RELATIONSHIP BETWEEN INDUSTRIAL ROBOTS ON COMPETITIVENESS OF LISTED MANUFACTURING FIRMS IN KENYA

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Abstract

Manufacturing firms in the industrialized world are spending enormous resources in upgrading their production technology to cope with the increasing competition from non-industrialized countries and to also improve competitiveness. The purpose of this study was to establish the relationship between industrial robots and competitiveness of listed manufacturing firms in Kenya. The study adopted descriptive research design. The study targeted 14 listed manufacturing firms in NSE (2014). The study population comprised of 42 heads of departments of listed manufacturing firms, 42 assistant heads of departments of listed Manufacturing firms, 14 CEO's of listed manufacturing firms, 52 staff of KAM and 8 industrialization directorate of Ministry of Industrialization and Enterprise Development. Pagano and Gauvreau (2006) formula was adopted to calculate the sample size of this study from a population of 158 respondents to give a sample size was 113 respondents. The sampling technique used was stratified random sampling method. The study collected primary data through use of a questionnaire and an interview schedule. The results were presented using tables, charts and graphs. Both descriptive and inferential statistics were adopted to analyze the data. The analysis was aided by Statistical Package for Social Sciences (SPSS) software. The study results indicate that there was little use of industrial robots, Tele-operated robots, cognitive robots or even use of hybrid forms of tele-operated and programmed robots. The findings also reveal there was a negative and insignificant relationship between competitiveness of listed manufacturing firms and industrial robots. There was low application of industrial robots by manufacturing firms in Kenya which might be as a result of limited resources or low return on investments. The study concludes that industrial robots are not economically viable and realistic solution to securing immediate competitiveness of manufacturing firms in Kenya as the Kenyan economy is characterized by low wages and youthful population unlike developed countries. However, in the long term they can be a source of competitiveness. The study recommends that manufacturing firms should install industrial robots to carry out onerous, dangerous, repetitive or tedious tasks. The Kenya manufacturing firms should aim to improve the competitive capacities and enable their manufacturing firms to meet international competitiveness requirements, such as product quality and cost.

Key Words: Automation, manufacturing firms, competitiveness, technology, industrial robots,

Background

Automation is a known tool for improving competitiveness, especially in the manufacturing industry. There are many reasons that justify automation; these are: to increase labour productivity; to reduce labour cost; to mitigate the effects of labour shortages; to reduce or eliminate routine manual and clerical tasks; to improve worker safety; to improve product quality; to reduce lead time; to accomplish processes that cannot be done manually; to avoid the high cost of not automating (Zafarzadeh & Jackson, 2013). Automation is often regarded as the main solution to improve efficiency in manufacturing (Winroth *et al.,* 2007). One possible way to improve competitiveness within operations is with the help of automation. Within the manufacturing industry, for example, automation is a well-known means of improving productivity and efficiency within; hence, it cuts costs (Frohm *et al.,* 2008).

Automation is mainly divided into three categories; mechanization, computerization and robots. Industrial robots are programmable devices consisting of mechanical actuators and sensory organs that are linked to a computer (Frohm, 2009). Robots are one element of automation they provide a measurable indication of levels of automation, and one that is reported internationally. The International Federation of Robotics (IFR) report (cited by Ford, 2012) shows that Germany had an installed base of 144,100 industrial robots, Italy 62,200, France 34,100 and Spain 28,800 whereas the UK records 13,900. In the United States, the number of robots has increased to 6.5 million overall worldwide in 2007. Around 1 million of these are used in the manufacturing industry (Kromann, Skaksen & Sørensen, 2011).

Much of the recent literature on the manufacturing firms has stressed the increase in competitive pressure in the last few years (Mwinyimbegu, 2005). It has been claimed that manufacturing firms have had to adapt their methods of operation and strategies in order to maintain their competitive position. It is likely that the adoption of manufacturing firms' automation may be rationalized as a response to those competitive pressures. Kenyan manufacturing firms are no exception. Manufacturing firms are now using automation in order to be competitive as it reduces the cost and also shortens the time for product development from initial phase to market delivery. According to Granlund and Friedler (2012), automation benefits can be presented as follow: labour productivity, reduce labour cost, mitigate the effects of labour shortages, reduce or eliminate routine manual and clerical tasks, improve worker safety, improve product quality, reduce lead time, accomplish processes that cannot be done manually and avoid the high cost of not automating. Kenya is on its early days of industrialization, thus there is a need to examine the extent of automation on its industries and how it relates to competiveness.

Automation and particularly robots can provide a solution to ongoing business operating costs and can also respond flexibly to changes in volume demand and product type (Engineering and machinery Alliance-EAMA Report, 2010). According to Noland and Pack (2003), robotics is a key enabling industry for manufacturing. Without a strong robotics industry, Europe would quite simply not be able to maintain or expand its current level of manufacturing. To maintain a strong base in manufacturing, it is thus imperative to develop the next generation of industrial robots which can work in close proximity to humans, are easy to program and can also be adapted to the needs of manufacturing firms.

Statement of the Problem

Strategic management in organizations focuses on issues concerning either the creation and sustainability of competitive advantage or the search for such an advantage (Mainardes et al., 2014). Considering the increasing global competition, competitive manufacturing capability is a critical and urgent matter for manufacturing companies. Automation through industrial robots of manufacturing firms are often regarded as highly efficient, potentially improving the competitiveness of manufacturing companies. However, they often increase the complexity in structures and control systems, resulting in inflexible monolithic production systems (Zuehlke, 2010). It is thus important to ensure that the choices made for automation to be appropriate for use.

In Kenya, manufacturing firms have struggled to attain a competitive cutting edge against multinational firms operating in the local market (Kinyanjui et al., 2014). Automation through industrial robots is a well-known means to increase productivity and cut costs, thus improving competitiveness. Currently, competition is based on better quality products, faster and cheaper production (Nyori & Ogola, 2015); and manufacturing companies in Kenya cannot afford to do otherwise, else they will not be locally and globally competitive.

A review of the local studies conducted shows that there is limited knowledge and research on how automation and more specifically industrial robots are influencing competitiveness of manufacturing firms in Kenya. For instance, Mate and Kabiru (2014) examined automation and changing technologies in the manufacturing industries in Kenya. The results revealed that a large number of manufacturing plants were applying automation and were trying to increase the automation levels of their plants through adoption of computer-based technologies. The study did not find use of industrial robots in the manufacturing industries in Kenya. Nyori and Ogola (2015) also explored the adoption of advanced manufacturing technology in manufacturing companies in Kenya and found out that manufacturing companies in Kenya invested least in robotics technology as compared to other technologies. This implies limited use of industrial robots in the manufacturing companies in Kenya. In this regard, very little is known on the level of use of industrial robots in listed manufacturing firms in Kenya and the extent to which it influences the competitiveness of the manufacturing firms in Kenya. It is against this background therefore that the study sought to analyze relationship between use of industrial robots and competitiveness of listed manufacturing firms in Kenya.

Research Objective

To determine the relationship between industrial robots and competitiveness of listed manufacturing firms in Kenya.

Research Hypothesis

H_o: There is no significant relationship between industrial robots and competitiveness of listed manufacturing firms in Kenya.

Review of Related Literature

This study was anchored on Technology Acceptance Model (TAM) which was designed by Davis (1989) and looks at the factors that influence users' adoption of technology in general. He contends that, users' acceptance of a given technology is affected by their perceptions on the usefulness and ease-of-use of that technology. Perceived usefulness is defined as the extent to which a person believes that using a particular technology (automation) will enhance job performance (Competitiveness of listed manufacturing firms) while perceived ease of use is defined as the degree to which a person believes that using a technology will be free from effort (Davis, 1989).

TAM believes system usage is determined by the behavioral intention, while the behavioral intention is jointly determined by attitude toward using and usefulness of sensibility. The attitude toward using Information system is determined by the usefulness of sensibility and ease of use. Perceived usefulness is determined by the perceived ease of use and external factors. Perceived ease of use is determined by external factors like skills which indirectly influence the user's perceived usefulness and risk of acceptance toward personal recommendation. This theory was relevant to this study as adoption of industrial robots is dependent on perceived usefulness and ease-of-use of the industrial robots.

Robotics is a discipline overlapping artificial intelligence and mechanical engineering and it is concerned with building robots. These are programmable devices consisting of mechanical actuators and sensory organs that are linked to a computer. The mechanical structure might involve manipulators, as in industrial robotics, or might concern the movement of the robot as a vehicle, as in mobile robotics (International Association for Automation and Robotics in Construction (IAARC), 2014). Frost and Sullivan (2011) noted that robotics has the potential to transform lives and work practices, raise efficiency and safety levels, provide enhanced levels of service and create jobs. Its impact will grow over time as will the interaction between robots and people. Information and Communication Technology (ICT) markets are exposed to more rapid cycles of innovation and obsolescence than most other industries. As a consequence, if the European ICT sector is to remain competitive, it must sustain rapid innovation cycles and pay attention to emerging and potentially disruptive technologies.

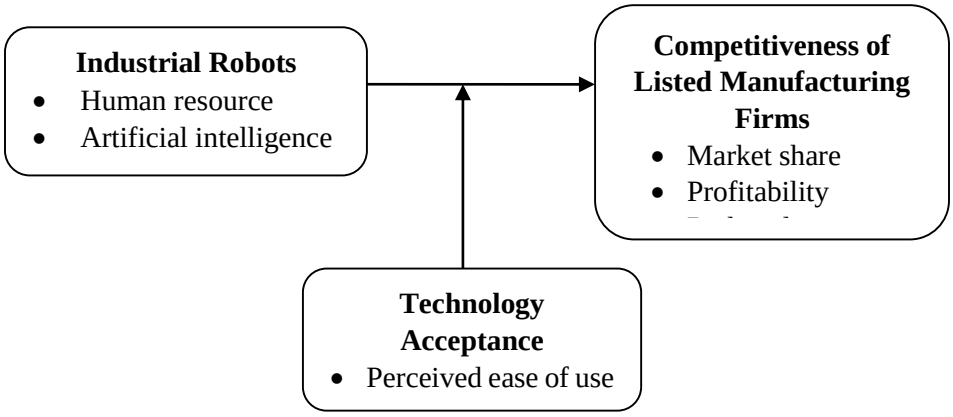
Noland and Pack (2003) revealed that robotics is a key enabling industry for manufacturing. Without a strong robotics industry, Europe would quite simply not be able to maintain or expand its current level of manufacturing. To maintain a strong base in manufacturing, it is thus imperative to develop the next generation of industrial robots which can work in close proximity to humans, that are easy to program and can also be adapted to the needs of manufacturing firms. Schmiemann (2009) also stipulated that industrial robots are on the verge of revolutionizing manufacturing. As they become smarter, faster and cheaper, they are being called upon to do more well beyond traditional repetitive, onerous or even dangerous tasks such as welding and materials handling. They're taking on more "human" capabilities and traits such as sensing, dexterity, memory, trainability, and object recognition. As a result, they're taking on more jobs such as picking and packaging, testing or inspecting products, or assembling minute electronics.

International Federation of Robotics (2013) further states that the concept of quality is a major advantage of robotized manufacturing solutions. Robot automation is superior in precision, perfectionism and repeatability. This level of consistency can dramatically improve product quality. This benefit is hard to achieve other than the use of robots.

With robots, throughput speeds increase, which directly impacts production. Robots have the ability to work at a constant speed in contrast to humans. A robot is capable of producing the exact same product or shape every time. Humans are not able to do this within the same time interval. More precise means more reliable. You can trust a robot to do exactly what it is programmed to do.

Conceptual Framework

As shown in the conceptual framework below, the independent variable is industrial robots while the dependent variable is competitiveness of listed manufacturing firms. The relationship was moderated by Technology Acceptance.



Independent variables **Moderating variable** **Dependent variable**

Research Methodology

The study adopted descriptive research design which is one of the best methods for conducting research in human contexts because of portraying accurate current facts through data collection for testing hypothesis or answering questions to conclude the study (Williams, 2007). The design was appropriate for this study since it helped in collecting data in order to answer the questions of the current status and describe the nature of existing conditions of the subject under study. Positivism approach was adopted to collect all the facts and figures in regard to the study objective.

The study targeted 14 listed manufacturing firms in NSE (2014). The study population comprised of 42 heads of departments of listed manufacturing firms, 42 assistant heads of departments of listed Manufacturing firms, 14 CEO's of listed manufacturing firms, 52 staff of KAM and 8 industrialization directorate of Ministry of Industrialization and Enterprise Development. The Pagano and Gauvreau (2006) formula was adopted to calculate the sample size of this study from a population of 158 respondents to give a sample size was 113 respondents. Stratified random sampling method was adopted. The sample size comprised of 30 heads of departments, assistant heads 30 of departments of listed manufacturing firms, 10 CEO's of listed Manufacturing firms, 37 Staff of KAM and 6 Industrialization Directorate of Ministry of Industrializations and Enterprise Development.

The study collected primary data through use of a questionnaire. Pilot test was conducted to test for validity and reliability of the questionnaire. Reliability was calculated through Cronbach's alpha test while validity was established by the supervision panel who reviewed the items in the questionnaire. An interview schedule was also used to collect additional information from the key informants. The interview guide gathered information from the CEO's of manufacturing firms and from industrialization directorate of Ministry of Industrializations and Enterprise Development on the extent of use of industrial robots and how this influences competitiveness of listed manufacturing firms in Kenya.

Both descriptive and inferential statistics were adopted for the study. These included frequency distribution tables and measures of central tendency (the mean), measures of variability (standard deviation) and measures of relative frequencies while inferential statistics included a multivariate linear regression analysis. Pearson product-moment correlation was also conducted to establish the relationship between use of industrial robots and competitiveness of manufacturing firms. The analysis was aided by Statistical Package for Social Sciences (SPSS) software. The results were presented using tables, charts and graphs.

The regression model used took the following form:

$$Y= \beta_0 + \beta_1 IR_{+} \varepsilon$$

Where: Y is Competitiveness of listed manufacturing firms in Kenya,
IR which is Industrial Robots,
B_o is the constant,
β_1, is coefficient and, e is the error term

Results

The study sought to establish the relationship of industrial robots on firm competitiveness. A scale of 1-5 was used to interpret the results where 5 represented strongly agreed, 4 was agree, 3 was Neutral, 2 was disagree, while 1 was strongly disagree. Results in Table 1 below show that there was limited application of industrial robots in the operations of listed manufacturing firms in Kenya. There was no use of hybrid forms of tele-operated and programmed robots (mean score =1.4444), tele-operated robots (mean score = 1.6341) and cognitive robots (mean score = 1.6463) or even artificial intelligence (mean score = mean score, 1.8415) and industrial robots in the firms operations (mean score = 2.2805). The respondent cited cost of a robotics system, technical aspects, and time it takes to set-up and install as factors that have greatly affected low adoption of industrial robots in Kenya manufacturing firms. The findings corroborates with those of International Federation of Robotics (2013) who indicated that in order to even considering a robotic solution, one need capital and liquidity and that it may take years to benefit from the investment. Despite the low use of industrial robots, the respondents acknowledged that they can lead to competitiveness of manufacturing firms.

Table 1: Industrial Robots in Manufacturing Firms

Statements on Industrial Robots	Mean	Std. Deviation
There is a great extent use of artificial intelligence in your firm operation	1.8415	1.01190
There is a great extent use of industrial robots in your firm operation	2.2805	1.17877
There is a great extent use of Tele-operated robots	1.6341	0.82420
There is a great extent use of cognitive robots	1.6463	0.90774
There is a great extent use of hybrid forms of tele-operated and programmed robots	1.4444	0.86603

The regression results in Table 2 show a statistically insignificant relationship between industrial robots and competitiveness of listed manufacturing firms (β = -0.170 and p= 0.098>0.05). This negative relationship may be as a result of low application of industrial robots in listed manufacturing firms in Kenya as indentified in the descriptive results; hence they are not able to get maximum results in the utilization of industrial robots. The insignificant relationship may also be as a result of what International Federation of Robotics (2013) established; that robotic solutions may take years to benefit from the investment. So in the short term, the manufacturing firms may not achieve competitiveness from the industrial robots but in the long term, they would achieve the competiveness

Table 2: Regression Coefficients

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	0.792 (a)	0.627	0.554	0.289		
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.893	.568		3.334	0.001
	Industrial Robots	-0.170	.102	-0.163	-1.674	0.098

a Predictors: (Constant, Industrial Robots
b Dependent Variable: (Competitiveness)

These Pearson correlation results in Table 3 are in tandem with the regression findings which also found a negative and statistically insignificant relationship between industrial robots and competitiveness of listed manufacturing firms in Kenya as shown by r = -0.178 and p= 0.113>0.05. Thus, we fail to reject the null hypothesis that: there is no significant relationship between industrial robots and competitiveness of listed manufacturing firms in Kenya.

Table 3: Pearson Correlation Results

		Competitiveness	Industrial Robots)
Industrial Robots	Pearson Correlation	-0.178	1
	Sig. (2-tailed)	0.113	.

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Conclusion

The study concludes that industrial robots are not economically viable and realistic solution to securing immediate competitiveness of manufacturing firms in Kenya as the Kenyan economy is characterized by low wages and youthful population unlike developed countries. The findings showed limited application might be as a result of limited

resources or low return on investments. The cost of entry is somewhat high, and they have trouble making the leap either because of human resource constraints/skills or because of the cost. Nevertheless in long run Kenya manufacturing firms should apply industrial robots as when they are rightful applied they can take on labor in ways that frees up and makes better use of human resources and unleashes innovation. Robots can be applied in applications that a current workforce is unable to carry out such as those of high precision or force which will open new opportunities of faster and greater production of existing products or, perhaps more important, enable altogether new product development.

The study concludes that it is imperative for the manufacturing firms in Kenya to consider the usefulness and use of ease of a technology before being adopted. The perceived benefits of the technology/automation should be highlighted; for instance can it increase quality products, efficiency, high volume of production and low production cost. The study also concludes that shift to automation may and specifically use of industrial robots may in the short term lead to job loss as technology would displace the jobs that were previously done manually. With increasing automation however, the manufacturing firms become more productive. The firms are able to produce more at low cost. With the rise in productivity, more jobs are created. Moreover, when factories automate, those workers who had not been trained (unskilled) are replaced with those workers with computer and technical skills which are required after the firms automate.

Recommendations

The study recommends that next generation technologies such as industrial robots are disrupting the status quo, and have immense potential to influence competitiveness. Thus, manufacturers need to carefully evaluate automation options to craft their strategies for them to be competitive. Accurately strategized and executed automation strategy present tremendous opportunities to be competitive globally.

The study recommends that manufacturing firms should install industrial robots to carry out onerous, dangerous, repetitive or tedious tasks. This can be done through identifying the readiness of a company to adopt robots and finding out the right type of industrial robots. Small and medium-sized manufacturers will likely need robotics that can accommodate smaller production runs and easily to program. Most small and medium-sized enterprises will need cheaper and more easily programmable robots to make that happen.

The government should also encourage higher learning technical institutions to design robots which are affordable and which can be used practically in our local manufacturing environment. Use of robots in manufacturing is very expensive for a normal medium sized company in Kenya. This can assist our local manufacturing companies in increasing their productivity, hence output and generating of more revenues through more competitiveness.

The Kenya manufacturing firms should aim to improve the competitive capacities and enable their manufacturing firms to meet international competitiveness requirements, such as product quality and cost. Thus manufacturing firms should aim to strengthen the capacities by automating for them to participate in international trade, and specifically to

enable them to be globally competitive. There is a widespread consensus that 'business as usual' is no longer an option, adoption of automation is a necessity.

As industrial robots get their ways into manufacturing, companies may grapple with their application to blend with the human labour. Manufacturers could be at trying to figure out the extent to which they should automate change in the varied manufacturing tasks and as they call for greater human-machine collaboration and still enhance competitiveness. Manufacturers should therefore prepare for the implications of displacing human workers with robots technologies. Employees are in jobs that could be at risk of being displaced by automation technologies. As automation technologies become more pervasive on factory floors, employers and employees will need to manage not only the benefits but also the human-resource challenges that their rise will likely prompt.

Because global competition is tough, manufacturing products may lose their competitive edge if the support environments such as regulatory framework (taxation, licenses) and business infrastructure (energy infrastructure, transport infrastructure) are inadequate. There is need for government to come up with policies for creation or upgrading of that support environment to a conducive manufacturing environment.

The government should formulate policies addressing the cost of doing business by addressing critical issues related to energy cost, cost of automation such as taxation and levies on machines, computer and computer systems and industrial robots. Companies' adoption automation should qualify for tax exemption and investment tax allowance.

Owing to the limited application of industrial robots in manufacturing firms in Kenya as compared to global patterns where industrial robots have been adopted to a great extent and enhance competitiveness; there is need for the government to establish an institute of robotics to promote and strengthen adoption of robots and also train on use of robots in Kenyan Manufacturing firms. The government should also promote public-private partnerships to enhance effective application of industrial robots.

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