

Technological Factors for Improved Productivity of Manufacturing Projects in the South-East Geopolitical Zone of Nigeria

Ibeawuchi I. Echeme Ph.D. and Ihuoma Okwara
Department of Project Management Technology
Federal University of Technology, Owerri

Abstract

The study focused on technological factors for improved productivity of manufacturing projects in the south-east, Nigeria. The study discovered that the level of productivity of manufacturing projects by firms is very low. The identified technological factors contributory to this level include; the size and capacity of plant, level of repairs and maintenance, level of waste reduction, and efficient materials management. Likert's five-point scale questionnaire was designed and distributed to 260 respondents for assessment on the level of effect of the technological factors on the productivity of manufacturing projects in the study area. Multiple regression analysis result showed that all the identified technological factors except the level of waste reduction are significant to the level of productivity of manufacturing projects. The result also show that the size and capacity of plant is a major technological factor for improved productivity in manufacturing projects, while waste reduction level is the least factor in the prediction of productivity level of manufacturing projects in the South-east geopolitical zone of Nigeria. In view of these findings, the study recommends increased size and capacity of plant and training of the project staff to guaranty improved productivity of the manufacturing projects.

Keywords: technological factors, manufacturing projects, productivity, size and capacity of plant, waste reduction.

Introduction

The rapid development of technology requires quick reaction by manufacturers in order to survive in an emerging competitive environment and keep up with new trend and innovative service which other competitors might be utilizing (Yang and Ying 2013). Productivity is considered as one of the most important factors affecting the success and overall performance of every organization, whether large or small, in today's competitive market (Sweis, & Abu, 2009). Due to the rapid growth of technological innovation, the product life cycle of new and other products is much shorter than earlier. Reducing the delivery time in these markets reduces costs and creates value.

In today's highly competitive market where technological innovation and its growth are very significant, time to market or on-time delivery is a very important aspect, among many other things, in order to achieve high level of product success. Introducing a new product faster, increase project velocity, profitability, customer satisfaction and overall sales volume. Successful

projects are necessary to complete on time, to budget, and with appropriate technical performance/quality. In the recent times, projects tend to be constrained with respect to time, cost, and quality specifications, and the ability to deliver a project quickly is becoming an increasingly important element in winning a bid. This is especially important for manufacturing organizations where in most cases other parties (suppliers, contractors) are also involved. Many manufacturing projects like batch and job shop production lots have been characterized with a lot of problems such as project deliverables not meeting specified requirements, inefficient execution process which cause delay and schedule slippage. Delaying the introduction of new / ordered products into the market can result to negative consequences like lower market share, lower margins, capital loss, and maybe most critical the loss of customers' goodwill, thus affecting the project's productivity. These problems affect the productivity of firms and the satisfaction of their customers because when there is delay in supply or delivery of an order, production is affected equally. For instance, consider a situation where some companies manufacture plastic containers use for packaging for some companies. One may discover that sometimes, the cork of the containers do not tight very well i.e. loose, sometimes due to rush orders and short delivery time, the project is not delivered as scheduled as a result of one technological factor or the other.

Technological factors are influences that have an impact on how an organization operates that are related to the equipment used within the organization's environment. Due to increased reliance on equipment, technological factors currently exert a considerably effect on the success of a business than they did many years ago. These technological factors can include materials, machines and processes that can present opportunities and treats but it is vital for competitive advantage and is a successful drive in globalization.

Within every sector, developments in technology directly reflect the priorities of the industry they serve. So in the highly competitive world of fast moving consumers' goods (FMCG), technological factors have evolved to enable firms to be commercially alert and responsive to change (Robinson, 2013). As every department in manufacturing industry understand their role in the cross functional processes, fully supported by technologies and systems aligned to the unique need of the industry, productivity is greatly improved.

High technology has become like a force of nature, it transforms the economy, schools, consumer's habits, and the very character of modern life. The reason while multinationals enjoy foreign competition is because of their superior and up to date technology which enables them to enjoy economies of scales and quality products (Holger, Alexander & Murakozy 2009).

Technological factors influence all activities in a company's value chain and technology which particularly affects a company's productivity and competitiveness in the field of manufacturing. Products manufactured and sold to the customer, processes used to make the products and information system use to integrate the various areas of a company are each a part of the technology in use and are expected to show an impact on the performance of the manufacturing system. Technological factors make room for improved products. For example, mobile phone technology has evolved with years; nowadays we use smart phones which have been an

advancement of an ordinary mobile phone. When these factors are considered in manufacturing it help to enhance innovations and creativity. It sparks the brain to work to its full potential.

Technological factors affecting productivity of manufacturing all over the world demands a changing behavior. A manufacturer does not need to relax because the market for his product is moving rather he has to always modify and or improve his products.

Technological factors upgrade/enhance technology in the sense that it makes technology to be constantly changing. This means that businesses must change in order to keep up. Technological factors bring about new technology which can be used to improve productivity. Robotics is a new technology and can work 24 hours a day, if necessary, can do jobs, do not need regular breaks and usually quicker, are consistently more accurate and can work in dangerous situations, like bomb disposal. Changes in technology are the only source of permanent increases in productivity (Gorman 2014).

In a research conducted on Canadian manufacturing industries, it was decomposed that technological progress has been the main driving force of productivity growth (Mahamat 2009).

Innovations and latest technology improves productivity to a greater extent. Automation and information technology help to achieve improvements in material handlings, storage, communication system and quality control (Ubani 2012).

For example, computer integrated manufacturing (CIM) as a part of the manufacturing system is unthinkable without information technology. Product design and product technology strongly influence the productivity in manufacturing and define the manufacturing technology required. Computer aided design (CAD) is also a means from the field of information technology speeding up the process development of new product. The computer aided manufacturing (CAM) is very useful to design and control the manufacturing system. It is used to achieve effectiveness in production system (Telsang 2006).

High standard product technology is seen as the pre-requisite for sustaining competition. The high plants use practices which increase their ability to introduce new products more frequently and faster (productivity) than their competitors.

Effective use of manufacturing technology is a means for the achievement of flexibility to changes in production volume to changes in job shop schedule and to changes in the type of product to be manufactured. High quality products are not solely a result of the application of comprehensive systems of quality management, rather quality is also influenced by the technology used in manufacturing which e.g. emphasis on smooth running machines with low deviation of tolerances, scrap and rework as well as the use of machines with automated inspections. Low cost are influenced by the manufacturing technology as well e.g. through economics of scale as well as economics of scope, low down time of equipment caused by production stoppages, short set up time and a low percentage of rework and scrap. It also has the role of ensuring a plant's ability to meet customer's demands regarding on-time delivery and short delivery time production.

Furthermore, technological factors have driven productivity upwards remarkably, for instance the energy capturing methodologies have dramatically increased efficiency while freeing up man hours. Similarly transportation and industrial machinery, communication, logistics in their various areas of need have greatly improved. Technological factors can provide manufacturers with a wide range of productivity enhancing benefits including increased efficiency, cost reduction, increased speed, greater reach, improved market access and increased reliability of processes and transaction (Webiner 2014)

The National Bureau of Economic research stated that “the strong performance of productivity growth in the second half of the 1990s was in fact attributable to accelerating technical change, not to poor measurement or to temporary factors (Gorman 2014)

Most times the ratio of output obtained from input resources are usually abysmal and poor affecting the productivity of manufacturing firms. As a result of poor productivity occasioned by poor technological capabilities, manufacturing firms are plagued with the inability to meet up with ordered quantity requirements on schedule, within budgeted cost and quality specifications. Poor technological capabilities results in problems to manufacturing firms and hinder the successful implementation and delivery of manufacturing projects such as ordered quantity production and job shop production. Prominent among these problems are: the project deliverables do not meet specified quality or quantity requirements leading to rejection or excessive reworks. The cost implications of these reworks also increase the cost of production, and as such profitability is low. The low level of technological capabilities and poor work flow also cause issues such as inefficient execution process, which cause schedule slippages and delay in the delivery of manufacturing projects. Many manufacturing firms in Nigeria (for instance Michelin) have either gone moribund or abandoned due to low technological capacity with decline in productivity arising from inadequate technological factors, such as unreliable and incessant electric power outage. Developing technological capability is very central to fashioning out a strong and competitive vibrant industry. Hence this study is set to determine the extent to which the identified technological factors can influence productivity of projects so as to meet up customer’s requirements regarding order quantity and custom designed products.

In order to achieve this aim, the following specific objectives were set:

- i. To determine the effect that size and capacity of plant have on productivity of manufacturing projects.
- ii. To establish the effect of repair and maintenance of machines on productivity.
- iii. To ascertain the effectiveness of waste reduction in production of outputs.
- iv. To establish the efficiency of materials handling on productivity

Based on the set objectives, the following research questions were raised as the basis for data collection:

- i. How does firm size and capacity of plant impact manufacturing productivity?
- ii. To what extent do repair and maintenance affect manufacturing productivity?
- iii. What are the advantages of waste reduction management on output productivity?
- iv. What are the benefits derived from efficient materials’ handling to stabilize productivity?

To answer the research questions, the following hypotheses were formulated:

- Ho₁** Size and capacity of plant do not significantly influence the volume of productivity.
- Ho₂** Repairs and maintenance of production machines do not significantly influence on productivity
- Ho₃** Waste management does not significantly affect the level of productivity.
- Ho₄** Extent of materials handling does not significantly stabilize the quantity of manufacturing.

Related Literature Review

Many authors and researchers have carried out researches on technological influence and productivity of manufacturing firms, though in isolation. However, no study and research have been cited in the area of evaluation of technological factors influencing productivity of manufacturing projects in Nigeria.

Extensive technology-based development of the manufacturing (productive) system has been seen as a veritable channel of solving the problem of low productivity. The combination of suitable technology, management techniques and other resources could be seen as a driver that would move manufacturing projects to a more automated and efficient system of production of goods.

The major research issue to be addressed looks at the key technological factors that influence the productivity of manufacturing projects in the South eastern zone of Nigeria.

Measurement of Productivity

The productivity of labour can be measured either as output per operator or output per man-hour, expressed in money value (economic productivity) or in quantities (physical productivity). Because of the interagency of output, it is more usually expressed in value a term which, for the manufacturing sub-sector, is easily calculated from ex-factory prices of finished products, estimated value of semi-finished products and other works and services of an industrial nature. When productivity is measured in physical units, the following formulae can be used to calculate productivity index.

$$X_t = \frac{Q_t}{Q_o} \div \frac{L_t}{L_o} \dots\dots\dots 1$$

Given that

X_t = Productivity index

Q = Output in physical unity

L = Labour inputs

t = and O are current and base periods, respectively

On the other hand, if the value of output is used to measure productivity, the following formula is used.

$$X_t = \frac{P_o Q_t}{P_o Q_o} \div \frac{L_t}{L_o} \dots\dots\dots 2$$

Where P_o is the base period unit price of output and other variables are as defined above.

Possible Technology Factors Affecting Productivity of Manufacturing Firms

a. Effect of Firm Size and Capacity of Plant on Manufacturing Productivity

The size and capacity of plant in manufacturing firms matter a lot. When consumers’ demands are high, the size and capacity of firm’s plant would not meet consumers demand. This is also affected if consumers require less products than potentially producible, plants will not work at full productive capacity. Large firms tend to have stronger capacity than small ones to learn technologies management practices that would enhance their productivity.

Haiyang, Li & Zhou (2010) stated that large firms are systematically found to be more productive than small ones. For example a large firm may count on economies of scale when designing and implementing new technologies or a training strategy. That is not always true in the sense that there are small firms whose productivity is high because the size and capacity machines used are high. It does not always follow that large firm are systematically found to be more productive than small ones Foreign firms typically enjoy technological superiority and strong management capabilities and their technologies and management practices can be transferred to or imitated by domestic (small) firms in emerging markets. Geroski (1998) claims that size may have a direct effect on productivity, that is as a variable that ceteris paribus improves efficiency, or indirect, that is conditioning the effect of other variable on productivity as they will show different patterns of behaviors for small and large firms. The organization for Economic co-operation and Development (2008) observes that large firms and plants have on average higher labor productivity than do small ones. Badwin and Sabourin (1998) showed that the use of advanced production technology rises with plant size in the Canadian and US manufacturing sector. The advantage large firms have over small firms is greatest in manufacturing, the firms with 100 or more employees are 80% more productive. That is to say that when the number of firm’s employee is high most times productivity increases and time reduces compared to when the firm’s size is small. Physical productivity of a product process can rely on faster and bigger machines performing simplified and repetitive tasks strictly matching the requirements (input-outputs) of further machines (assembly line) typically this method of increasing the number of products obtained per hour corresponds to repetitive task performed by low skilled labour whose low wages leads to high economic productivity. A manufacturer can use its productive personnel and generate high value products in short time, an extremely high productivity largely irreproducible by machine. High labour skill- possible in connection with all purposes high capacity machines like computers generate high productivity. The economic productivities of such process is enhanced by a market which recognizes and pays for quality and

innovativeness and a business/network organization and routines that allows for such creativity to flourish (instead of being repressed).

A similarly world agriculture has undergone some fundamental changes in the past few decades. One has been that many developing countries have greatly expanded their capacities in agricultural research and innovation combined with support from international agricultural research centers, this has led to the availability of improved technologies and practices for local farmers.

Complementing this have been institutional and policy reforms, improvement in farmer education and health, and investment in rural infrastructure, all of which help create an environment where new far, technologies and practices are adopted more rapidly. Greater productivity growth in developing – country agriculture can certainly pull up the average for global productivity (Keith & Alejandro, 2012)

b. Effect of Repairs and Maintenance on Manufacturing Productivity

Some of the challenges that led to the moribund situation of the Nigeria Machine Tools industry was the over reliance on technical expertise of the Foreign country (Hindustan company of India) whose withdrawal had always cost the total closure of machine tools industry. This is because installations of equipment were half done , manpower development and training stopped while assistance in the form of donations or aid from the multinationals like the World Bank, IMF which had always been channeled through Hindustan company were all stopped. The problem of normal financing for maintenance and expansion of operations had also adversely affected the Nigeria machine tools. These problems have been seen as technological factors that influence manufacturing productivity in Nigeria.

Introduction of new technologies and systems of production in industries demands careful planning and scheduling for increasing productivity, efficiency and success of industries in production and services (Masoumi, Bagheri, & Arabi 2013). In the developed countries / complex industries, machines and equipment with wide range of scientific and technological achievements are used. These machines are equipped with the scientific system of maintenance and repairs management which reduces production cost and increase output. Near zero downtime should be the goal of a maintenance crew to maintain a company's throughput and high productivity. Preventive maintenance is intended to eliminate machine or process breakdowns and downtimes that would lower productivity. Repairs can be made at times that least affect production (Lee and Qiu 2015). Duffua *et al* (2002) opined that maintenance is not just about ensuring proper function of machine and equipment(in order to continue to fulfill it intended purpose) but also play a key role in achieving company's goals and objectives by improving productivity and profitability as well as overall performance efficiency.

Alsyouf (2007) stated that the impact of maintenance on business performance aspect such as productivity and profitability has increased in recent times due to its role in ensuring and improving machine availability, performance efficiency, product quality and swift delivery, environmental and safety requirements.

Manufacturing firms should employ workers that would be able to maintain and repair factory equipment and other industrial machinery, such as conveying systems, production machines and packaging equipment. These workers should have the capacity to install, dismantle, repair, reassemble and move machinery in factories, power plants and construction sites.

c. The Influence of Waste Reduction Management on Productivity

Hassan (2013) wrote that waste reduction is a crucial subject in the quality and productivity improvements of manufacturing process.

Arabe (2001) stated that process and utility waste can take huge bites out of manufacturer's profits. Robertson (2014) stated that preventing waste is the holy grail of the drive for a zero waste economy.

Elliot 2007 emphasized that for an organization to be relevant in the dynamic and changing environment, productivity improvement effort must be focused on. Any manufacturing company reaches to higher profit level only by improving productivity of its product. Kumar (2012) wrote that process checks might be accomplished with product parts instead of monitors eliminating what is effectively downtime (waste) for a sector. He explained that by implementing set up reduction, waste time is reduced and productivity increased. In a research, carried out on productivity improvement of computer numerical control (CNC) set up in manufacturing company, waste time is reduced from 113.75h in June 2008 to 59.75h in May 2009 with 585.00h available time for machining while productivity of machine also increased from 19 platens in June 2008 to 44 platens in May 2009. The fast changing economic conditions such as the severe global competition, declining profit margin, customer demand for high quality product, product variety and the need to reduce lead-time have major impact on productivity of manufacturing industries. In manufacturing industries, to overcome the competition problem and to retain the share of the market, it is necessary to constantly improve the quality of the product without the increase in the price. The price is influenced by the cost of production, which in turn is influenced by waste, rework, rejection and downgrading rates. Attention to quality assurance can reduce the process waste, which results in a quality production and company's growth and profitability.

Any operation in a process which does not add value to the customers is considered 'waste' they are as follows:

- i. Over-production: Product made for no specific customer or the development of a product, a process or a manufacturing facility for no added value.
- ii. Waiting time: While people, equipment or producer is waiting it is not adding any value to customer.
- iii. Transportation: Unnecessary product movement to several locations if the product is in motion and not being processed then no added value to the customer.
- iv. Over processing: When a particular process step does not add value to the product.

- v. Inventory: Unnecessary storage of products intermediates or raw materials is considered waste of money.
- vi. Motion: Excessive movement of data, information or the people who operate the manufacturing facility is wasteful. While they are motion they cannot support the processing of the product.
- vii. Defects: Errors during the process either requiring re-works or waste of the product.

Manufacturing industries should adopt and apply some methodologies such as lean six sigma LSS methodology which is known to quality and waste improvement.

Lean six sigma is a disciplined, data-driven methodology used to eliminate/reduced the process hence the product defects and waste. To achieve six sigma qualities, a process must produce no more than 3-4 defects per million. The lean six sigma methodology is characterized by the DMAIC phases of problem solving which stands for Define, Measure, Analyze, improve and control. DMAIC process of the lean six sigma was followed to achieve quality and productivity improvement in a welding wire company. The company manufactures welding wires in a wide range. Many opportunities for improvement were recognized during the investigation stage early in the beginning of the Define stage of the lean six sigma methodology. These opportunities drawn the attention for multiple areas for improvement and empathizes the need for research leading to improvement by applying methodologies such as the lean six sigma. The contribution of the current research proved that the lean six-sigma methodology is a suitable approach to be followed to reduce the waste in the welding wire manufacturing process. Waste reduction is a crucial subject in the quality and productivity improvement of such manufacturing process.

As a part of the define phase of the lean six sigma methodology, historical preliminary data was collected to define the size and nature of the existing problem.

The records of the waste in the previous four years from 2009 to 2012 were collected as given in the table below.

Table 1 Waste Reduction of Welding Wire Manufacturing Company Waste in Between 2009 and 2012

Year	Production (Jan)	% waste
2009	8020	6.90
2010	5346	6.14
2011	6605	4.90
2012	7471	4.25

The 6.90% waste in the year 2009 was taken as the base year to study and compare the subsequent years improvement efforts done by the factory towards a target waste of less than or equal 2% of the total input material. The reason for the decrease in the waste improvement ratio is due to the limited capability of the traditional work management and follow up techniques to reduce the waste behind certain limits. Given the waste ratio achieved in year 2012 which was

4.25% and the target ratio of 2% which means a reduction in waste of 2.25 was required. Effect of waste reduction, quality is improved, cost reduced, productivity increased, safety enhanced, morale of the team environment boosted.

Many companies often neglect basic issues and are faced with difficulties in improving or sustaining the productivity of their operations, especially during periods of rapid growth of the company (Chan 2015) studies have shown that companies could have saved millions of dollars if they had strategically made efforts to reduce waste found in all aspects of their operations.

The seven waste techniques is a good framework to help companies identify opportunities for eliminating of waste in operations. The techniques can be implemented either as a driver or as a tool. The former requires companies to set up a companywide organization to manage the program and to set waste elimination objectives for deployment through the organization. When used as a tool, it complements others productivity improvement programs like lean management, 5S quality circles, green productivity etc.

d. Effect of Efficient Materials Handling on Productivity

Iornum 2007 defines material handling as an aspect of material management which is concern with the safety of material in transit with the regularity of delivery as well as the flow of materials.

According to Badi (2004) materials handling refers to the movement of materials inside the work premises from raw materials stage to finished product storage. Maximum movement activity takes place on work in progress. Material handling is actually the process of moving through a full cycle of operations from the procurement of raw materials include reception and storage prior to use, handling into and between processes and the handling of the finished goods, packaging, storage and distribution. In other words, materials handling is the art of moving things economically and safety when used property, materials handling result into the linking of all the proceed without the functions of business into a single efficient machine or system.

However, materials handling absorbs time, manpower and money. It adds nothing to the value of items, but only its cost materials handling must therefore be controlled and carried out properly if a high standard of efficiency and cost effectiveness is to be achieved.

Efficient material handling reduces, handling cost, space cost, damage for poor handling and storage, labour cost, fatigue, production waiting time on one hand, increases effectiveness and quality controls, increases safety level, Increases productive capacity level.

Place of material management in a production system. Westing and Zone (2003) defines material management base on production system as “one of the several activities dealing with the planning for acquisition and ultimate organization structure which involve those activities such as purchasing, inventory control, traffic, material handling and production control. For the survival of a production organization will no longer be producing organization. In fact, materials are the main input in any production system it is the importance attached to raw materials that calls for a proper management.

Moreover, the benefits occur to organization/firms as a result of materials management concept cannot be the major responsibility of single department (material department). Therefore such responsibilities has to be shared to various departments in the materials under one umbrella known as material management for better control, better handling, maximum efficiency necessary recording of data required and reduction to various acquisition cost.

Materials today are life blood of any industry and no government, industry, organization or private organizations operates without them. Materials must be available at the proper time in proper quantity, at the proper place and at the right time. Failure of any of those responsibilities concerning material, add to firms cost and decreases firms productivity and profit.

Baggot (2000) informed that the importance of material handling cost varies widely between different industries. He said in sugar refining material might represent over 90% of the total production cost whereas in the extraction industries there is really no direct cost of material at all.

Health and safety issues are perhaps the most talked about costs and consequences related to economics, yet ergonomics historically grew from the business realm of efficiency and quality improvement. Today, business and social forces have driven the science to encompass a large set of concerns, including productivity quality and health and safety.

The new dolly and hugger design (caster technology) based on ergonomics, safety, usability on all system types and configurations, product damage avoidance and cost has helped to achieve increased productivity by almost 400% in terms of man-hours. There have not been any injuries recorded since its adoption. Manufacturing firms should as well adopt this method in order to reduce regular handling of materials thereby avoiding losses through breakages and injury.

In a manufacturing industry the layout and material flow in the shop floor decides its productivity. Material handling system also plays a key role in influencing productivity throughout time and cost of the product.

Tuohy (2003) stated that, improving material handling efficiency can help increase the amount of perfect orders being shipped and in so doing ensure customer satisfaction and promote increased sales

Methodology

The method of research design adopted is the survey technique survey research technique of some manufacturing firms in South-eastern zone. The survey design allows the researcher to have a better understanding of the technological factors in the selected manufacturing industries. In line with the survey, questionnaires were designed and administered to the production managers, sales manager, quality control manager, engineers and other employees of the selected firms. A total of seven hundred and forty-five was calculated as the population of the study. This figure forms the population of the study. From the above population, using the sample size formula by Taro Yamane (1967) and stratified random sampling technique,

Taro Yamane’s formula,
$$n = \frac{N}{1 + Ne^2}$$

Where n = sample size

N = total population, and e = error margin because a 95% confidence level was assumed.

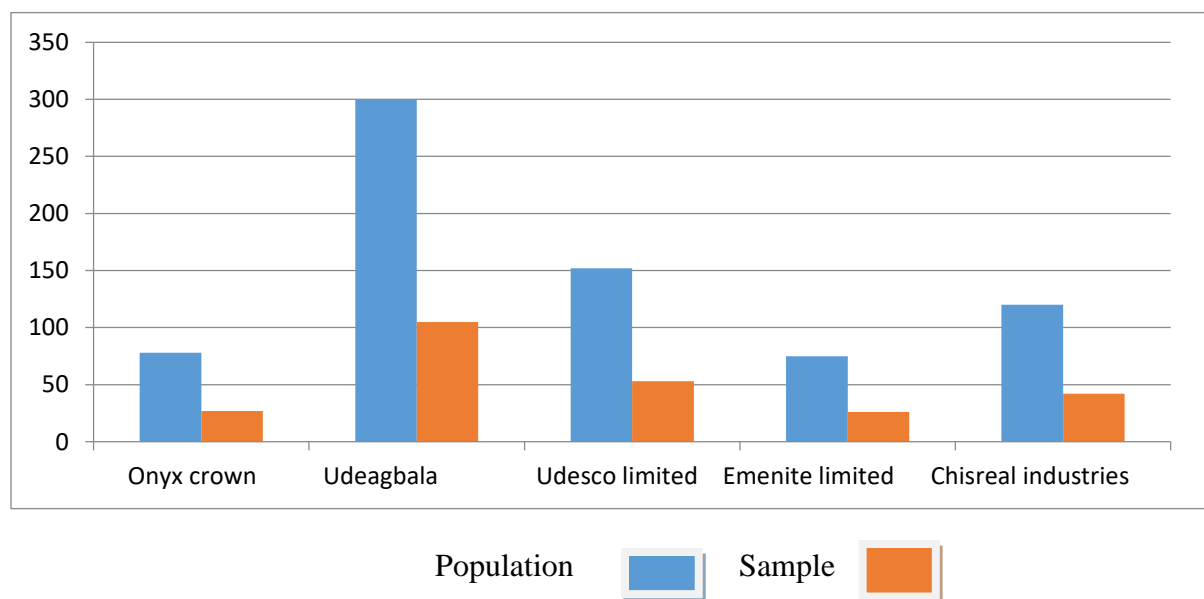
Therefore
$$n = \frac{745}{1 + 745 (0.05)^2} = 260,$$

the study sampled two hundred and sixty (260) respondents to assess the formulated questionnaire for data collection purposes. The selected manufacturing firms in the South east geopolitical zone of Nigeria, their staff strength and sample sizes are shown in Table 2.

Table 2 Names of the Manufacturing Firms, their Staff Strength and Sample Sizes.

S/No	Names of Company	Population	Sample Size
1	Onyx crown, Owerri Imo state	78	27
2	Udeagbala in Abia state	300	105
3	Udesco limited in Anambra	152	53
4	Emenite limited in Enugu	75	26
5	Chisreal industries Ebonyi	120	42
	Total	745	260

Figure 1: Number of Population and Sample



The data collected were analyzed and presented in tables from where the hypotheses were tested and inferences were finally drawn, and the result interpreted.

Reliability of the Research Instrument

Several methods of ascertaining reliability of data exists, tout for the purpose of this study, the test-retest method was adopted after the instrument has been retrieved from the sample used for the pilot study.

Hence, the research instrument was administered to certain group of the respondents, the result collected and after a month, the same instrument was also given to the same respondent group. The two results were correlated and an r value of 0.853 confirms the reliability of the research instruments.

Finally, the hypothesis was tested with a multiple regression analysis model and tested at 5% level of significance.

Variable Definition

- i. Size and capacity of plant (scp)
- ii. Extent of material handling (emh)
- iii. Repairs and maintenance(r&m)
- iv. Waste Management (wm)
- v. Level of Productivity (LoP)

Results and Discussions

The data collected via the questionnaire were presented and analyzed as follows;

Table 3 Descriptive Statistics

Identified Technological Factors	Mean	Std Deviation	N
LOP	37.2192	3.19316	260
Scp	18.6423	5.68604	260
r &m	15.8231	5.18532	260
Wr	16.4769	5.56564	260
Emh	17.6577	5.60493	260

Average productivity witnessed is 37.22, this is low. It is below average. There is need for more research in this area in order to improve the level of productivity. Size and capacity of plant have

the highest contribution to the level of productivity meaning that if the size and capacity of machines are high, in good shape and maintained from time to time without waiting for it to be spoilt, production will continue to go on without delay.

Table 4. Test for Multicollinearity and Independence of the Variables

		LOP	scp	r&m	wr	emh
Person correlation	LOP	1.000	.568	.374	.374	.477
	scp	.568	1.000	.150	.150	.446
	r & m	.374	.150	1.000	1.000	.339
	wr	.223	.163	.049	.049	.250
	emh	.477	.446	.339	.339	1.000
Sig. (1-tailed)	LOP	.	.023	.060	.034	.022
	scp	.023	.	.008	.004	.000
	r & m	.060	.008	.	.008	.293
	wr	.034	.004	.008	.	.000
	emh	.022	.000	.293	.000	.

Pearson correlation in Table 4 show that all the factors have high level of independency meaning that they are truly independent and can answer for themselves in subsequent analysis in this study, hence the problem of multi-collinearity does not exist. Also, the table revealed that the highest correlation exist between the level of productivity (LoP) and the size and capacity of plant (scp). This implies that scp is critical in achieving high LoP.

Table 5 Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the estimate	Durbin-Watson
1	.824 ^a	.715	.606	.24562	3.643

Table 5 show that the value of level of correlation (r) is 0.824, implying that there is high level of correlation existing among the variables. This means that the relationship existing between the variables is 82.4%. While the co-efficient of determination (r^2) which tests the level of variation explained by the identified factors. An r^2 -value of 0.715 shows that all the four (4) variables collectively explained 71.5% of the variation that occurred in the study. A Durbin Watson value of 3.643 is good and also confirmed the absence of multi-co-linearity.

Table 6 Multiple Regression Coefficient Analysis

Model	Unstandardized Coefficients	Standardized Coefficients		T	Sig.
		B	Std. Error		
1	(constant)	36.823	1.165		
				31.615	.000

scp	.631	.047	.458	7.651	.000
r & m	.541	.046	.401	4.595	.011
wr	.180	.044	.126	.408	.084
emh	.562	.048	.417	6.668	.006

a. Dependent Variable: LOP

From Table 6 above, the resultant predictive model;

$$LOP = 367.823 + 0.631scp + 0.541r\&m + 0.180wr + 0.562emh \dots \dots \dots (4.1).$$

From model 4.1 above, the following deductions can be made;

Scp value of 0.631 shows that for every 1 unit increase in scp, LoP will increase by 0.631 while holding the other factors constant. Similar argument can be made on the three other factors. The study also noticed that the size and capacity of plant (scp) exert the highest influence in an effort to improve the level of productivity (LoP) whereas waste reduction has the least influence on LoP.

**Table 7 Test for the Significance of the Model (F-test)
 ANOVA^b**

Model	Sum of squares	Df	Mean square	F	Sig.
1. Regression	3669.529	4	917.382	95.213	.000 ^a
Residual	2456.975	255	9.635		
Total	6126.504	259			

a. Predictors: (Constant), emh, r & m, wr, scp

b. Dependent Variable: LOP

The F- calculated value of 95.231 and a p-value of 0.000 shows that at 5% level of significance, model (4.1) is significant in predicting level of productivity in any given firm. This implies that the inclusion of the entire factors in the model is justified.

Hypothesis Testing

To do this, Table 6 above become important. The t- values in the table were used to test the formulated hypotheses.

Hypothesis I (H₀₁): Size and capacity of plant do not significantly influence productivity.

A t-value of 7.651 is significant at 0.000 level of significance, meaning that the size and capacity of plant (scp) is significant at 0.05 level of significance. We accept the alternative hypothesis and conclude that size and capacity of plant significantly influence productivity. Hence, as size and capacity of plant increases, the level of productivity increases.

Hypothesis II (H₀₁): Repairs and maintenance of machines do not have significant influence on productivity.

A t-value of 4.595 is significant at 0.011 level of significance, meaning that the plant repairs and maintenance (r&m) is significant at 0.05 level of significance. We accept the alternative hypothesis and conclude that Repairs and maintenance of machines have significant influence on productivity. This means that repairs and maintenance of equipment, tool and machines significantly increase the level of productivity.

Hypothesis III (H₀₃): Waste reduction management does not significantly affect productivity.

Waste reduction (wr) has a t-value of 0.408 with a p value 0.084 implying that wr is not significant in predicting the level of productivity. We accept the null hypothesis and conclude that Waste reduction management does not significantly affect productivity. This study agree that repairs and maintenance will ensure that during production, if processes and methods are done the right way and machines are in order that waste will be minimized.

Hypothesis IV (H₀₄): Efficient materials handling does not significantly stabilize the quantity of output.

A t-value of 6.666 is significant at 0.006 level of significance, meaning that efficient materials handling (emh) is significant at 0.05 level of significance. We accept the alternative hypothesis and conclude that efficient materials handling significantly stabilize the quantity of output productivity. When efficient material handling is practiced in manufacturing firms, it stabilizes the quantity of output produced. This also increases the level of productivity.

Conclusion

Based on the result of this study, the following conclusions are reached: Size and capacity of plant, efficient materials handling, repairs and maintenance of tools and equipment do significantly lead to improved productivities. They are the significant technological factors in this study that would influence the productivity of manufacturing projects.

Hence, the study recommends that, manufacturing firms should seek to enhance their technological capabilities as a way of improving their productivity. This is based a strong relationship between enhanced technological factors and improved productivity.

Manufacturing firms should pay attention to size and capacity of plant to ensure improvement in productivity. Manufacturing firms should also seek to improve their capacity building to guaranty full utilization of the plant and other manufacturing equipment. This will help them take advantage of economies of scale, and have relatively lower unit costs of production.

Effective material handling should be another goal of manufacturing firms seeking improved productivity levels and successful delivery of manufacturing projects. Ineffective material handling can increase the cost of production, and reduce the quality of material inputs; and this can seriously compromise the quality of the finished ordered quantity.

Repairs and maintenance of machines, tools and equipment are also important in influencing productivity because they would help to minimize waste.

References

- Alsyouf, I. (2007) The Role of Maintenance in Improving Companies Productivity and Profitability, *International Journal of Production Economics*, Vol. 105, No. 1, pp.70.
- Arabe K.C. (2001) Reducing Manufacturing waste, Industry Market trends, *International Journal of Marketing*, 2(1), pp. 15.
- Badwin, J.R. & Sabourin, D. (1998), Innovation, Output & Firm Size, *Journal of Small Business and Entrepreneurship*, vol. 15, No. 4, pp.34.
- Chan, K. (2015) Productivity Methodologies, “Tools and Techniques”, Increasing Productivity through Reducing Seven Wastes in Operations, *Asian Productivity Organisation (APO), Basic Programme*, pp. 24.
- Duffua, S.O., Al-Ghandi, A.H., & Al-Amer, A. (2002) Quality Function Deployment in Maintenance Work Panning Process, the 6th Saudi Engineering Conference, *KFUPM Dhahra*, Vol. 4. pp. 12.
- Eliot, D. (2007) *Productivity Improvement and Performance-based Remuneration, An Investigative Study*, Faculty of Management Science, Tshwane University of Technology, pp. 34
- Enofe, O.M. (2010) *Maintenance Impact on Production Profitability- A Case Study*, Linnaeus University School of Engineering Department of Tero, pp. 65.
- Geroski, P.A. (1998) An Applied Econometricians View of Large Company Performance, *Review of Industrial Organisation*, 13, pp. 271.
- Gorman, L (2014) *Technology and Productivity Growth*, the National Bureau of Economic Research, Massachusetts, Cambridge.
- Haiyangli, Y., Li, S., and Zhou, L. (2010) FDI spillovers in an Emerging Market, the Role of Foreign Firms in diversity and domestic firms absorptive capacity, *International Journal of Marketing*, 3(1), pp.45.
- Hasan R. (2002) The impact of imported and domestic technologies on Productivity of firm, Panel data evidence from Indian manufacturing firms, *Journal of Development Economics*, 6(9), pp.23-49
- Holger U., Alexander R., and Murakozy T. (2009) The Role of Technology in productivity, *International Journal of Technology and Management*, 1(3), pp.34.

- Hussan (2013) *Applying lean six sigma for Waste Reduction in a Manufacturing Environment*, A handbook of Quality Control in Manufacturing Process, pp. 12.
- Iornum, F. (2007) The Effect of Materials Handling on the Profitability of a Manufacturing Company, *Journal of Production Management*, 2(1), pp. 23.
- Kumar P.C. (. 2012) Set up reduction- A perfect way for productivity improvement of computer numerical control (CNC) Set up in manufacturing company, *Journal of Mechanical Engineering Research*, 3(1), pp.45.
- Lee and Qiu (2015) Near-Zero down time: Overview and trends. *Journal of Technological Advancement*, 2(1), pp. 87.
- Mahamat H. (2009) Technological Progress Metrics in Manufacturing, *International Journal of Production Management*, 2(2), pp.23.
- Masoumi, S., Bagheri, S.M.B., Arabi, I.A.M. (2014) Role of Maintenance and Repairs to reduce Production Costs in the Industries of Mazandaran from Managerial View, *World of Science*, 1(3) , pp.45
- Michelin G., Norbert J. and Pierre M (2006) *what drives productivity in Tanzanian manufacturing firms' technology or institution*, A paper presented at an Inaugural Ceremony of Michelin Tyre, June, 13.
- Robertson, B.O. (2014) Towards a Circular Economy, A Zero Waste Programme for Europe/*com/2014/0390 final/2*
- Robinson J. (2013) The Role of Technology in driving productivity and harnessing revenue, *Journal of Engineering, Science and Management*, 3(3), pp.197
- Sweis, R.J., Sweis, G.J., Abu Hammad, A.A. and Abu Hummad, M.A. (2009) Modelling the Variability of Labour Productivity in Masonry Construction. Jordan. *Journal of Civil Engineering*, 3(3), 197-212
- Telsang, M. (2006) Industrial Engineering and production management, *Journal of Construction Engineering and Project Management*, Vol. 5, No. 1, pp. 20.
- Touhy, J. (2003) Manufacturing firms, in developing countries. How well do they do and why? *Journal of Economic Literature* 38, pp.11
- Yamane, T. (1967) *Statistics: An Introductory Analysis*, 2nd Edition, New York: Harper and Row.
- Yang and Ying (2013) Technological factors affecting business all over the world, *European Journal of Scientific Studies*, Vol.2. no. 3, pp. 21.

About The Authors



Ibeawuchi I. Echeme, PhD

Owerri, Nigeria



Ibeawuchi Ifeanyi Echeme is a lecturer in the department of Project Management Technology, Federal University of Technology, Owerri. Echeme has a B.Tech, MSc, and PhD in Project Management Technology and has published more than fifteen (15) articles in both international and national reputable journals. Dr. Echeme has published a textbook on Project Time, Cost and Quality Management. He is a Certified Project Director (CPD) and a member of International Project Management Professionals (IPMP). Dr. Echeme has presented papers in conferences and workshops within and outside Nigeria. He can be contacted through ibeecheme@yahoo.com



Ihuoma Kwara

Owerri, Nigeria



Ihuoma Okwara is a lecturer in the department of Project Management Technology, Federal University of Technology, Owerri. She has a bachelor's degree and M.Sc. in Project Management Technology and is currently pursuing her Ph.D. in the same discipline. Ihuoma Okwara has many international and national publications in reputable journals.