufacturing sector, foreign-owned production has the potential to be re-shored when automating processes elsewhere become more productive. South African-owned firms, however, have less capacity to offshore production to developed countries than the developed countries themselves. For example, a German manufacturing firm would find it easier to return production from South Africa to Germany than would a South African firm relocating to Germany for the first time. One survey of 600 South African manufacturing firms (Roberts, 2006) illustrates the difficulty of South Africa outsourcing production to other countries. Only three of the 600 firms preferred to outsource production.

Because this phenomenon is pertinent to the future of labor in South Africa, it is necessary to draw a distinction between South African labor in South African-owned and foreign-owned manufacturing firms. Essentially, it is crucial to investigate whether or not manufacturing jobs leaving South Africa for other countries may play a role in the future of South Africa's manufacturing labor. To know this, it is important to know if that labor is primarily employed by South African or foreign-owned firms.

Determining the exact number of laborers that work for South African-owned manufacturing firms and those who work for foreign-owned manufacturing firms is problematic. The existing data on offshoring is poor, and the companies and governments that do collect this data have little incentive to publish it (Gereffi & Fernandez-Stark, 2010; Kirkegaard, 2007; Sako, 2005). The analyses that have been performed have differed substantially in their methodologies, resulting in inconsistent findings (Gereffi & Fernandez-Stark, 2010).

Statistics South Africa is the national statistical service of South Africa and publishes the country's production, labor, and census statistics. It does not, however, publish any data on the number of domestic employees working for foreign-owned firms. One possible source of this information could be the South African Corporate Income Tax, but its database does not include or publish data on the number of employees in each firm it taxes (Kreuser & Newman, 2016). The Oxford Handbook of Offshoring and Global Employment (2013) suggests capturing this data by analyzing foreign direct investment (FDI) inward flows in coordination with data from trade-in-services. Chapter 24 of this handbook, "Industrial Strategy, Offshoring, and Employment Promotion in South Africa," was unable to arrive at any set of statistics using this methodology, referring to the data as "neither consistent nor complete" and stating,

> The representation of trends often relies on nonscientific measures offered by business associations, sector-based consulting firms, or the press. This makes scrutiny of data near impossible. Moreover, reports may mix definitions, so it is not always clear what is included or excluded in any representation (Altman, 2013).

For these reasons, the statistics on the number of laborers in South African versus foreign-owned firms may not be available, but the lack of these figures does not preclude an analysis of the marketability of South Africa as a destination for offshoring manufacturing production.

Further, in 2016, Deloitte published its "Global Manufacturing Competitiveness Index," which is based on a global survey of over 550 CEOs and senior manufacturing executives. The Index ranks the manufacturing global competitiveness of 38 countries from one (most competitive) to 38 (least competitive). Of the 38 countries ranked, South Africa was ranked number 24 (Deloitte, 2016), far from even the top ten optimal locations to offshore productions to, according to this analysis. One study (Roberts, 2006), found that of labor-intensive manufacturing small and medium size enterprises (SME) in clothing and textiles, only three percent of ownership was foreign, and for fabricated metals and furniture production, SMEs had zero percent foreign ownership. The apparent lack of foreign ownership in manufacturing SMEs buttresses the findings of Deloitte.

## Snapshot of Automation Potential in South African Manufacturing

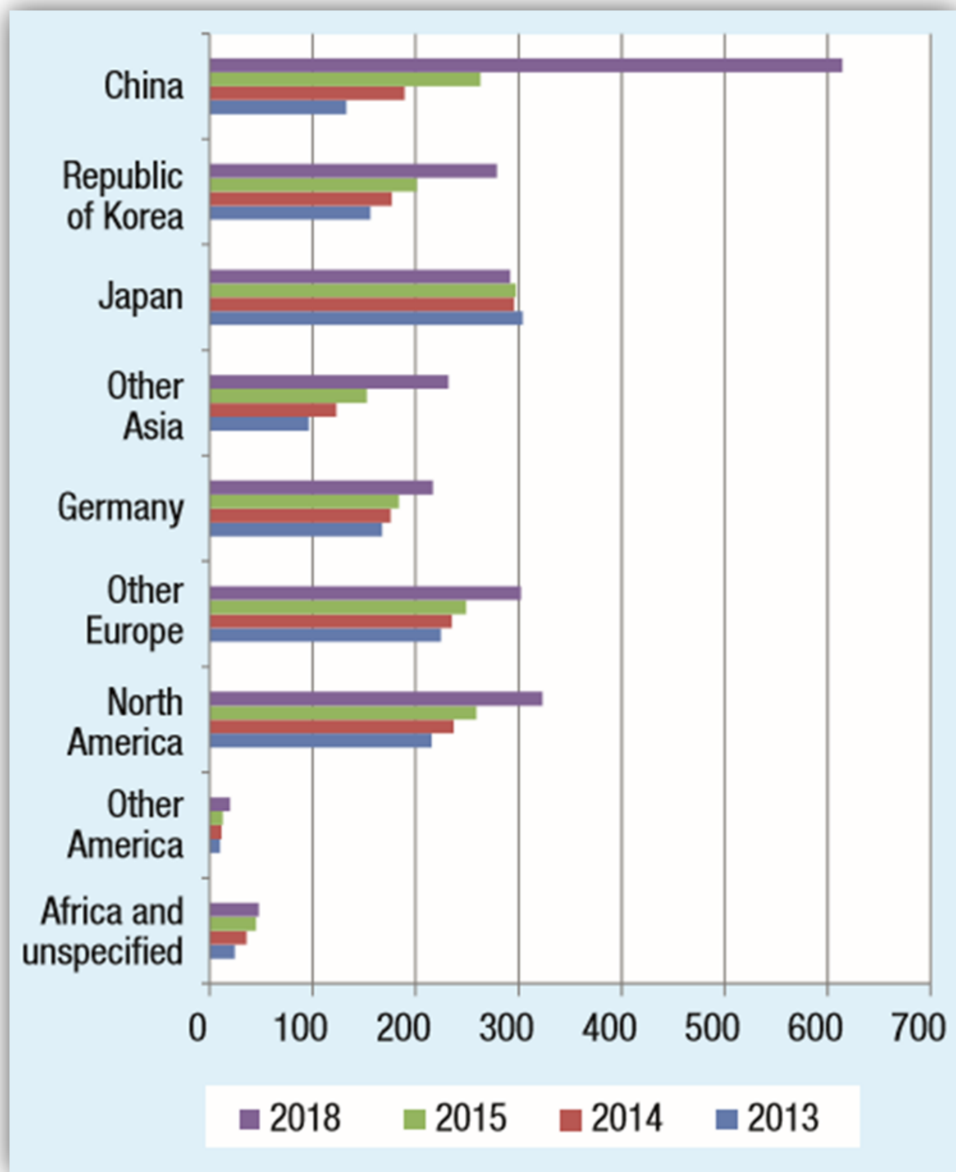
Based on the above analysis, a clearer picture of the automation potential within South African manufacturing begins to emerge. Five of the ten sub-sectors have both a high potential for automation, and a high priority level. This accounts for 892,000 workers employed in the sector, or 75 percent of the total labor force, based on the Statistics South Africa figures from its 2014 financial report (Statistics South Africa i, 2016). Further, over 1,000,000 workers are employed in sub-sectors that have a high potential for automation, accounting for 84 percent of the entire manufacturing labor force (see table one).

**Table One: Automation Potential and Sub-Sector Priority Intersections**


Although the stark majority of laborers in the South African manufacturing sector work in sub-sectors that have a high potential for automation, there is no implication that all of the jobs within each sub-sector are equally susceptible to being automated. For example, it is intuitive that a semi-skilled, assembly-line laborer working in transport equipment is more likely to be displaced than an occupational therapist. But it is also intuitive that assembly-line laborers far outnumber occupational therapists in this industry. In fact, Bhorat and Rooney (2017) found that "craft and trade workers" and "operators and assemblers" account for over 50 percent of the jobs in South African manufacturing. What the above analysis illustrates is the high potential for automation in sub-sectors that account for most of the manufacturing workforce, and that all of the high priority industries have a high automation potential.

What is also evident is that South Africa is lagging behind the rest of the world in its adoption of automation technology (see figure six). This implies a relatively low level of automation at present, and presages future investments in automation if South Africa is to remain competitive. Although it is beyond this thesis to examine the entire panoply of forces that play a role in the adoption of automation technologies in manufacturing, it has been demonstrated that there exists significant automation potential in the manufacturing sector in South Africa, and that South African firms have strong incentives to automate production.

**Figure Six: Estimated Year-End Operational Stock of Industrial Robots by Region (Thousands of Units)**




Source: UNCTAD, 2016

Re-shoring may present another challenge for South African manufacturing but it is unclear how many workers, if any, will be affected. South Africa as a destination for large-scale future offshoring, however, does not seem likely. The combination of rising wages and comparatively dismal investments in industrial robots render South Africa increasingly less attractive to foreign direct investments in manufacturing, a trend that has been captured by the Deloitte survey explicated earlier (Deloitte, 2013).

The preceding points do not bode well for the future of labor in the South African manufacturing sector. Although specific figures or occupations cannot be deduced from the preceding analysis, the consistency of trends toward automation and away from human labor in the industries with which South Africa is engaged herald job displacement for many South African workers. The next chapter will explore the socio-demographic characteristics of manufacturing laborers so that policies targeted toward them can most efficaciously advance their welfare.

# CHAPTER FIVE

# SOCIO-DEMOGRAPHICS OF SOUTH AFRICAN MANUFACTURING LABORERS

## Gender in South African Manufacturing Labor

Any policy of import to the welfare of the South African laborers in the manufacturing sector should consider the sector's demographic characteristics. This chapter will thus explore the characteristics of the South Africa labor market, and where data is available, the socio-demographic characteristics of laborers in the manufacturing sector specifically.

As discussed earlier, the unemployment rate in South Africa was 27.7 percent in 2017. Of the unemployed, 10.7 percent were previously employed in the manufacturing sector (Statistics South Africa b, 2017). Table two, below, outlines the general landscape of the South African labor market[8].

**Table Two: South African Labor Market Figures**

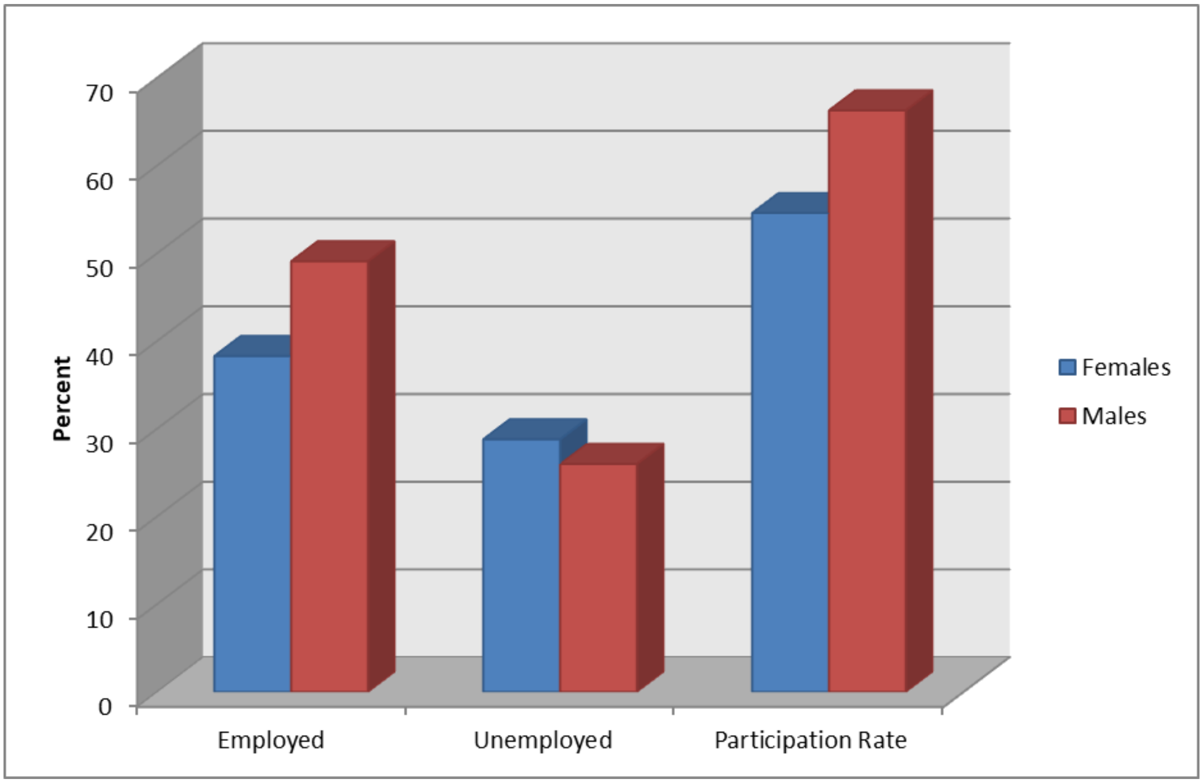
| | Total Working Age Population | Total Employed | Percent Employed | Total Unemployed | Percent Unemployed | Total Not Economically Active | Labor Force Participation Rate |
|---|---|---|---|---|---|---|---|
| Total Population | 37,061,000 | 16,212,000 | 43.7 | 6,214,000 | 27.7 | 14,634,000 | 60.5 |

Data compiled from Statistics South Africa b, 2017

Statistics South Africa's Quarterly Labor Force Survey (QLFS) for the second quarter of 2017 also published employment statistics disaggregated by gender. Figure seven displays the same figures as above, but distinguishes between men and women in the labor force.

[8] The figures in this chapter are primarily based on Statistics South Africa's 2017 second Quarterly Labor Force Survey, whose numbers slightly differ from Statistics South Africa's industry financials in 2014, expounded earlier.

**Figure Seven: South African Labor Force Disaggregated by Gender**



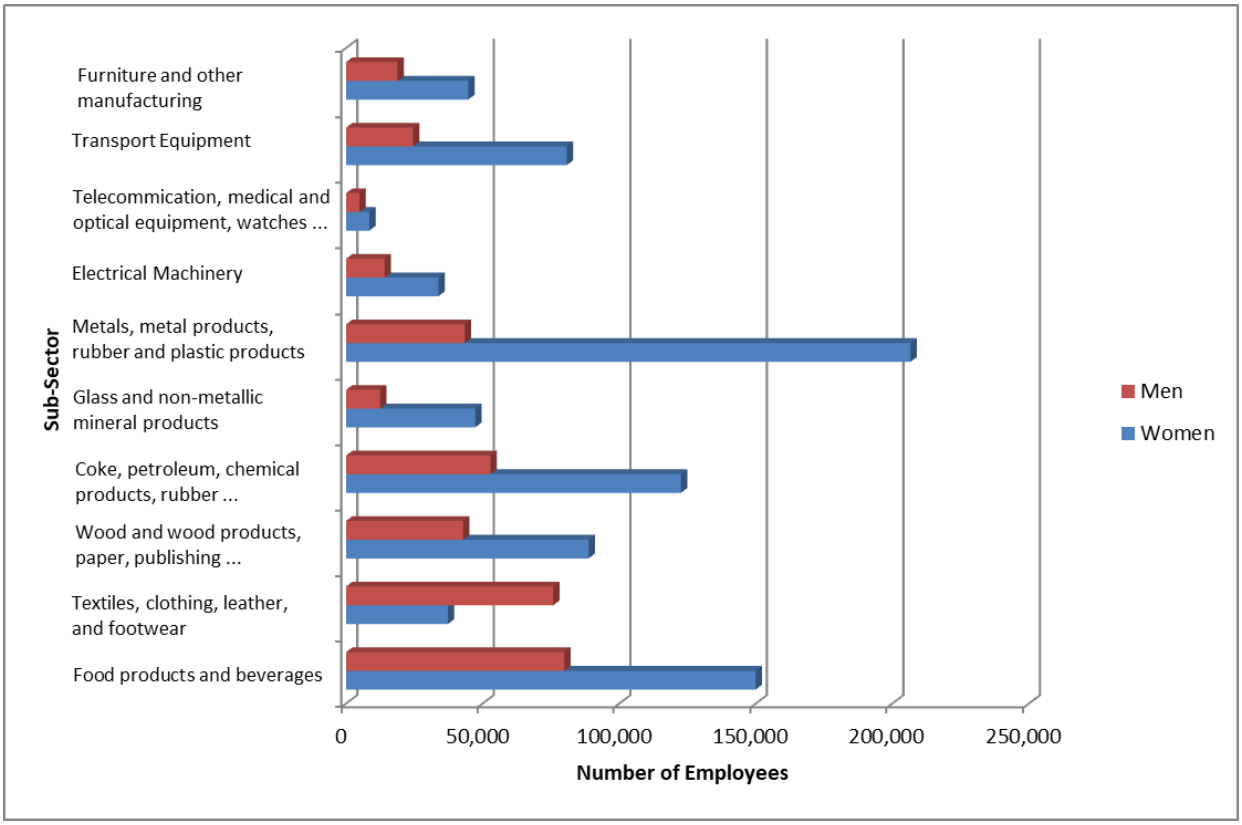

Data compiled from Statistics South Africa b, 2017

From these figures, it is clear that a notably higher percentage of males are employed than female. The unemployment rates, however, are closer to parity. When accounting for labor force participation rates, however, it becomes evident that the lower participation rates for females can account for the lower employment percentage.

The lack of female participation in the labor force does not necessarily entail a lack of will to participate. The QLFS considers an unemployed person an individual capable of work that at some point in the preceding four weeks, from the time of the survey, actively sought work, but did not work during that time (Wilkinson, 2017). It is perfectly conceivable that many women that the QLFS considers not participating in the labor force have either been searching for work for more than four weeks or have stopped searching for work due to a lack of opportunities, but would be willing to work.

In the manufacturing industry, the labor force is dominated by males. According to the 2017 QLFS, the sector employs 820,623 males and 369,813 females. Figure eight displays the employment within each sub-sector broken down by gender.

**Figure Eight: Manufacturing Sector Labor by Sub-Sector and by Gender**




Data compiled from Statistics South Africa i, 2016

Only in the textile industry do females outnumber males. Despite this, however, the Department of Trade and Industry claims that 50 percent of senior management positions employ females (Department of Trade and Industry, 2017). Surmising that laborers in low or semi-skilled positions are more susceptible to job displacement due to automation, females already working in the manufacturing sector may have, proportional to total employment, more protection than men. Even if employment by skill level were assumed proportional to employment by gender, because more than twice as many males are employed in the manufacturing sector than women, if job displacement were to occur in this sector at scale, it would likely result in more unemployed males than females.

## Age in South African Manufacturing Labor

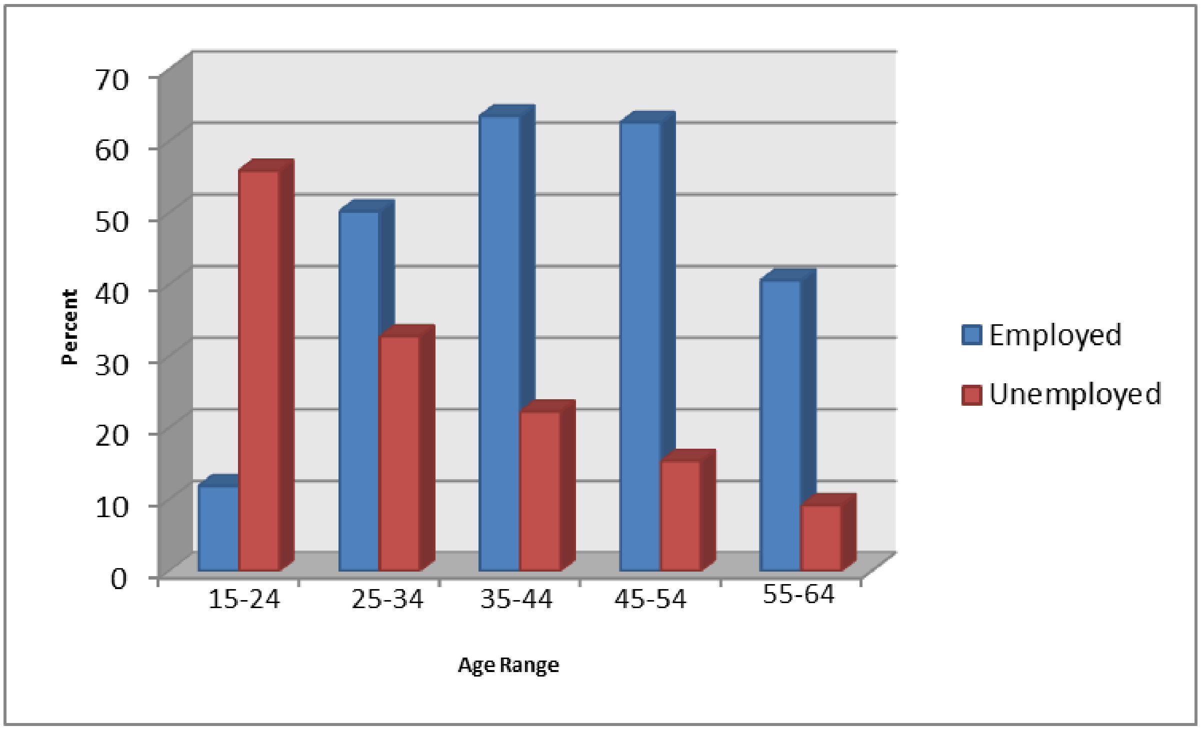
Also compiled from Statistics South Africa's 2017 QLFS for the second quarter, the table and graph below displays South Africa's employment statistics by age (see table three and figure nine).

**Table Three: South African Labor Force by Age**

| | Total Working Age Population | Total Employed | Percent Employed | Total Unemployed | Percent Unemployed | Total Not Economically Active | Labor Force Participation Rate |
|---|---|---|---|---|---|---|---|
| 15-24 | 10,315,000 | 1,226,000 | 11.9 | 1,552,000 | 55.9 | 7,537,000 | 26.9 |
| 25-34 | 9,780,000 | 4,907,000 | 50.2 | 2,399,000 | 32.8 | 2,473,000 | 74.7 |
| 35-44 | 7,943,000 | 5,040,000 | 63.5 | 1,450,000 | 22.3 | 1,452,000 | 81.7 |
| 45-54 | 5,467,000 | 3,420,000 | 62.6 | 623,000 | 15.4 | 1,424,000 | 74 |
| 55-64 | 3,712,000 | 1,506,000 | 40.6 | 153,000 | 9.2 | 2,053,000 | 44.7 |

Data compiled from Statistics South Africa b, 2017

**Figure Nine: South African Labor Force, Percent Employed, by Age**




Data compiled from Statistics South Africa b, 2017

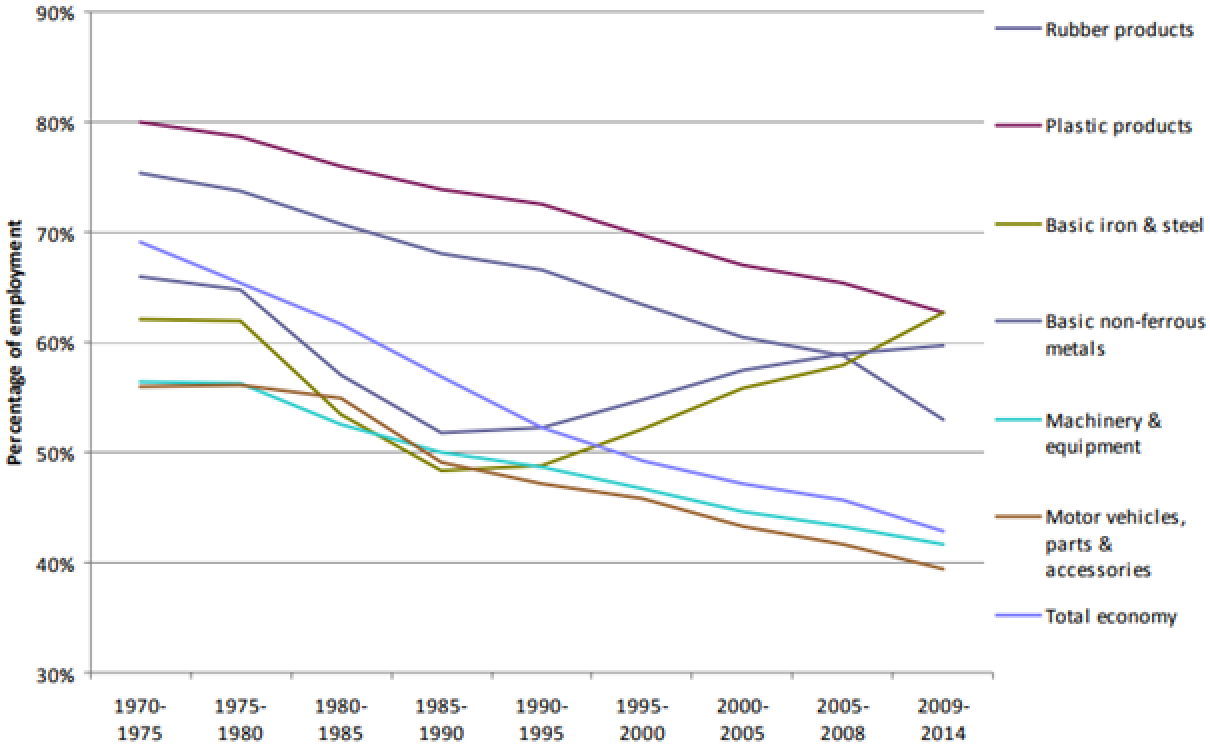
From table three, the total working age population distribution clearly exhibits the properties of a pyramid-like structure. This distribution, though, is not represented in the numbers of total employment, and continues to deviate in the distribution of percentages of employment. The 25-34 age range's total employment figure swells at nearly 5,000,000 people, but so does its total number of unemployed. As much as 38.2 percent of the working age population in this age range is unemployed, accounting for more than 2,000,000 people. And although this age range accounts for 38.2 percent of the nation's unemployed persons, it only makes up 26 percent of the working age population.

The 15-24 age range represents a disproportionate percentage of unemployed persons as well, comprising 25 percent of unemployed persons and 28 percent of the total working age population. Although these two percentages do not differ significantly, this age range accounts for over half of those not participating in the labor force at all. This is ostensibly due to many individuals from this range being still in school. These figures are consistent with Sachs and Kotlikoff (2012), discussed earlier, who found that lower levels of skill exist in younger demographics and thus are less attractive in the labor market.

## Education and Skill Level

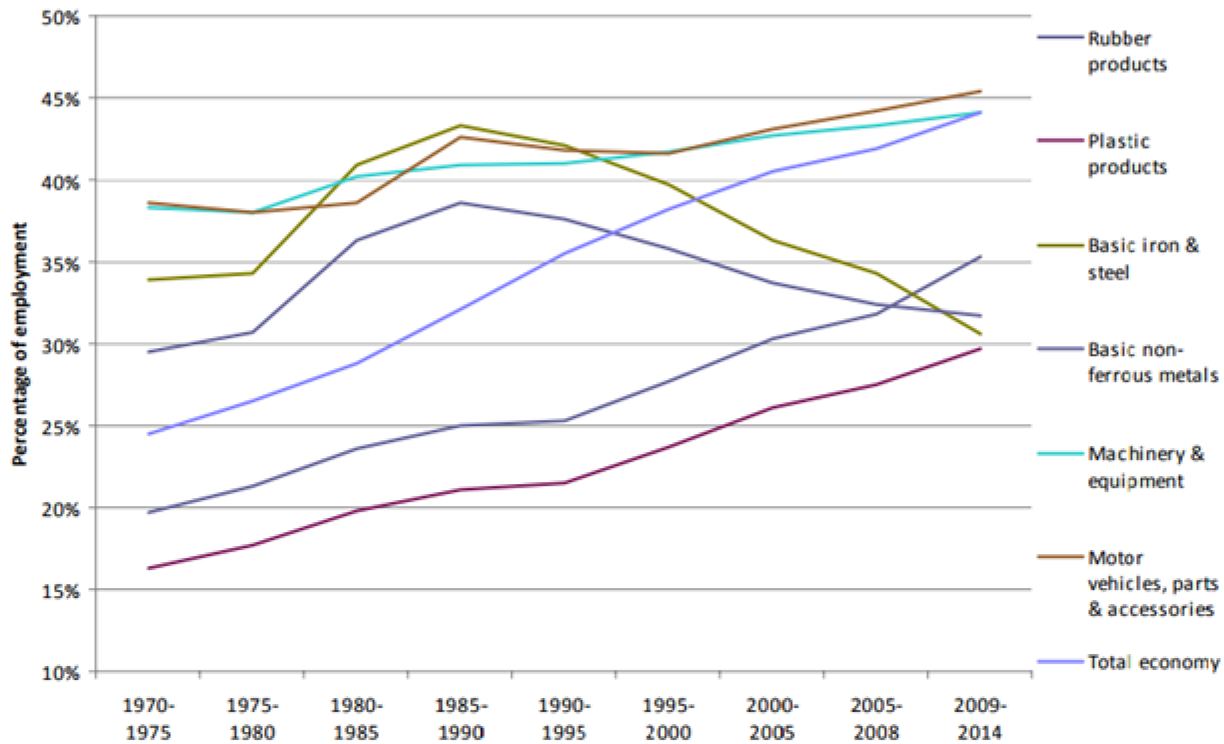
As discussed earlier, the skills gap between low or semi-skilled and skilled labor is manifesting in employment trends. While demand for low and semi-skilled labor decreases, the demand for skilled labor sees a corresponding increase. This is true of the South African manufacturing sector as well. Figure ten displays the trend away from semi-skilled and unskilled labor, where in a 44 year period some industries saw a drop of as much as 15 percent of employment of this skill demographic. Figure eleven shows the similar trends in skilled labor, and figure twelve in highly skilled labor.

**Figure Ten: Trends in Semi-Skilled and Unskilled Labor in South African Manufacturing**



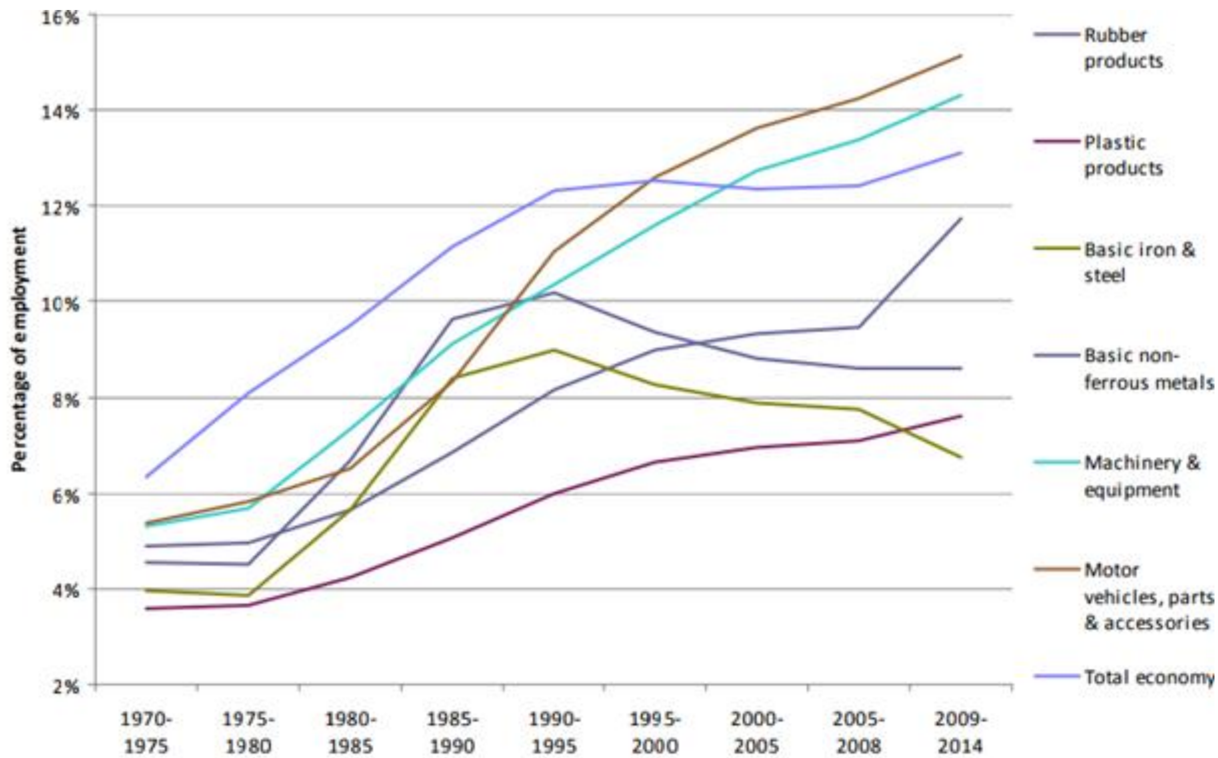

Source: merSETA, 2010

**Figure Eleven: Trends in Skilled Labor in South African Manufacturing**




Source: merSETA, 2010

**Figure Twelve: Trends in Highly Skilled Labor in South African Manufacturing**




Source: merSETA, 2010

### Race in South African Manufacturing Labor

The last demographic characteristic to be unpacked is race. Table four, below, displays the breakdown of employment by race. Graph thirteen displays the breakdown of the total working age population by race, and figure fourteen illustrates the employment disparity between races.

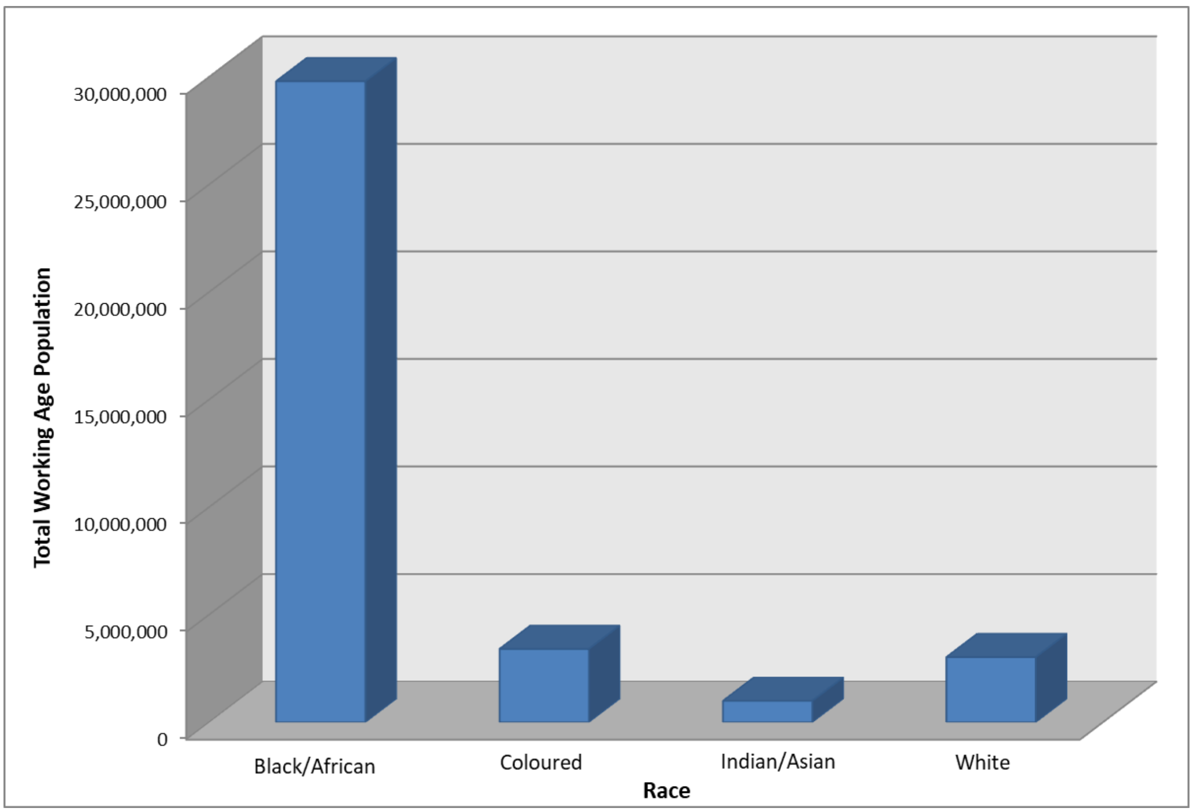
**Table Four: South African Labor Force by Race**[9]

[9] These are South Africa's four primary official categories of race

| | Total Working Age Population | Total Employed | Percent Employed | Total Unemployed | Percent Unemployed | Total Not Economically Active | Labor Force Participation Rate |
|---|---|---|---|---|---|---|---|
| Black/ African | 29,798,000 | 12,025,000 | 40.4 | 5,479,000 | 31.3 | 12,294,000 | 58.7 |
| Coloured | 3,406,000 | 1,631,000 | 49.8 | 503,000 | 23.6 | 1,272,000 | 62.7 |
| Indian/ Asian | 992,000 | 526,000 | 52.9 | 80,000 | 13.3 | 388,000 | 61 |
| White | 3,028,000 | 1,918,000 | 63.5 | 115,000 | 5.7 | 987,000 | 67.3 |

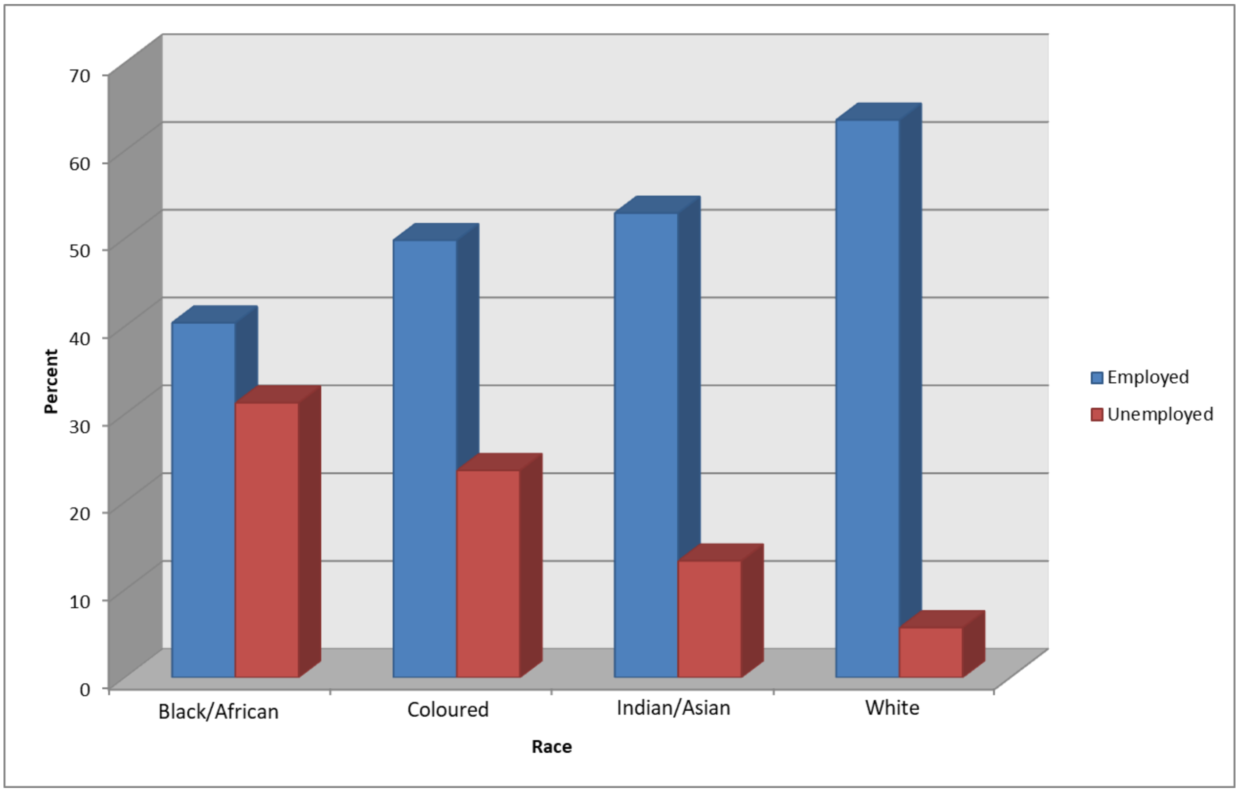
Data compiled from Statistics South Africa b, 2017

**Figure Thirteen: South African Labor Force, Total Working Age Population, By Race**




Data compiled from Statistics South Africa b, 2017

**Figure Fourteen: South African Labor Force, Percent Employed, by Race**




Data compiled from Statistics South Africa b, 2017

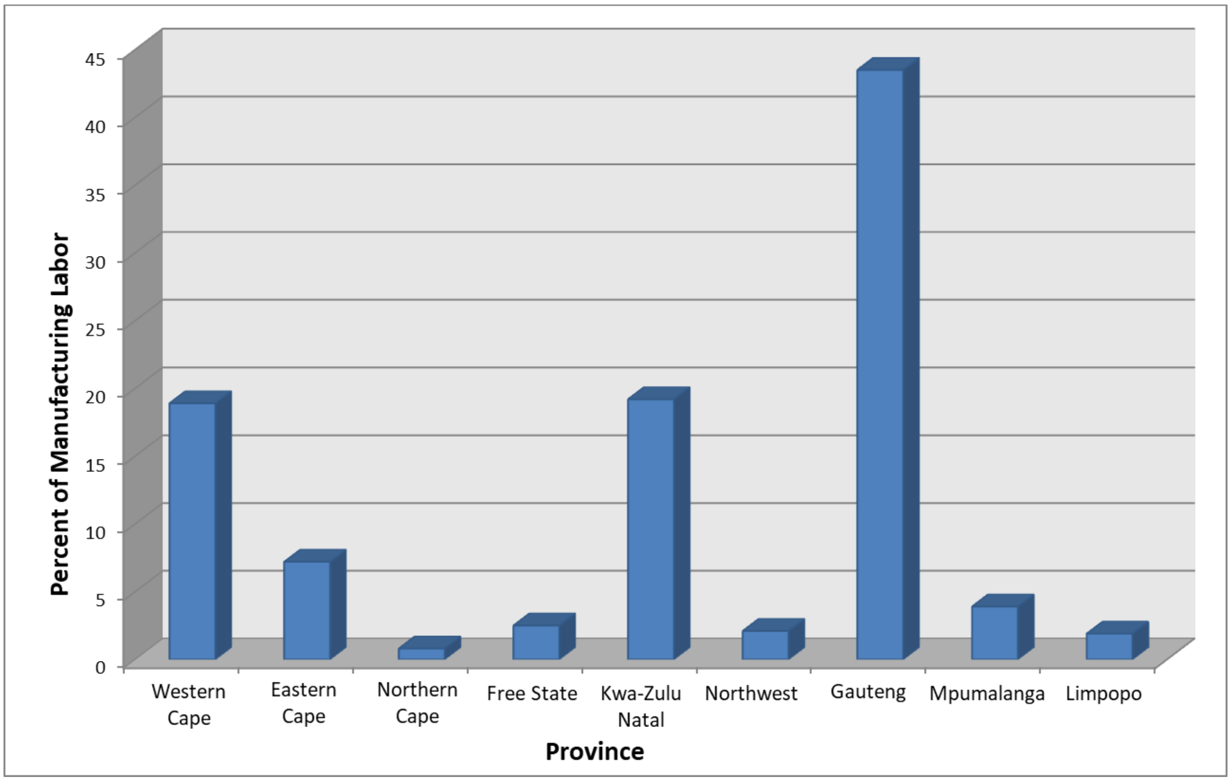
What is lucidly clear from the above figures is that Black/African population experiences significantly higher levels of unemployment than the others listed. This is both a factor of the substantial difference in the size of populations by race, and the higher percentage of unemployment among the Black/African population.

## Snapshot of South African Labor Force

The South African labor market is primarily comprised of Black/African workers. It is also dominated by males. In the manufacturing sector, this is especially true, where more than twice as many males are employed than females. Every sub-sector within this industry sees predominantly male employment, with the exception of the textiles, clothing, leather, and footwear sub-sector.

The labor market at large sees its highest rates of unemployment among younger demographics, namely, the age ranges of 15-24 and 25-34. Unemployment among these populations corresponds with a lack of skills. This, as well, is especially true in the manufacturing sector, where low and semi-skilled labor is in decline and high-skilled labor is rising. Further, figure fifteen below displays labor in the manufacturing sector by province.

**Figure Fifteen: Percent of Manufacturing Employment by Province**




In the context of potential job displacement due to automation in this sector, low and semi-skilled, young, black males appear most at risk. This is because labor in this sector, assuming at least a loose representation of race in the South African labor force, is primarily comprised of Black/Africa peoples, and specifically males in this sector. Moreover, unemployment exists in its highest percentages among young demographics, and in manufacturing, is moving away from low and semi-skilled labor. It is thus this population with which policies intending to embrace unemployment in manufacturing should be most urgently concerned.

# CHAPTER SIX

## POLICY RECOMMENDATIONS

### Sector Security

As discussed, job displacement due to automation is not a new phenomenon, albeit its vicissitudes of degree and variety may be particularly unfavorable to future workers. Boasting employment for nearly 11.2 percent of the total workforce (Statistics South Africa b, 2017), the manufacturing sector is critical to South Africa's economy and social fabric. Policy makers should take proactive measures to promote the sector's competitiveness as it finds its footing in the twenty-first century, while also considering the welfare of those whose livelihoods are supported by their employment within it. The first of three policy suggestion areas is concerned with securing the sector's role in the future of global manufacturing.

In Deloitte's report on enhancing manufacturing competitiveness in South Africa (2013), the importance of cooperation between public and private sectors is proffered as a crucial means to secure a competitive edge. Two policies already included in the DTI's IPAP stand out as contenders for frameworks of cooperation between the private and public sectors in South Africa. They are the Protection of Investment Act of 2015, and the National Supplies Procurement Act of 1970.

The IPAP provides the following description of the 2015 Protection of Investment Act: to "provide for the protection of investors and their investments; achieve a balance of rights and obligations that apply to all investors; and provide for matters connected therewith" (Department of Trade and Industry, 2017). This policy is further discussed in relation to bilateral investment treaties under review by the DTI. In its review process, the DTI has terminated 15 out of the 22 first-generation treaties germane to the industry. The “Interministerial Committee of Investment” is in the process of negotiation of? a new model bilateral investment treaty which will be aligned with the Protection of Investment Act of 2015, with a specific focus on intellectual property rights.

The interim nature of the implementation of this policy and its effect on bilateral trade agreements provides an opportunity for consideration of the future of the manufacturing sector and its increasingly important relationship with automation. As shown earlier (see figure six), Africa as a continent has invested dolefully less in industrial robotics than the rest of the world. Germany alone, for example, had roughly an order a magnitude more industrial robots in stock in 2013 than the entire continent of Africa. The Interministerial Committee of Investment should include provisions in the model bilateral investment treaty, off of which future bilateral investment treaties will ostensibly be based, to promote investments in industrial robots, perhaps by reducing tariffs on imports or establishing reliable apparatuses of dispute resolution for potential investors.

Second, and related to the Protection of Investment Act, is the National Supplies Procurement Act of 1970. The IPAP provides the following description of the policy: to “empower the responsible Minister to manufacture, produce, acquire, hire or import goods; acquire, hire or supply services; exercise control over goods and services, and the manufacture, production, processing and treating of goods; and provide for the establishment and administration of a national supplies procurement fund” (Department of Trade and Industry, 2017). Although this Act was put forth in 1970, it is still part of the DTI’s IPAP, and provides a framework for the acquisition of automation technologies which can keep South Africa competitive. Perhaps the negotiations of the Interministerial Committee of Investment should consider allocating specific powers to the relevant Ministers mentioned in the National Supplies Procurement Act, which would facilitate import of industrial robots and technologies necessary to automate future productions and keep up with the technological changes of the sector.

Lastly and more broadly, to reiterate the advice of UNCTAD in "Robots and Industrialization in Developing Countries" (2016), intra and inter-sectoral linkages help the sector take advantage of existing strengths and intrinsic comparative advantage. For example, South Africa is well known for its robust mining industry and abundance of natural mineral wealth. Many manufacturing processes utilize or refine the same minerals excavated in the mining sector. There therefore exists an opportunity to leverage policy in order to encourage linkages between these two sectors. Policies that advantage South African manufacturing firms' access to domestically-mined mineral goods may be in order. It is, however, critical to enact policies that refrain from disadvantaging the mining industry, such as an export tariff on mineral goods. One alternative may be tax breaks for mining firms that sell a certain percentage of their mineral wealth domestically, indirectly providing incentives that reduce input costs to South African manufacturing firms and crafting a comparative advantage.

## Skill Upgrading

The second set of policy recommendations pertain to upgrading skills of some manufacturing workers to both meet the rising demand for skilled labor in the industry and provide job security to workers. This is especially germane to younger populations and the existing skills development and educational institutions, about which the OECD has stated in a policy brief, "with low quality, low status and low labour market relevance, the system is ill-prepared to address the needs of the country's burgeoning youth population" (South Africa Policy Brief, 2015).

In 2015, Ireland's official agency for international development, Irish Aid, published a comprehensive study on the youth labor market in South Africa's manufacturing sector (Irish Aid, 2015). The study interviewed representatives of government institutions, employers, youth currently undergoing related training, and other stakeholders. Of the 18 employers interviewed, there was a clear consensus that training youth employees internally was preferred to outsourcing to government training programs. It was also clear that employers preferred to hire from within rather than from pools of recent graduates from vocational and technical colleges, noting a lack of confidence in the nominally higher qualifications of recent graduates.

One existing activity which exhibits potential for expansion is the use of the Sector Education Training Authority (STEA) Grant. This grant provides financial backing for internships, apprenticeships, and learnships[10] for workers entering or already working in the manufacturing industry. The SETA grant supplements employer contributions to training programs. This bypasses the otherwise necessary delegation of training to technical colleges, and instead allows employers to train employees directly, while not incurring the entirety of the costs. Further, the same Irish Aid survey found that manufacturing firm employers have consistent access to these grants, and that the grants allow them to train "beyond their immediate company needs" (Irish Aid, 2015). An expansion of support for this grant may help manufacturing firms prepare for the reskilling needs as technology prompts industry advances.

[10] A vocational learning program comprised of 1,200 hours of practical training experience in a trade, which leads to a qualification registered in South Africa's National Qualifications Framework.

Government and private sector cost-sharing initiatives for training and reskilling manufacturing employees is not new. In addition to SETA grants, the 2015 IPAP announced a 1.6 billion Rand investment in a South African Mercedes-Benz assembly plant's equipment upgrades and the reskilling to complement the upgrades (Department of Trade and Industry, 2015). But if the manufacturing sector experiences net job losses, the government may consider supporting career-change grants in the same spirit of SETA. For example, Autor and Dorn (2013) have linked losses in manufacturing jobs with the growth of the services industry. A grant modeled off of the successful SETA grants that, instead of cost-sharing the upgrading of skills within sectors, provided cost-sharing for retaining between sectors could be of import to manufacturing workers displaced by automation. This grant scheme could easily be targeted toward youth populations.

### Social Net Expansion

The last arena of policy suggestions exists in the domain of social welfare, and is the most controversial. As stated earlier, it is unrealistic to expect that all of the labor within the manufacturing sector at present can be adequately retrained as the labor market changes, and that the net total of jobs proportional to the population will remain the same. It is thus evident, in order to maintain the welfare of those displaced and unable to find similar work, that there must exist policies which embrace the needs of those left behind, should such a population manifest.

South Africa already has a well-established social grant system. SWGs are meant to support the basic needs of individuals with certain circumstances that warrant government support to meet those needs. There are six grant classes that determine eligibility for a SWG, namely: a grant for older persons, a disability grant, a war veteran's grant, a foster child grant, a care dependency grant, and a child support grant. These grants range in value from 380 to 1,620 Rand, all on a monthly basis (South African Social Security Agency, 2017).

These grants have been shrouded in controversy in both political and private circles. In response to controversy, Neves et al. (2009) conducted a large, mixed method investigation and published their findings in. "The use and effectiveness of social grants in South Africa." The qualitative component of this study built upon previous studies of the same nature, and the quantitative component conducted a propensity score matching analysis on QLFS statistics. There were a number of key findings. The authors found that not only do social grants provide a fiscal safety net for those most vulnerable, but that social grants catalyze consumer activity. Such consumer activity has the effect of buttressing the informal market, as well, increasing net economic activity in the country by increasing transactions. Further, the authors found that, compared to similar individuals not receiving social grants, those receiving them saved more and invested in production capacities at a higher rate.

The above paper, however, is far from the only opinion or analysis. Others such as Bhorat (2002) argue that an UBI in South Africa of merely 100 Rand a month would bankrupt the country. Although it is outside the domain of this thesis to run an econometric analysis and determine a feasible financing scheme for expanding South Africa's SWG system, it is evident that the social welfare landscape will have to respond to changes in society, and that part of this may be an expansion of SWG to embrace the needs of unemployed, young, Black/African, low-skilled persons. This demographic suffers from the highest levels of unemployment, and is consistent with the demographic most likely to be displaced by automation in the manufacturing sector, except that males are particularly vulnerable in manufacturing.

This alludes to a much broader social problem than that with which this thesis can address with the required degree of depth: unemployment among South African youth at large. The demographic most vulnerable to job displacement due to automation in the manufacturing sector, namely young, Black/African, low-skilled males, is thus a subset nested within a broader population that shares its demographic characteristics. To devise a social welfare policy that *only* addresses the manufacturing subset of the unemployed, young, low-skilled South African demographic seems discriminatory in an unnecessary and imbalanced manner. Any solution that aims to address unemployment among young, Black/African, low-skilled South Africans will thus, by default, address the demographic subset with which this thesis is mainly concerned. To advise on social welfare policies that address this entire population is outside of the purview of this thesis. Those not able to be reskilled, or whose jobs are not protected by the preceding two policy suggestion areas, will ultimately fall into a broader category of unemployed, Black/African, low-skilled youth. Continued research is required to explore policies to accommodate the needs of this broader demographic, but an expansion of the SWG scheme should reside at the core of such research.

## Conclusion

The South African government expressly considers its manufacturing sector to be both a source of future employment for its citizens and an integral driver of the nation's economy. Although these objectives appear to run parallel to one another at first glance, moving into the twenty-first century, further scrutiny begins to reveal future deviation in their respective trajectories. The same advances that can keep the manufacturing sector competitive and producing wealth for the South African economy threaten to displace low and semi-skilled laborers. In the United States, for example, from 2004 to 2014, manufacturing output in dollars increased 0.7 percent annually on average. This increase in output ran in concert with a -1.6 annual rate of decrease in employment, resulting in two million lost jobs (U.S. Bureau of Labor Statistics, 2015).

The South African government appears not to recognize this trend away from low-skilled, labor-intensive employment. The Department of Trade and Industry stated in its 2015 IPAP:

> "The manufacturing sector is critical to sustainable growth, as set out in all previous iterations of IPAP. The undeniable, repeatedly demonstrated facts are that manufacturing has the highest growth and employment multipliers of all the economic sectors…"

After breaking down the South African manufacturing sector into ten sub-sectors, this thesis assigned a high, medium, or low potential for each sub-sector to see integration of labor-displacing automation into its production lines. It also assigned a priority level of each sub-sector to the sector's vitality as a whole. It was found that 75 percent of the total manufacturing labor force is employed in high priority sub-sectors that are highly vulnerable to automation. By breaking down the South African labor force's socio-demographic characteristics, it was found that the most vulnerable population to job-displacing automation in the manufacturing sector is young, low-skilled, Black/African males.

Three classes of policy suggestions follow from this analysis. The first policy suggestion area pertains to protecting the sector's competitiveness internationally. The second proposes policy options to support employee retraining and skill upgrading. The third policy suggestion area is concerned with buttressing South Africa's social safety net in order to accommodate for potential job-displaced persons who do not find alternate employment.

Although the future of the relationship between automation and labor is shrouded in bitter disagreements, Delphic prophesies, naïve optimism, and tired cynicism, the trend toward the integration of automation technology into manufacturing production lines and process chains is undeniable, and South Africa is not exempt. It may not be possible to precisely predict the employment figures in decades to come, but it is as obvious that South Africa's job-creation plans are flawed, as it is necessary that the nation revisits its industrial policies. Political interests that promise jobs in labor-intensive industry should be viewed with suspicion. Only by being realistic about the future of labor in the South African manufacturing sector can the nation deliver effective policies to simultaneously promote employment and the vitality of the sector.

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