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An Evaluation of the Applications of Quantitative Techniques (QTs) to Production Planning and Control in Manufacturing Industries

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Abstract
This study examined the factors that affect applications of Quantitative Techniques (QTs) to production planning and control in selected Nigerian manufacturing industries. Data were collected using questionnaire administered on 160 staff of 20 companies randomly chosen from each of the 8 purposively selected Nigerian Small-Scale Industries. Analysis of data was done descriptively and quantitatively using cross tabulations, percentages and inferential statistical tools respectively. Specifically, student t test was used to test the significance of the number of companies that apply QTs, The results showed that the types of QTs commonly in use include: Graphical and Charting Techniques, Control Charts, Forecasting Techniques (Simple Regression and Time Series Analyses), Inventory Model, Range, Variance and Standard Deviation, Capacity Utilization Model, and Acceptance Sampling. Control Charts topped the list with 14 (35 %). Also, 40 companies (25 %) of the 160 surveyed actually apply QTs. This number was significant at 0.05 level with t= 8.819. Metal Works industry led others in the applications of QTs with 8 (40 %) of the 20 companies surveyed in each selected industry; it also recorded 8 (20 %) of the 40 companies from all the selected industries. The study concluded that certain QTs are being applied to production planning and control by a significant number of companies from the selected Nigerian small-scale industries. Lack of adequate financial resources was the most important of all the assessed factors.
Keywords: Product planning and control, Operations research models, resources utilization decision making

1. Introduction

In the production of goods and services, manufacturing firms, are faced with the decision problems of how to determine the least –cost combination of inputs needed for actual production and , how best to produce, in the right quantity and quality for customers' satisfaction. These in turn, necessitate allocation problems concerning the utilization of limited resources. It is noted that in most industries generally, the thinking or philosophy of the production manager (or any other person acting in that capacity) determines what efforts he puts in the process of production. Further, Ogbo *et al*, 2012, posited that a production manager is an entrepreneur and, entrepreneurs have reasons for engaging in entrepreneurship, herein planning production. They also referred to the Resource – Based Theory which states that entrepreneurship is facilitated where there are capabilities and resources which the manager either possesses or can acquire and deploy in sustainable manner. The choice of a particular industry by implication of the above theory depends on a vision of the resource potentials. The identified resources include physical resources, reportorial resources, organizational resources, intellectual and human resources and, technical resources (Ogbo *et al*, 2012).

There is, also the Sociological Theory that sees entrepreneurship as a function of social and cultural or religious factors (Ogbo *et al,* 2012). They submitted that, intentions and means comes through interaction. The Psychological Theory is another theory which sees strength of will to achieve power as responsible for efforts made to improve one's fortunes. Also, the Economic Theory of production states that the reasons for becoming entrepreneurs or owners of factors of production are purely economic. For instance, being economic entails productivity (for example increased output volume) and profitability. Here in this study, productivity aspect is considered. The Economic Theory accepts Resource-Based Theory and emphasizes the principles of supply and demand. The supply of managerial services is a function of need of the society (Ogbo *et al*, 2012). The issue of QTs' applications by firms in their respective industries is related to decision-making. As such, QTs' applications assist managers generally in decision-making. Thus, this study considered and adapted the Economic theory of production as more appropriate. The need for improved general performance (and especially productivity), could rightly be seen as a function of the awareness created for, and the actual, applications of relevant QTs to production planning and control. This specific function is the one out of all others in the entire production management system that is solely saddled with the responsibility of turning out goods or services, in the required quantity and quality and, in the least-cost combination of inputs so as to satisfy customers; this, consequently, brings about increased productivity and profitability as well.

These efforts are made in such a manner to actually handle the raised issues of: how to determine the least cost combination of inputs needed for production; how best to produce in the right quantity and quality for customers'

satisfaction and; allocation problems concerning optimal utilization of limited resources. Applications of QTs to production planning and control in selected Nigerian small-scale industries could be seen as very important if the purely economic reasons are to be accomplished.

Management problems are complex in nature and are essentially resource allocation decisions (Lucey, 2007). The solutions to these problems could be obtained through qualitative approach, quantitative approach or both as they relate to production planning and control activities in industries. But application of suitable quantitative techniques is more realistic and deterministic. The study's general objective is to examine the applicability of quantitative techniques to production planning and control of selected Nigerian Small-Scale Industries. The specific objective is to describe the types of quantitative techniques that are commonly applied by small-scale industries in the chosen area of study.

2. Literature review

2.2.1 *Qualitative Techniques*

Qualitative techniques refer to all such techniques that are connected with the nature or quality of something. In Qualitative techniques, use is made of personal judgment, opinion and past experience. Though the last aspect – past experience, gives these techniques some advantages in the scheme of things, the disadvantages (for instance, sales people being overly optimistic or pessimistic regarding their predictions and inaccuracies due to broader economic events that are largely beyond their control), however, outweigh the advantages. This could be attributed to the fact that opinion and judgment are subjective; being human attributes that can change from time to time, situation to situation, and from individual to individual. Their types include: Historical Analogy, Market Survey or Research/Consumer Survey, Executive Opinions, Sales Force Polling, and Delphi – the most sophisticated of all the others. In applications, these tools are relatively easier and more straight – forward to handle. Little wonder, they attract a wide range of users limited also to the areas of marketing and general administration. Low costs implications could also be another reason for attraction to users (Caniato, 2010; Putra, 2009).

2.2.2 *Quantitative Techniques*

Quantitative Techniques are about the analysis of quantities (measured in physical, so-called objective data). These techniques are scientific in nature, their objective is to provide procedure and process that will aid or assist problem solving. These techniques being scientific in nature are model (mathematically) – based and therefore, follow very good logical (step by step) order.

Consequently, the areas of applications include: Accounting – cash flow planning, credit policies, planning of delinquent accounting system; Construction – allocation of resources to projects, determination of proper crew size, maintenance crew scheduling and project scheduling; Facilities planning – factory size and location, hospital panning, international logistics system; Marketing – advertising allocation, product introduction timing, selection of product mix; distribution channels; Military – general logistics and supply; simulation; trajectory etc; Forecasting – profit, sales volume, market shares, brand switching, production output, etc; among various others too numerous to list here. Furthermore, they are devoid of personal opinions or judgment.

Their advantages in applications, therefore, surpass a few disadvantages, especially, when compared with Qualitative techniques. Largely, QTs offer: Systems approach to organizations; recognition of risk and uncertainty (while offering tremendous solution methods to all associated problems no matter how complex); assistance to management decision making and control. Higher degrees of accuracy are attainable with the applications of QTs, as well. The choice of QTs over Qualitative techniques is based on their advantages in applications as mentioned above, and including numerous other accruable benefits, especially in production planning and control aspects of organizations' management.

Quantitative Technique (QT) is otherwise called Operations Research (OR), Decision Science (DS), Analytical Technique (AT), Quantitative Analysis (QA), among others. The first formal activities of this, were initiated in England during the second World War when a team of British scientists set out to make decision regarding the best utilization of war materials. At the end of the war, however, the ideas advanced in military operations were adapted to improve efficiency and productivity in the civilian sector (Taha, 2006, Imaga, 2003; Lucey, 2007).

Since its evolution, QTS have also been developed within the field of management science or adapted from other disciplines such as Natural Sciences, Business Administration, Mathematics, Statistics and, Engineering. Further development is evident in the increasing popularity of management science (quantitative technique) as reflected in the number of Colleges, Polytechnics, and Universities offering undergraduate courses and degree programmes in quantitative techniques (Taha, 2006). From the foregoing, the following are an attempt to define quantitative techniques and further explain what it means, especially, in the management of all organizations, (whether big, medium or small).

Quantitative technique (QT) is the attack of modern science on complex problems arising from, or in the direction and management of large systems of men, machines, materials and money, in industry, business, government and defence, going by the British Standard (Taha, 2006). Lucey (2007) went on to remark that its

distinctive approach is to develop a scientific model of the system incorporating measurements of factors like change and risk, with which to predict and compare the outcome of alternative decisions, strategies or controls.
Quite convincingly, quantitative technique is concerned with the efficient allocation of scarce resources, being both an art and a science. The art lies in its ability to express, clearly, the ideas in a well defined mathematical model of a given situation, while the science consists of the derivation of computational methods for solving such models (Bronson, 1997). It is important to note that optimal allocation of resources (which quantitative techniques help to achieve) is of utmost importance to decision making in many traditional disciplines including all production concerns.
Quantitative technique is seen as a scientific method of providing executive departments with a quantitative basis for decisions under their control; likewise, it is a scientific approach to problem solving for executive management (Anderson *et al.*, 2003). Also, it provides a basis for decision making. As such, if business no matter its nature is to be controlled effectively and efficiently, there is need for established businessmen and those pursuing a career in business, (including their counterparts in manufacturing world), to appreciate quantitative technique as basic, important and necessary tool for decision-making. Further, it was noted that now is the era when managers, necessarily, should be numerate, no matter their background (Owen and Jones, 1984).
Organizations (big, medium and small) in the developed world economies have recorded a good number of applications of QTs among companies and therefore have been enjoying accruable benefits as well. Companies in the United Kingdom (UK), United States of America (USA), Japan, China, France, are good examples, among others. Similar successes with QTs' applications have also been noticed with organizations in the developing nations like South Korea, Hong Kong, and New Zealand (Bisgaard, 2000; Bjerke, 2002; Gauri, 2003; Htzes, 2001; Srikaeo and Hourigan, 2002; Voss, 2002; Goodwin and Fildes, 1999; Song, 2008; Dueker, 2005; Ducker, 2005; Mahmoud, 2006; Pable, et. al 2010; Reddy, 2010)
The level of application and relevance of operations research (OR) techniques (that is, QTs) in the developing countries have long been generating controversy. Various scholars posited that there is extensive but unpublished application of such techniques by some developing countries. Several others argue that such decision-making techniques are irrelevant to the business operations of the developing countries, and thus are not used there. (Argozie, 2005) However, Nigerian organizations, especially the manufacturing ones (including small-scale industries) have few records of such level of applications of QTs. This is part of the reasons for this study.
The application of quantitative techniques in planning and control activities of production management is therefore vast, especially as they enable managers to understand and predict organization production system. It is pertinent here, to note that these techniques only assist managers in understanding the production system and in taking decisions. These techniques do not take decisions on their own for the production planners; rather they only provide a systematic approach to helping a decision-maker choose a course of action by investigating the problem, searching out objectives and alternatives, and comparing them in the light of their consequences using appropriate framework to bring expert judgment and intuition to bear on the problem (Okoko, 1999; Oyelere and Anene, 2007).

2.2.3 *Basic Principles of Production Planning and Control (PP &C)*

In manufacturing organizations, different production types are employed. However, irrespective of the production types employed, organizations in order to achieve set objectives of minimum costs, efficient work and high productivity, maximum profit and growth, and customers' satisfaction, among others, must carry out certain functions properly. In production management, therefore, these functions include: production planning and control, jigs and tools inspection and quality control, maintenance and repairs, research and development, personnel health and safety, purchasing and stores, worker training, cleanliness and good housekeeping, and some others. But what the system produces and demands to be satisfied in relation to market situation must be co-ordinate and regulated. Production planning and control is seen and regarded as the function that must specifically address and ensure the realization of production objectives stated above when compared with all other production management functions (Anene, 1993; MacCarthy, 2006).
Thus, it could be taken as the integration, co-ordination, overseeing and regulation of the use of manpower, machines and other materials for efficient output of goods or services to meet customers' demand and requirements at minimum costs. It guides production, regulates and controls "how", "where", and "when" work is to be done. The tasks include: inventory control – regulating quantities of stock and replenishing and issuing materials and tools; routing designating processing methods and the operation sequence, deciding which machine to use and who uses it; scheduling establishing output rate and the beginning and ending dates of production; dispatching – carrying out manufacturing orders through clerical control of factory work: expediting helping to enhance performance of various manufacturing operations to minimize or eliminate surprises that may develop; Production control – following up and checking to ensure achievement of the planned output goals.
Production planning and control can be separated into two – production planning and production control, for more simplification and understanding (McGregor, 1960; Shubin, 1972; Plossl and Wight, 1979; Omorodion,

1986; Agbadudu, 1996; Wild, 1998).

2.2.4 *Quantitative Techniques in Production Planning and Control*

Past and present records show that more quantitative techniques abound and are increasingly being needed for application to production planning and control activities especially, of the manufacturing industries. These according to Wild (1998), include: Graphical and Charting techniques; Control Chart; Linear Programming; Forecasting techniques like Regression and time series analyses, Markov Chain; Critical Path Scheduling (CPS) analysis; Programme Evaluation and Review Technique (PERT) analysis ; Inventory Models; Dispersion measures such as range, variance and standard deviation; Capacity Utilization Model; Vendor rating; Acceptance sampling and Break Even Analysis

Specifically, further classifications can be made putting some of the above techniques according to their applications to production planning and control when considered as separate activities. However, it is noted that a few of these techniques can actually be applied to both production planning activities and production control activities.

3. Methodology

3.1 *Area of Study*

The study area consists four (4) towns in Nigeria - Aba (for South -East and South South zones), Kano (for North Central, North East and North- West zones), Osogbo (for South-West zone) , and Lagos were purposively selected. This is done because the towns are commercial and/or industrial nerve centers of where they represent. These towns, also, have in abundance (naturally or otherwise) most of the necessary raw materials and the largely unskilled and semi-skilled manpower (Anene, 1993; Chibundu, 2006).

Eight Small-scale Industries (SMls) were also purposively selected. The towns also have the history of companies from the 8 purposively chosen small-scale industries whose products include: .dresses, beddings, (bed spreads), window and door blinds (curtains), blocks, shoes, sandals and slippers, hand bags, boxes, washing and toilet soaps, cooking oil, chairs, tables and beds, door and window shutters, burglary protectors, safes, machine tools, and farm implements (mowing and ploughing equipment).

3.2 *Method of Data Collection*

The questionnaire approach was used to obtain necessary data with questions constructed in such a way that respondents gave options or ticked suggested option(s) as appropriate for their answer(s). For this purpose, also, twenty (20) companies from each of the purposively chosen industries (garment, block-making, foot wears bag-making, domestic soap-making, edible oil extraction, furniture, and metal works) were randomly selected. Each of either the Managing Director or Production Manager or any other designated staff directly concerned with production planning and control activities of these companies responded to the constructed questions. The questions were on: whether or not quantitative techniques (QTs) are applied in the stated area of activities; the actual type of quantitative techniques (QTs) was being used; factors affecting the applications of such techniques; and the effect on performance in terms of productivity.

3.3 *Sampling Procedure*

Random sampling techniques' using balloting approach was adopted to draw sample from the population of the study. In doing this, the names of companies within each of the 8 purposively chosen small-scale industries were written each on a piece of paper, folded and put in a bag. The bag was thoroughly shaken before picking any five (5) of the folded pieces of paper. The above procedure was repeated in each of the four towns/cities purposively chosen for this study.

3.4 *Method of Data Analysis*

The retrieved questionnaire, were collated and the responses coded. For instance, the number of companies that apply quantitative techniques was recorded under "A" while those that do not apply quantitative techniques came under "NA". The sub-total and the corresponding percentages were calculated. Data collected for this study were analysed descriptively and quantitatively.

Descriptively, tables and percentages were used in analyzing part of the data collected. The quantitative analyses were carried out using results from the tests that were done on the stated hypotheses. Specific statistical techniques like Student t - test was used in testing the stated hypothesis, this is because student t-test was considered suitable to determine the significance of the number of companies that apply QTs.

4. Data Presentation and Analysis

4.1 *Data Presentation*

Table 4.1.1: Summary of Responses on Types of QTs Applied and the number of companies from the selected industries applying QTs

Types of QT Applied	No of Companies Applying QTs	%
(i) Graphical and Charting Techniques Graphical	5	12.5
(ii) Control Charts	14	35
(iii) Forecasting Techniques Like: Regression and Time series Analysis;	6	15
Markov's chain	-	-
(iv) Critical Path Scheduling (CPS) Analysis	-	-
(v) Programme Evaluation and Review Technique (PERT) Analysis	-	-
(vi) Inventory Models	1	2.5
(vii) Dispersion measures like: Range Variance and Standard Deviation	12	30
(viii) Capacity Utilization Model	1	2.5
(ix) Vendor Rating	-	-
(x) Acceptance Sampling	1	2.5
Total	**40**	**100**

Source: Field Survey, 2014

Table 4. 1. 2: Responses of Industries that Apply ("A") , Do Not Apply ("NA") and the % of the number of companies (40) that apply QTs "A"

Selected Industries	"A"	"NA"	% of the no. of companies (40) that apply QTs, "A"
(i) Garment	6	14	15
(ii) Block-making	4	16	10
(iii) Footwears	4	16	10
(iv) Bag-making	3	17	7.5
(v) Domestic soap making	4	16	10
(vi) Edible oil-extraction	5	15	12.5
(vii) Furniture	6	14	15
(viii)Metal works	8	12	20
Total	**40**	**120**	**100**

Source : Field Survey, 2011

Table 4.1.1 depicts the list of quantitative techniques applicable in the industries understudy. In table 4. 1. 2, it is observed that in all, 40 companies (25%) out of 160 surveyed actually apply QTs. Further, it shows that companies from metal works industry, led the pack of all the selected industries in the applications of QTs to production planning and control activities, with 8 (40%) out of the 20 companies studied in each of the selected industries. Garment, and Furniture, follows second, jointly, with 6(30%) companies applying QTs. In the 3rd position is Edible Oil Extraction, which 5(25%) companies also apply QTs. Three of the selected industries - Blocking-making, Foot wears and Domestic soap-making, are tied as second to the least in number of companies that apply QTs with 4(20%) each. Bag-making, however recorded the least number, having only 3(15%) of the 20 companies studied applying QTs.

From table 4.1.2, it shows the responses from the selected small-scale industries that do not apply QTs to PP&C with their percentages. The above results are peculiar to this study because the actual number of companies

applying QTs to PP&C and the entire production management was not specified in some other related studies. Such studies include: a Survey of 900 small and medium-sized manufacturing companies in a cross section of United States of America (USA), British food organizations, a study of the Application of Operations Research Methodology in Corporate Decision-Making in Selected Manufacturing Firms in Nigeria and, the case of Improving Production Planning and Control through the Application of Breakeven Analysis in Manufacturing Firms in Nigeria (Coccari, 1989; Grigg and Walls, 2004; Arozie, 2005 and Ogbo, et. al., 2012)

Also, results from Table 4.1. 2 are in line with those revealed by Table 4.2. As shown, 8 companies (representing 20%), of the actual number of companies (40) that apply QTs are from metal works industry, which topped the table. Garment and Furniture industries followed with 6 (15%) each. Edible oil-extraction industry with 5(12.5%) took the third place. Block-making, Foot wears and Domestic soap-making industries recorded 4(10%) companies, each to occupy a joint fourth (second to the last) position. Bag-making industry with 3(7.5%) companies brought up the rear in this category.

4.2 Test of Hypotheses

4.2.1 *Hypothesis 1*

H_o1: The number of companies that apply quantitative techniques in the study area is not significant.

Figures from table 4.1.2 were subjected to student's t-statistics as paired values using SPSS package. The result gave, t_{cal} = - 8.819 as shown in the result table 4.2 below

Table 4.2: t – test results

Paired differences				
		95% Confidence interval of the difference		
Mean	Std. Deviation	Std. Error Mean	Lower	Upper
-10.00	3.207	1.134	-12.681	-7.319

T	Df	Sig. (2 –tailed)
- 8.819	7	0.000

Source: Test Results, 2014

Interpretation of results

With n = 8; degree of freedom, df = n - 1 = 8 - 1 = 7; Critical t-value significant at 0.05 is table value), $t_{abulated}$= 1.895. The calculated t-value, $c_{alculated}$= - 8.819. Disregarding the negative sign, then $c_{alculated}$= 8.819. It follows therefore; that $c_{alculated}$ is greater than the critical t-va1ue, t_{tab} (thus, 8.819 > 1.895); the null hypothesis that the number of companies that apply quantitative techniques in the study area is not significant, is rejected. Hence the alternative hypothesis; that the number of companies that apply QTs in the study area is significant, therefore, is accepted. The above result supports and strengthens the ordinary figure for the number of companies applying QTs, which is 40. This means that 25% of the 160 companies surveyed in the selected industries do apply QTs in the area of concern. The small proportion notwithstanding, the number of companies (40) that apply QTs could be said to be of some reasonable importance.

5. Conclusion

The study found that control chart, dispersion measures (range, variance and standard deviation), forecasting techniques (regression and time series analyses), graphical and charting techniques, inventory model, capacity utilization model and, acceptance sampling, are the QTs being applied by the various companies from the selected industries. Control chart was found to be the most frequently applied techniques with 14 companies representing 35% of the actual number that apply QTs. This is in line with the findings of Grigg and Walls (2004) where control chart was topmost in use in production management activities (a superset of PP&C). Dispersion measures (Range, Variance and Standard Deviation) came next in frequency of application with 12 (30%). Forecasting techniques (Regression and Time Series Analyses - the two traditional forecasting methods), Graphical and Charting techniques followed with 6(15%), 5 (12%) respectively, Inventory model, Capacity Utilization and Acceptance Sampling, were jointly the least frequently applied techniques, having only 1 company (2.5%) each.

It was also revealed that a total of 40 companies (25%) out of the 160 surveyed, apply QTs. This number was found to be significant at 0.05 level when subjected to student t - test for hypothesis 1, (the number of companies that apply QTs in the study area is not significant) which result gave t = 8.819. Further, Metal works industry led all the others in applications of QTs with 8(40%) of the 20 companies surveyed in each of the selected industries: it also recorded 8(20%) of the 40 companies from all the selected industries that apply QTs.

These other industries are Garment and Furniture with 6(30%) each, to place a joint second. Edible Oil Extraction recorded 5(25%), Block - making, Footwears and, Domestic soap - making had 4(20%) each, and Bag - making with 3(15%) took the third, fourth and last positions respectively: (Considering the number (Percentage) out of the 20 companies studied in each industry applying QTs.

In managing any organization generally, and particularly applications of quantitative techniques to actual management, certain important aspects are often overlooked. These are the cost in time and the cost of required resources for developing and using QTs. The manpower requirements, financial cost, staff skills and in recent time, information technology (IT) equipment required to develop and use quantitative techniques (QTs) can be high. Any consideration to apply QTs, therefore, should include an estimate of the benefits and costs involved. Thus, the study concludes that certain QTs are being applied to production planning and control activities by a number of companies from the selected Nigerian small – scale industries. This number was found to be significant, despite the low percentage; that is, 40 out of 160 representing 25%. Control charts were first on the list with 14(35%). Metal works industry, with 8(40%) of the 20 companies surveyed in each selected industry, topped the list of others that apply QTs. Lopsidedly, 120(75%) of the surveyed 160 companies do not apply QTs.

The study, thus, recommends that the companies within the selected industries, should seek ways to increase general awareness on the use of available quantitative techniques even if it is for the common ones that are easy to come-by and also easy to apply like simple charts, standard deviation among some others. This will ensure that the attendant benefits of QTs' applications are enjoyed.

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