The Future of Automation in Human-Based Manufacturing: The Case for Manufacturing in South Africa

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Abstract

The fourth industrial revolution (4IR) has brought with it an excess of possibilities for automation within various industry sectors. The 4IR will be achieved by using technology to change the way of life, to change how products/services are produced/provided by manufacturers and to change the mechanics of globalization significantly if not completely. This new way of life will see many occupations being replaced by automation while completely new ones are created. In the South African context, there is evidence from the banking sector where, occupations that previously required human consultants for customer queries have been replaced with self-service platforms for consumers. This phenomenon has led some big companies in SA have plans to close down their call center departments. Additional reports on 4IR point to the unfortunate eventuality of job losses in the auditing, legal and health industries just to name a few. This paper looks into the future of this advanced wave of automation in the context of the South African manufacturing sector. It examines the subject of automation in manufacturing in South Africa, a means to gauge the state of automation compared to global competitors. The intention was to determine how this automation has been implemented on a global scale and how this has eventually affected the human operator. The necessary pre-conditions for automation have been investigated. Their linkages with the levels of automation were examined.

Keywords
Automation, Robotics, Manufacturing, 4IR.

Introduction and background

As business companies strive towards more agile and responsive production systems, many companies have employed or at least have considered employing automation within their manufacturing value chains. The input factor to this change in pace within the market is the ever-changing needs of the modern-day customer. As such, most companies try to be ahead of customer needs while ensuring that the innovation rate within the organization is greater than or equal to the innovation rate outside the organization. Although innovation can, to a large extend, be influenced by customer needs, it can also be influenced by market forces through competition. Organizations constantly seek ways to minimize production costs and maximize throughput while aiming to transfer the savings in production costs to the customer through lower products' prices. Accordingly, manufacturing facilities have been filled with automated machines to perform some of the repetitive activities that were previously performed by humans. Advances in robotics have seen robotic arms performing welding operations that were previously performed by artisans. Such robots are able to perform these activities at a fraction of the time that human operators can perform similar tasks. There is an added advantage of reducing the numbers of defects and errors usually made by humans.

South Africa's economy declined by -3.2% in the first quarter of 2019 as compared with the last quarter of 2018. One of the biggest contributors in the decline of the economy is the manufacturing sector at -8.8%. The manufacturing sector in South Africa has been performing poorly in recent years, both in terms of GDP growth and job creation. This loss may be attributed to increased global competition (Bhorat and Rooney 2017) and partially South Africa's skills shortage.

In recognizing that the country needs a vibrant manufacturing sector to save the economy, the South African government published a national economic plan with the aim of increasing employment (National Planning Commission 2015). Despite this government's effort, the manufacturing sector has continued to decline over the recent few years. Manufacturing has also undergone a steady decline in volumes of production due to electricity supply shortages, high input prices (in particular fuel) and a weak domestic demand (Statistics SA 2019). The decline in output in the manufacturing sector and a subsequent decreased contribution to the GDP has consequentially resulted in job losses in South Africa over the past years. Over 13000 jobs were lost in the sector by the third quarter of 2018 (Statistics SA). The total number of job losses in South Africa during this period was 69000. Local manufacturers need to look at ways on how to improve efficiency and productivity. The answer to this predicament might just be lying in automation.

The manufacturing industry in South Africa comprises of various sub-sectors. These sub-sectors range from food and beverages, textiles, wood and paper, petroleum, metals, electrical machinery, and furniture and other manufacturing. Global technological changes have also adversely affected South Africa's manufacturing sector. The decline in output can be attributed to how SA is still lagging behind technologically as compared to global competitors. Job losses that may result post-implementation of automation are a major contributing factor to the grip of technology in manufacturing or lack thereof (Hagedorn-Hansen et al. 2016). Consequently, automation in manufacturing has been perceived as an enemy rather than a channel that will take the manufacturing sector back to its rightful position of being one of the major contributors towards the country's GDP.

Some countries have realized that automation does not necessarily bring job losses but in contrast, create new jobs. This is achieved through the primary switching of tasks to machines and leaving humans to perform complementary tasks in support of automated systems. This approach requires the prior up-skilling of current operators. Automation creates growth and growth creates jobs which then essentially means companies that are embracing automation are set to also create new jobs. Limited research has been done on the impact of automation in the developing world (Le Roux 2017). Hence, it is still unclear how South Africa will make its' way around automation with the current high number of low skilled workers as well as an education system that is not meeting the future needs of the country.
With the onset of the 4th industrial revolution, automation is set to take over more activities that were previously performed by humans. This research explored meaningful ways organizations can approach the subject of automation without totally eliminating the labor force. The work benefits all industries and academia alike. It creates awareness, to executives, on factors to consider as preconditions to automation. It also alerts employees in the business sector to take proactive steps in equipping themselves for this eventuality.

Preliminary work on this topic shows that there hasn't been ample effort put into the human factor element when automation is explored. While company executives assess the feasibility of automating human performed activities, very little has been done to assess the human-capital needs of those employees that will keep their jobs post the implementation of automated machines. Hence, organizations are yet to strike a balance between human and machine and ensure there exists a symbiotic relationship between activities that will continue to be performed by humans and those performed by machines.

1.1 Research Objectives

The main objectives were:

- To explore and identify necessary conditions (factors) for decisions to automate
- To determine whether there are significant correlations among the respective factors and the level of automation
- To explore any links between organizational targets and the level of automation.
- To gauge the relative importance of the affecting factors as perceived by the participants of the survey.
- To establish whether there is any linkage among affecting factors and the levels of automation and observe the strength of the link, if any.
- To determine if any of the levels of automation had any influence on achieving organizational targets.

2. Literature Study

Automation can be defined as "the application of machines to tasks once performed by human beings or, to tasks that would otherwise be impossible" (Britannica encyclopedia). It seeks to replace repetitive tasks, usually performed by human operators, with machine executed tasks. Automation is thus, meant to remove the need to perform repetitive tasks by humans, it is not meant to replace the human operator. It is for this reason that automation has not grown as it should have in most countries, especially in developing countries, due to a striking connotation that all it eventually introduces is unemployment. Automation thus replaces many of the activities, previously performed by humans, with machines. Robots can perform such tasks at a fraction of time that the human operator is able to complete it. An example is the application of robot welding machines that perform tasks that were previously performed by welding artisans. Although automation replaces repetitive activities aimed at high-volume production of uniform products, its implementation is still a challenge in manufacturing environments where there is a variety of products to be produce at a given time. Even though it appears as if automation increases production by minimizing the human headcount, there are some manufacturing activities that are difficult to execute manually.

Automation reduces product variation thus offering better reliability. It improves human operator's safety through less human interaction within the manufacturing system. It prompts reskilling of the operator so that they can be useful in new roles. However, automation cannot work independently without human interaction. Humans are still desirable for activities in manufacturing that require decision-making, cognitive awareness as well as instantaneous interventions to address problems when they occur on the factory floor. So, humans will still be entrusted to perform critical tasks that contribute to an organizations' performance. According to McKinsey & Company, 59% of all manufacturing activities in America could be automated but, however, humans will still be needed to perform the remaining 41% of activities.

Allocation of automation to tasks previously performed by humans should not increase the likelihood of contrary incidents within the human machine relationship (Bainbridge 1983). As an example; the intention in introducing semi-automated vehicles includes the reduction of the number of basic control monitoring tasks performed by humans. However, research on semi-automated vehicles has shown that incorporating automation in such vehicles increases the probability that drivers will perform non-driving related tasks which reduces their road-awareness and lowers their response to alerts (De Winter et al. 2014)

Modern day manufacturing is influenced by numerous factors which if ignored by organizations may lead to companies eventually being outdated. This can be understood through the case of Nokia and how they lost the smartphone market (Vuori et al. 2015). Such factors include technology. Through technology, improvements in efficiencies, utility and throughput within manufacturing plants have been observed. Use of digital developments and advanced data analysis are at the forefront of optimizing manufacturing systems. The introduction of disruptive innovations that influences customers' requirements, is another factor. Such innovations are often by organizations that take advantage of available technologies to gain market share and deliver better on their organizational goals. Innovation is about observing consumers/clients in order to satisfy them by providing new products/services as well as to have a strategic position in the market and withstand attacks from competitors (Kuncoro and Suriani 2015).
Globalization (free movement of goods, services and technology across borders) has forced many organizations to re-think and re-strategize on novel approaches to operations management when serving their particular market segment. Globalization has increased the level of competition amongst organizations. To remain relevant within their markets, organizations have to look at their responsiveness, robustness and resilience (the "Triple R") as key objectives in global manufacturing and as a way of gaining competitive advantage in the global marketplace (Kristianto et al. 2017). Globalization has given consumers excess options when searching for products and services. Because consumers

constantly seek to increase product/service utility they continuously seek the best value for money from the many services/products provided in the market already. These factors require organizations to be continually monitoring and positively responding to change introduced by market forces beyond the control of any individual organization. Some manufacturers have explored the implementation of automation in their production lines as a technique to meet market and customer requirements. Automation is also done in an effort to have agile production systems that will achieve, if not exceed, their pre-stated objectives of increasing production throughput while reducing operational costs. It has been noted that it improves quality by reducing variation within products of the same kind, promotes productivity and reduces operational costs (Tilley 2017).

An element that contributes significantly to the human machine relationship is trust. Thus, the level of trust humans have towards automation (Parasuraman and Riley 1997). Humans use a collection of mental processes coupled with habits, before opting to rely on certain automated support systems (e.g. cruise control in cars) or rely on their own decisions. Trust stems from humans realizing that the automated support system is more reliable than manual operation.

A human-machine team is aimed at improving productivity levels in ways that neither the human nor the machine will be able to achieve independently although human-machine relationships do not always produce optimal results (Dzindolet, M., and Peterson, S. 2003). Humans often opt for self-reliance. Lack or reliance of humans on automated support systems result in the disuse or misuse of automation (Parasuraman and Riley 1996). The disuse or misuse of automation may lead to humans ignoring automated signals that are aimed at assisting them. An Example is drivers ignoring a low fuel gauge signal on the instrumentation panel of a vehicle as vehicle owners perceive that they know their vehicle better than the fuel level monitoring system.

Attempts to increase the performance of either human or machine have not always increased the overall performance of the human machine team. While synergy may exist between human and machine, it may be unlikely that collective performance may be gained by increasing the performance of the human alone or the computer alone (Dalal and Kasper 1994). Consequently, a close look needs to be taken into the human machine interaction.

On the other hand, humans can place a high reliance on an automated system if they perceive the automated system to be more reliable than manual operation. This kind of behavior leads to complacency by the human operator and is a mental state characterized by a low index of suspicion (Singh et al. 1993). Such over reliance on automated systems may lead to human operators misusing the systems and failing to exercise judgement to those situations that needs it the most.

However, there are functions within organizations that are not automatable, such functions contribute immensely to the speed and agility at which organizations report to customer requirements. These functions include: raw material procurement activities, management of lead times for critical items, product quality from external suppliers, and environmental considerations attributable to the production value chain. These situations require the dexterity, mental agility and creative problem-solving abilities of humans" (Erlich 2017).

Due to ever increasing variety of consumer requirements, automation falls short as companies will have to constantly reconfigure machines and production processes to cater to these requirements. This will have a consequence of creating complexity that machines cannot typically handle by themselves, it will require humans to reconfigure, re-programme, maintain and setup such activities. Worth noting that automation, together with artificial intelligence, cannot undertake the task of product innovation which to a large extent is the reason why most companies are still operational. Innovation separates an entity from its industry equals.

With the obvious dependency that automation will have on human intervention, any industry exploring the possibility of automation needs to consider how the added machines (to production processes) will interact with human operators. Thus, not only should industry think of which occupations of operational activities to be trimmed down, but should also think of ways to repurpose the affected operator roles to aid in the automation effort. While automation may bring with it, a range of new ways to achieve the same purpose, executives must equip their workforce accordingly by providing the necessary training required to ensure a swift transition from manual operations to a combination of both manual and automated type of operation. The manual work is important to keep the machinery running, increasing the reliability and availability of this machinery, performing maintenance and setup, responding to break downs, trouble-shooting system bugs and re-programming machinery as and when necessary, operations management and decision making, and finally providing the much needed expertise of innovation for ensuring the organization retains current customers and adds more customers who consume their products (Kuncoro and Suriani 2015).

2.1 Factors to be considered when making decisions on Automation

Given the range of technologies that manufacturing industry can use, organizations need to sensibly define their automation approach. This involves assessing the extent to which automation is adopted within a specific company's manufacturing operations. Looking at which occupations to replace with automation as well as which activities within their production value chain they seek to automate. Companies should also evaluate how operationally and technically feasible will it be to automate such activities. This will reveal to companies on where and how to automate.

McKinsey & Company 2017, have identified five factors that need to be considered as necessary preconditions for automating any given work activity or a set of activities. The factors include: technical feasibility; cost for developing both hardware and software required for automation as well as, cost of labor versus the cost of automation; the holistic benefits brought about by automation beyond those limited to replacing manual labor; and finally, regulation requirements as well as how socially acceptable is automation in any particular locale. The supply and demand dynamics of labor is also an element worth looking into in automation decisions.

Merely replacing human performed activities does not guarantee long term value attainment. What needs to be monitored is whether companies will realize value beyond the replacement of human activities by automation. Does automation really improve product quality, improve productivity, reduce operational costs, reduce variability, and improve the company's agility and flexibility in production and operations. Eventually companies should also interrogate if the introduction of automation really does achieve higher levels of safety in the workplace as per claims viewed on business cases for automation.

2.2 Automation Maturity

Maturity can be defined as the state of being complete, perfect or ready. This denotes to the level at which progress has been made in a certain discipline. A maturity analysis methodology is widely used for assessing the maturity of organizations and provide a framework for process improvement or benchmarking (Willner et al. 2016). Maturity models are commonly used as an instrument to conceptualize and measure maturity of an organization or a process regarding some specific target state (Schumacher et al. 2016). It is for this reason that automation feasibility studies need to look into how far along the automation spectrum a given manufacturer is. This level of maturity denotes the availability of infrastructure and data capturing systems to implement automation.

2.3 Human Capital

The introduction of automation in manufacturing will arouse the need for humans to work alongside the machinery. This introduction of automation brings along substantial job security risks for employees with only "ordinary skills" (Brynjolfsson and McAfee 2014). Hence the people will need to be trained to interface with the machinery. Human operators need to be prepared and trained to work harmoniously and in tandem with the introduced technology of automation. Automation can bring negative impact on unskilled labor giving rise to the questions on whether robots should be taxed as human operators traditionally are taxed (Gasteiger and Prettner 2017). On the other hand, lack of skilled labor, mainly in developing countries, will have a strong negative effect on the advance of automation (Stieber 1964).

3. Conceptual Framework

A framework was built around the four factors (necessary preconditions) for implementing automation: technical feasibility of automation; cost of automation; benefits of automation; and regulation requirements. Under technical feasibility are: infrastructure, facilities, design and architecture, data compliance, platforms and APIs, components, tools, integration, information security, equipment, procurement and operations. Included in the benefits of automation bene are: monetary, non-monetary, flexibility/agility, effectiveness, efficiency, productivity and quality. The cost factor is of top importance as financial resources within organizations are often limited. The variables include: human labor cost, time loss thus, the time lost due to errors in manufacturing which in most cases might result in defective products and operational bottlenecks thus, any element within a manufacturing operation that limits or stifles the effective flow of product from downstream to upstream phases of production. Compliance areas for manufacturing organizations encompass: health, safety and environment; product safety; data protection; IT safety and security; employment laws; fair competition; export controls and anti-corruption. Further to this, links among the affecting factors and the levels of automation as described by Frohm, et al, 2008 have been determined. These levels range from manual through too fully automated (table 1).

Table 1. Levels of automation (LoA)

Level	Mechanical LoA	Example	Automation Class
L1	Manual	Physical strength	Manual assembly
L2	Static hand tool	Screw driver	Manual assembly
L3	Flexible hand tool	Adjustable spanner	Manual assembly
L4	Automatic hand tool	Hand drills	Manual assembly
L5	Static workstation	Turning lathe	Hybrid assembly
L6	Flexible workstation	CNC machines	Hybrid assembly
L7	Fully automatic	Autonomous system	Automated assembly

Additionally, links among levels of automation and organizational goals were explored. The goals included: revenue, profit margins, operational costs, efficiency and agility.

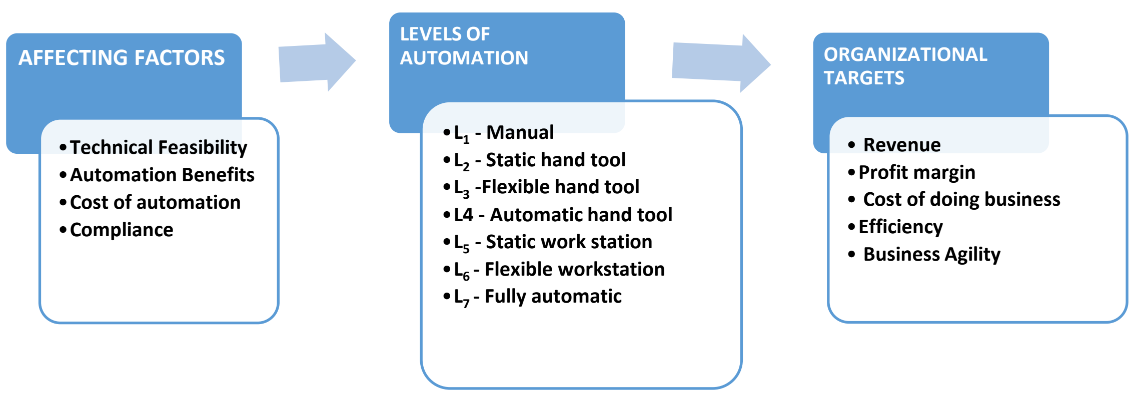

Figure 1. Conceptual Framework

4. Research Approach

The research used a combination of qualitative and quantitative research methods that were aided by descriptive statistics and analysis where data analytics tools were used to gain insight from the data. South African companies within the rail and automotive sectors that have successfully implemented automation within their operations were identified, permission to have access to their informational databases was acquired. The rail sector of South Africa has levels of automation that are moderate to none while the automotive sector has higher levels of automation with basically every section of production having some level of automation. It is for these reasons that these sectors were selected. So, convenience sampling was used as the knowledge of the researcher and experience were used to create samples. Respondents were from organizations using varying levels of automation.

Participants of the survey were asked 26 questions linked to the factors that affect the level of automation in an organization. They were asked to give an indication by percentage of the levels of automation that were employed in their organizations in the past 3 years. The data entered by respondents was coded.

Table 2. Data entry on data sheets

Respondent Entry from Survey	Data Entry on data sheet
0% - 10%	1
10% - 20%	2
20% - 30%	3
30% - 40%	4
40% - 50%	5
50% - 60%	6
60% -70%	7
70% - 80%	8
80% - 90%	9
90% - 100%	10

Linkages among the various levels of automation and organizational targets were tested. Each factor was tested individually as an independent variable relative to the dependent variable which in this case was the level of automation. Explored if a links existed between the levels of automation chosen and organizational targets set out in a firms' business plan.

The conceptual framework defined in the previous section was used to gather the required data using questionnaires and interviews to acquire the data analyzed. The participants were asked to give an indication by percentage on the extent to which organizational targets were met either directly or indirectly due to the level of automation implemented.

To ascertain if there is any level of correlation between the independents and dependent variables. A paired two sample for means t-test was used for this exercise. The following conditions had to be met for acceptance of the hypothesis:

P(T<=t) two-tail < 0.05
Pearson correlation coefficient (r) > 0
The following guidelines were further followed for the Pearson coefficient:

Table 3. Pearson Coefficient guidelines *(Source: Laerd Statistics)*

	Coefficient r	
Strength of Association	**Positive**	**Negative**
Small	0.1 to 0.3	-0.1 to -0.3
Medium	0.3 to 0.5	-0.3 to -0.5
Large	0.5 to 1.0	-0.5 to -1.0

5. Results and Discussion

Through literature, factors that need to be considered when making decisions to automate were identified as technical feasibility, cost of automation, benefits of automation and regulation requirements. A study of these factors and how they applied within a South African landscape gave a practical indication of where South African manufacturing companies are in terms of automation maturity. This current automation state assisted in gauging the future of automation within South African manufacturing companies. It also aided in forging a future path for automation while considering employment concerns that have plagued South Africa. Seven levels of automation have been used to assess the current levels of automation.

A framework, has been proposed and used to investigate the factors that contribute to the decisions for automation in the manufacturing industry in South African. The extent to which these factors influence levels of automation within an organization has been investigated. Potential correlations that could exist among the various levels of automation and achieving of organizational targets have been explored. The studied factors have been used to ascertain whether they are applicable and significant to the manufacturing sector in South Africa. The extent to which these factors affect the level of automation was determined.

5.1 Affecting Factors and level of automation

Based on the results above, the following deductions can be made:

1. Survey results suggest that existing infrastructure (which is part of the technical feasibility) does not have a strong bearing on the level of automation an organization pursues.
2. Respondents show monetary factors which are part of automation benefits, to be of great importance in decisions to automate. However, they also show non-monetary factors to be fairly important as they are the underlying thread that will eventually enable automation as mentioned by one of the respondents. A common consensus was reached in terms of the effectiveness and the efficiency that automation brings with it.
3. As part of the cost of automation factors, participants have placed a strong importance on the time spent to produce as it almost always forms part of the business case for automation.
4. Operational readiness level for potential automation is questionable. Effectively, this means that firms not capable of deploying, operating, and maintaining the systems that automation comes with.
5. The respondents indicated that there is no evidence to prove that automation has significantly improved on quality.

From their experience, quality is a factor that remained relatively the same pre and post any incremental automation that was implemented in their operations. The survey results show a relatively small standard deviation which indicates that the respondents were somewhat in alignment in populating the survey.

The frequency of the affecting factors is shown the Figure 1 below.

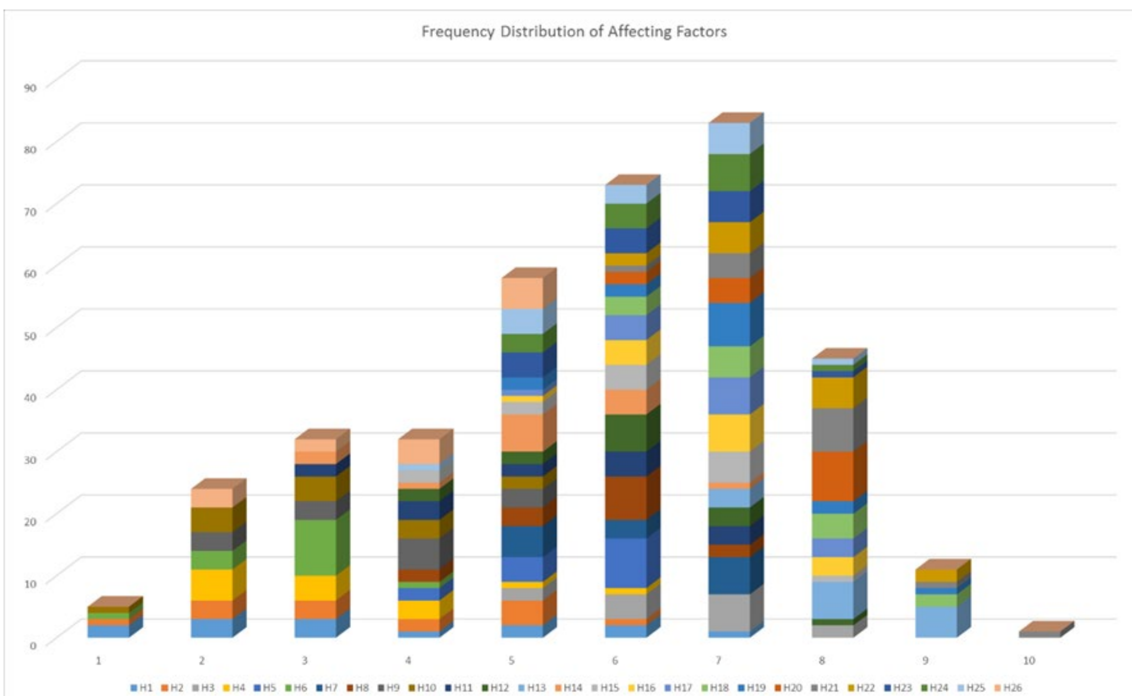

Figure 2: The frequency of the affecting factors

5.2 Level of automation

The determined mean, mode and median for the levels of automation show that:
The firms involved in this study have varying levels of automation. Most of these firms in the past three years have produced products with the usage of more advanced machines within a workstation (lathe, laser cutting, bending machine, CNC machines etc.).
Only a few firms have fully automated production lines. This is evident through the low average seen for L7.
A majority of the firms have automation levels ranging from L4 to L7 as can be seen with the relatively similar averages.
The mode and medians for these levels of automation support this deduction.

Table 4. Spread for Levels of Automation

			Frequency									
			Bin									
Variable	**Description**	**Standard Deviation**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
L1	Manual	1.342460	0	0	10	3	0	0	0	1	0	0
L2	Static hand tool	1.160239	0	0	11	1	1	0	1	0	0	0
L3	Flexible hand tool	1.499084	1	0	8	2	1	1	1	0	0	0
L4	Automatic hand tool	1.L4392681	0	0	5	2	6	0	0	1	0	0
L5	Static workstation	1.955550	2	0	2	6	1	1	1	1	0	0
L6	Flexible workstation	2.766559	3	0	3	2	0	3	1	1	0	1
L7	Fully automatic	1.761930	11	0	1	1	0	0	1	0	0	0

The frequency distribution chart confirmed these results.

5.3 Organizational Targets

The survey results indicate a moderate performance in the past three years for organizational targets met. In the past three years, only 40% to 50% of all products produced managed to achieve revenue target. From the data results we observed a striking similarity between scores for revenue and scores for profit margins. The respondents view profit as a function of revenue and by that logic gave both targets the same scoring. The rationale is that the higher the revenue the higher the profit. The results show that in the past three years only 30% to 40% of products within these firms managed to achieve cost of doing business targets. This however might not be as a result of automation only, this could also be as a result of a broad range of initiatives undertaken by these firms to bring down the cost of doing business. Cost of doing business involves, and is not limited to, cost inputs of goods and services, cost of licensing if applicable, compliance costs, advertising, management of facilities, costs of monies borrowed, cost of labor and costs of taxes to name a few.

The results show a moderate percentage of products which met efficiency targets. This was found to be slightly higher than figures for revenue and profit. Thus, products that were produced with the least amount of time, money and effort. This may be attributed to less touch time for the product that is due to the implementation of incremental levels of automation within these firms. The results show that 30% to 40% of products met this organization target with regards to responding to ever changing market needs of product type and product quantity. It is a less than moderate but however a significant performance level as business agility is becoming more and more important given the current dynamics found within manufacturing. Figure 3 shows the frequency distribution of Organizational Targets

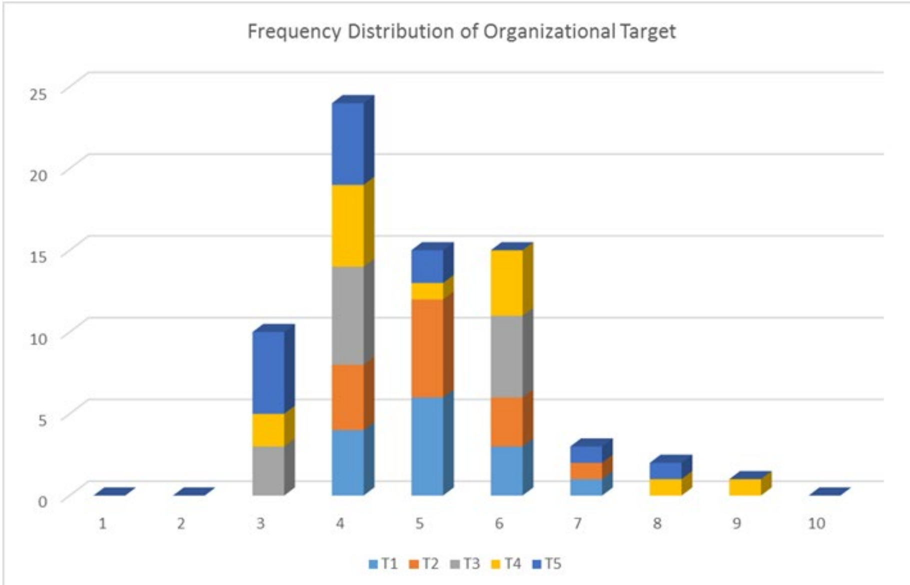

Figure 3. Frequency distribution of Organizational Targets

6. Conclusions

Evidence that automation does have a future within South Africa for those companies that are aiming to grow profits, increase efficiency and improve productivity has been provided. Meaningful deductions have been made from the data collected. The results analyzed and the hypothesis tested show that:

• The level of automation has a medium to large strength of correlation to the level to which organizational targets are met. All hypothesis tested in this regard resulted in the null hypothesis being accepted. Participants to the survey believe any incremental automation that is implemented within an organization will to some extent positively influence the targets listed for the purpose of this study.

Six (6) of the affecting factors studied showed that there is no apparent bearing on the level of automation. These factors are

Infrastructure towards level of automation
Facilities towards level of automation
A firm's data integrity towards level of automation
Availability of tools towards the level of automation
Information security
Product safety

The majority of the affecting factors, in varying degrees of correlation, are influential towards the decisions to automate.

Benefit factors together with cost of automation factors, health and safety and product factors display a stronger importance based on analysis on centrality and spread. They also display a stronger correlation to the dependent variable.

As participants to the survey were from organizations that with varying levels of automation, there could have been relative bias within the results as the scores provided by each participant were not necessarily supported by data. These scores were somewhat subjective and somewhat objective in varying degrees based on the exposure of each participant to the affecting factor under discussion.

The results produced from the survey and the relative analysis and tests performed do, to a large extent, give an accurate account on the state of automation and the dynamics attributed to it within these organizations.

6.1 Correlations among affecting factors and levels of automation

There was an indication that a great majority of the factors had a correlation with the dependent variable. Out of the affecting factors that were tested, only 6 could not be validated. These factors are:

- Infrastructure towards level of automation
- Facilities towards level of automation
- A firm's data integrity towards level of automation
- Availability of tools towards the level of automation
- Information security and
- Product safety

This indicates that the majority of the affecting factors, in varying degrees of correlation, are in fact influential towards the decisions to automate.

In terms of strength of correlation, benefit factors, Cost of automation factors and regulatory factors (with the exception of data protection) displayed a stronger correlation to the dependent variable. These factors also displayed a stronger relative importance based on analysis performed on centrality and spread. Some factors were found to be more influential than others and hence had to be treated as such in terms of priority when an automation effort is undertaken.

6.2 Correlations among levels of automation and organizational targets

The level of automation has a medium to large strength of correlation to the level to which organizational targets are met. So, the level of automation has an influence on the extent to which organizational targets are met. Any incremental automation that is implemented within an organization will, to some extent, positively influence the targets studied. Higher levels of automation have a stronger influence on the efficiency and agility of an organization. Increasing the level of automation relates to the ability of a firm to produce desired products with less time wasted, less materials wasted, less energy wasted and with minimal effort expended. Increasing the level of automation also means that firms are more able to respond to the needs of the market and are able to adapt to changes of the market as and when required.

7. Recommendations

The achievement of some of the performance areas such as profit, efficiency and productivity through automation will be at the expense of employment. This presents a more pressing questions of how can automation be implemented within these organizations while still preserving the much-needed jobs that form a significant part of people's livelihoods. Addressing this question would require new research to investigate a model to be used in implementing incremental levels of automation while considering job security for those job roles that will be affected by automation. A further recommendation is that SA government apportions more attention and funds to medium sized manufacturing firms as there is evidence that these firms form the lifeblood of every economy (Peretti, J. 2017.). If such firms are empowered accordingly they can absorb the job losses posed by automation. These firms are the very same firms that provider services for those big firms that outsource work as a way if being cost-efficient.

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