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Optimizing Just-In-Time Inventory System for Resource Allocation in Plastic Manufacturing Industry in Nigeria

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Abstract:-The study focused on optimizing Just-in-Time (JIT) Inventory Control System for Resource Allocation in the Plastic Manufacturing Industry with a focus on Double-Diamond Plastic Manufacturing Firm, Aba. The objective of the study was to optimize cost and improve production efficiencies of inventory allocation in the production of Over-Head Tank of 700 meters. The study employed a quantitive research design, of which secondary data were used. Data collected were estimated using regression models via (SPSS) of which Ordinary Least Square (OLS) formed the basis for estimation. The study showed that optimal (functional) Economic Order Quantities (EOQ) of Linear-Load Density Earthylene, Carbon, Colour, and Ultra-Violet Pigment were 1,214.47kg, 81,833.06kg,75,075kg, and 9,741.60kg, respectively. The linear-Load Density Earthylene (LLDE) as inventory material minimized most, the total cost of inventory, followed by Ultra-Violet Pigment (Addictive), Colour, and Carbon, respectively. From the foregoing, the study concludes that estimated optimal (functional) Economic Order Quantity (EOQ) yields realistic (lower) values that minimizes the total cost of inventory and therefore, recommended that organization should groom their staff on the use of estimated optimal Economic Order Quantity (EOQ) in the procurement of their inventory materials, because it is the order quantity that minimizes the total cost of inventory.

Introduction

The quest for excellence and the desire to maintain competitive edge giving the dynamism of business environment have predisposed many manufacturing firms to place emphasis on Just-In-Time (JIT) inventory management system. The pressure to satisfy the increasing demands of the environment led the way for further foraging on how best to strengthen its productive capacity with respect to efficient allocation of resources, make organizations to strategize on laudable policy to induce production efficiency. Inventory based manufacturing firms according to Scott (2007) exert considerable efforts in making vital decisions that border on inventory procurement and efficient allocation of resources in an attempt to meet the demands of the changing business environment. Just-in-time inventory system is an operational philosophy developed by Toyota Automobile in Japan in the 1950s (Chen and Tan, 2011). This was developed as operating system in an attempt to effect zero-error and quality management of inventory materials in organization. Abara (2011) argues that just-in-time inventory management system uses different approach to minimizing total carrying cost and set up cost by attempting to drive these costs to zero and that explains the push for zero inventories in JIT system. Therefore, it is concerned with due-date performance by not building inventory, rather, reducing lead times.

Musara (2012) sees Just-in-time inventory system as an operational management approach designed for manufacturing firms to improve performance through waste reduction. Frank, (2000) argues that Just-in-time inventory control system is a management philosophy designed for continuous search for ways to make processes more efficient with the goal of manufacturing goods and services without incurring any waste. It encompasses the successful execution of all manufacturing activities required to produce a final product. Therefore, Just-in-time (JIT) inventory system is a production and inventory control system in which materials are purchased and units are produced only as needed to meet actual customer demand. Most organizations use Just in Time (JIT) manufacturing and inventory control system, they purchase materials and produce units only as needed to meet actual customers demand. In just in time manufacturing system inventories are reduced to the minimum and in some cases is zero. Thus, inventory is a stock of economic resources that are idle at a given point in time. This includes raw materials awaiting use in manufacturing or service-oriented organizations, semi-finished goods temporarily stored during the manufacturing process and finished goods.

Efficient production has been associated proportionately with smooth operating activity that allow manufacturing firms to maintain and sustain greater operational effectiveness and efficiency that will afford them greater leverage for success. It is therefore pertinent that operation managers, in Double Diamond Plastic Manufacturing Firm have a basic understanding of the inventory phenomenon and associated benefits as well as it's associated cost components for effective control of inventory.

Double Diamond Plastic Manufacturing firm is a key player in the production of house hold products to include bread wrappers, polythene bags, jerry cans, plastic chairs. Over-head tank, plastic buckets, bowls, plastic plates, spoons, hangers, plastic sheeting, bottle carriers, bundles of carefully packed products and roles of plastic sheeting of different colours and sizes and containers of various shapes and sizes as specified by the customers. The company uses the following inventory materials for the production of over-head tanks (700 liters): Linear-Load Density Poly-Earthylene (LLDPE), Carbon, Colour and Ultra violet pigment (additive) (Double Diamond Plastic Industrial Limited, 2013).

The Problem

The success or failure of any inventory-based manufacturing firm depends on its operational capability with regards to effective management of inventory system in the organization (Bhavan, 2008). Double-Diamond Plastic Manufacturing Firm through observation seems to have problem of inventory operating system with regard to determining when to order its material inventories and how much of each inventory to order per order period. The department responsible for inventory management seemingly has little knowledge of Just-in-time inventory control system for effective inventory decision making. The forgoing makes it difficult for the organizations to determine the optimal order quantity of inventory materials that would have reduced the total cost of inventory. As a result of that, incur high cost in their operations due to over-stocking of inventory items. Over-stocking of inventory materials according to Abara (2011) could lead to waste of inventory items as a result of obsolescence, deterioration, theft, pilferage, etc, which subsequently affect the organizational performance. From the aforementioned therefore, this study is designed to explore how the operating doctrines of Just-in-time inventory system could be employed to enhance effective control of inventory in Double-Diamond Company.

Related Literature

Researchers have done studies that sought to solve different inventory problems in different parts of the world. For example, Musara (2012), carried out a study on "Impact of Just-in-Time (JIT) Inventory System on Efficiency, Quality and Flexibility among Manufacturing Sector Small and Medium Enterprise (SMEs) in South Africa. The objective was to ascertain the impact of Just-in-Time (JIT) inventory management system in the manufacturing sector. The study employed a survey research design for data generation while split-half technique and Pearson product moment correlation method were adopted to determine the internal consistency of the instrument. Weighted mean and standard deviation were used to answer the research questions. The study used t-test statistics to test the hypothesis. It was found that majority of SMEs in the manufacturing sector do not apply JIT inventory principles. In addition, the study revealed that the challenges that hinder the implementation of JIT principles in the manufacturing sector of SMEs in South Africa include lack of reliable supplier network, lack of capital and lack of knowledge of immediate financial gains.

Deveshwar and Dhawal (2009) carried out a study on "Inventory Management" Delivering Profits through Stock Management in Manufacturing Industry in Haryana, India. The study was aimed at determining the level of awareness of inventory management fundamentals in most organizations. Inventory management has emerged as focal points in organizational efforts to reduce losses. The management of capital within an organization has a substantial contribution towards profits and inventories are usually organizations largest assets. The study employed a survey research method of which structured questionnaires were distributed to the randomly selected sample of the study. The questionnaires were distributed to 200 selected firms from Automobile, Auto Ancillary Industry. The study found that increase in profits is possible through reductions of losses due to stock management and concluded that stock management has opened numerous avenues of profits realization with negligible investment. Therefore the study recommended that organizations should focus on these techniques intended to help organizations achieve increase profits and enhanced customer service expectation.

More so, Adeyemi and Salami (2010) conducted a study on "Inventory Management: A tool For Optimizing Resource in Manufacturing Industry," with a special interest in Coca cola Bottling Company, Ilorin plant, Kwara State. The study sought to determine whether or not inventory management in the Nigerian Bottling Company could be evaluated and understood using the various existing tools of optimization in inventory management. The study used secondary data which were analyzed using variance analysis, economic order quantity model and chi-square method. The study found that Coca Cola company in Ilorin always adopt the classical Economic Order Quantity (EOQ) model in placing orders for its raw materials and this accounts for the variations between the calculated EOQ and the expected order sizes of the company.

A study by Liyanage (2010) analyzed Inventory Management Practices of processed Food supply Chains in Sri Lanka. The aim of the study was to identify the issues in inventory management practices of processed food supply chains in Sri Lanka. The study employed a survey research method with structured questionnaire was administered to the staff of the food supply chain in Sri Lanka. The findings showed that there were manual operations of inventory management process, improper linkages within the supply chain partners, lack of focus towards developing computerized inventory management system, and that improper analysis of demand data and raw materials constituted a major hindrance to the existing inventory management practices.

Inventory Control and Management as Effective and Efficient Tool in Achieving Organizational Growth in Nigeria was studied by Egberi, and Egberi, (2011). They studied Eternit Limited, Sapele in Delta State. The objective was to determine the relationship between efficient inventory management and organizational productivity on Eternit Limited. The study employed a survey research design of which structured questionnaires were administered to 140 respondents as the sample of 216 member staff of Eternit Limited. The study equally formulated two (2) hypotheses. Data collected were analyzed with simple percentages and chi-square statistical tool. The findings revealed that there is significant relationship between inventory control and profitability; there is also a significant relationship between inventory control and cost of production. In the light of their findings, the study concluded that inventory control has contributed immensely to the growth and survival of organizations, helping to improve on their profitability, reducing cost of production, creating buffer between input and output and avoidance of inventory build-up. The authors therefore recommended that a concerted attention shall be given to inventory management and adequate storage facilities of inventories shall equally be provided in addition to maintaining a proper records as well as the volume of inventories to hold at a given time because of its pertinent role in organizations.

Optimization Theory

Abara (2011) argued that the objective of most inventory models is to minimize the total cost of holding inventory. The significant costs are the ordering cost and carrying cost. Therefore, the moment ordering cost and carrying cost are minimized, the total cost of the inventory is minimized. The optimal order size, Q, is the quantity that minimizes the total costs. The theory of optimization is illustrated in Figure 1 which shows the relationships. The minimum point along the total cost curve approximates the EOQ, q*, where the ordering cost equals the carrying costs. These relationships are illustrated in Figure 1.

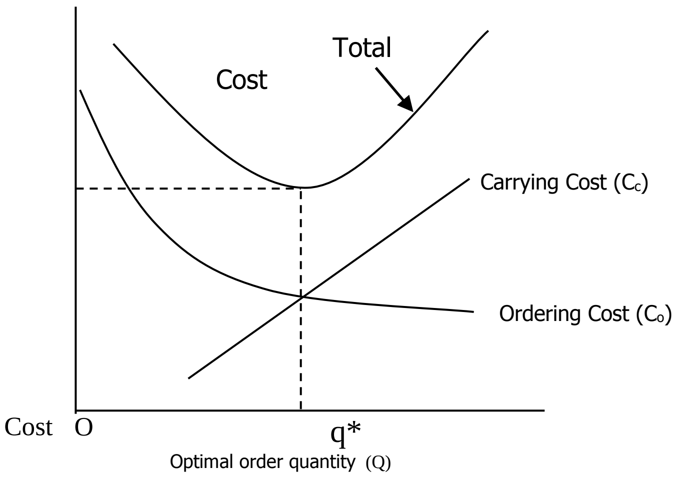


Figure 1: Optimality Condition

Methodology

The study employed a quantitative research design. The research design builds mathematical cum statistical models that captured the relationship among modeled variables. The independent variables in the model describe or explain such relationship with the dependent variables. The study used secondary sources of data, on annual demand, carrying and ordering costs components per production run, quantity of materials used per run. Therefore, data was collected for Linear-Load Density Earthylene (LLDPE), Carbon, Colour and Ultra Violet Pigment (addictive) as inventory materials used in the production of Over-head Tank of 700 liters in Double-Diamond Plastic Company. The focus of the model was on raw material inventories, their relative costs, and demand requirements. Ordinary Least Squares (OLS) therefore formed the estimation basis of the regression models such that:

$X_i = a_o + a_1Y + \varepsilon$, for cost of each raw material

1

where X= carrying cost or ordering cost, Y = quantity of material (kg), b_o is the slope, t is the time period (days) and ε is the random (stochastic) disturbance term.

Thus, determining the functional form of Equation 1 was a necessary condition for this study. Doti and Adibi (1988) have shown that when dealing with relationships that involve a constant rate of growth in the dependent variable, which should be assumed, an exponential relationship of the following type was postulated for both the carrying and ordinary cost functions.

$X_k = bo\ e^{biYk} + \varepsilon$

(2)

where: X_k the carring or ordering cost component, Y is input for the kth (carrying or ordering) cost function, and e is the base of natural logarithm and Kj is the error term.

Equation 2 form is usually used to represent the functional relationship between equal changes (increasing/ decreasing) in the level of the independent variable, and a constant rate of growth in the dependent variable. The sign before the parameter bi for i= 1,2 was determined as the function for carrying cost or for ordering cost. Theoretically, b parameter should be positive (b>o) for carrying cost when estimated, while it would be negative (b<o) for ordering cost when estimated.

Results

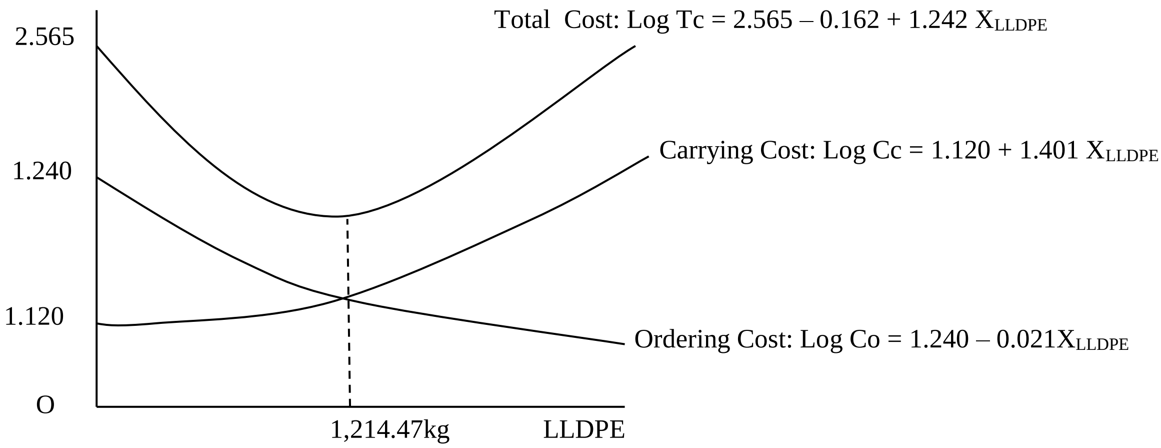
In order to obtain the estimated optimal quantities for Linear-Load Density Earthylene (LLDPE), Carbon, Colour, and Ultra-Violet Pigment (Addictive) as inventory materials used in the production of Over-Head Tank of 700 meters, the ordering cost (C_o) equation for each material was equated to its carrying cost (C_c) and the optimal quantity obtained. The result was further transformed to its anti-logarithm.

Linear-Load Density Earthylene (LLDPE)

Ordering Cost: Log Co = 1.240 – 0.021X_{LLDPE}

Carrying Cost: Log Cc = 1.120 + 1.401 X_{LLDPE}

Total Cost: Log TC_{LLDPE} = 2.565 – 0,162 + 1.242 X_{LLDPE}



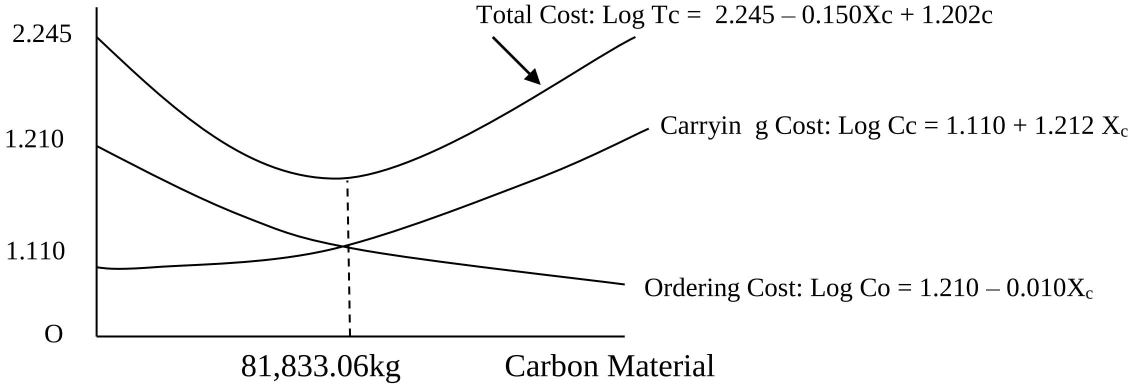
The optimal Quantity of LLDPE is 1,214.47kg.

Carbon

Ordering Cost: Log Co = 1.210 – 0.010X_c

Carrying Cost: Log Cc = 1.110 + 1.212 X_c

Total Cost: Log Tc = 2.245 – 0.150 X_c + 1.202cc



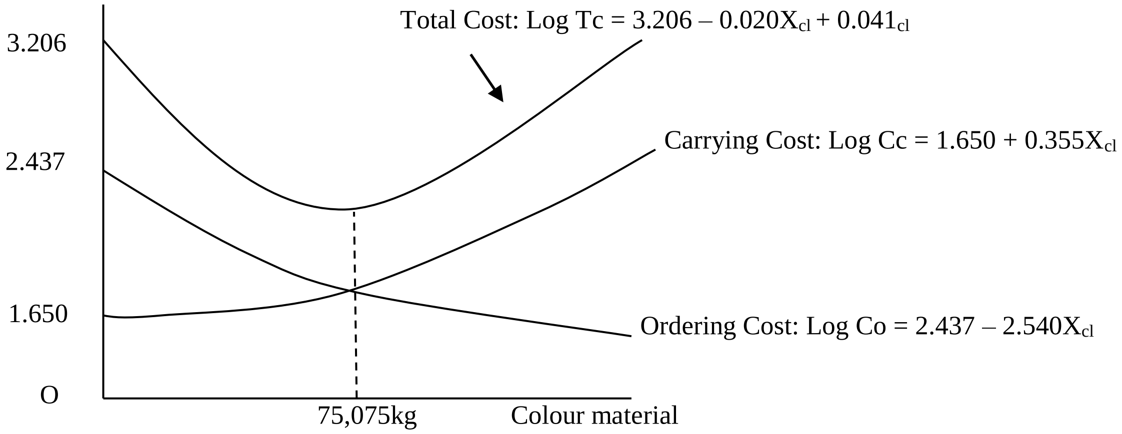
The optimal Quantity of Carbon material is 81, 833.06kg.

Colour

Ordering Cost: Log Co = 2.437 – 2,540X_{cl}

Carrying Cost: Log Cc = 1.650 + 0.355X_{cl}

Total Cost: Log Tc = 3.206 – $0.020X_{cl}$ + 0.041_{cl}



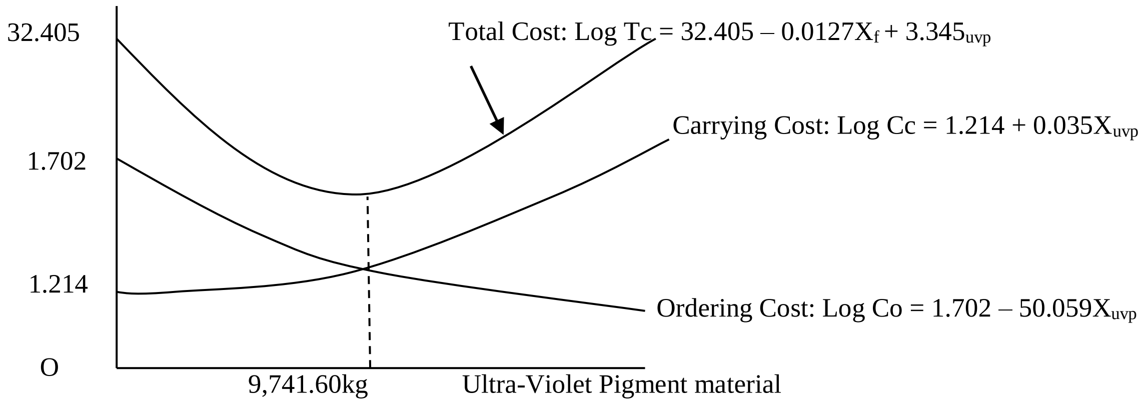
The optimal Quantity of Carbon material is 75,075kg.

Ultra Violet Pigment (Addictive).

Ordering Cost: Log Co = 1.702 – $50.059X_{uvp}$

Carrying Cost: Log Cc = 1.214 + $0.035X_{uvp}$

Total Cost: Log Tc = 32.405 – $0.0127X_{f}$ + 3.345_{uvp}



The optimal Quantity of Ultra-Violet Pigment is 9,741.60kg

The estimated optimal (functional) quantities of Linear-Load Density Earthylene, Carbon, Colour, and Ultra-Violet Pigment were 1.214.47kg, 81,833.06kg, 75,075kg, and 9,741kg, respectively. The obvious result that could be considered novel is the fact that, Linear-Load Density Earthylene as inventory material minimized most, the total cost associated with inventory, relative to other inventory materials. By the same interpretation, it is followed by Carbon. Ultra-Violet Pigment, and Colour that minimizes the least of the total cost of inventory.

From the aforementioned, the estimated functional approach of optimizing (minimizing) the total cost of inventory, gives a more realistic values of the desired Economic Order Quantity (EOQ), because it takes into cognizance the possible variants in inventory management. Such variants as change in production technologies, price of materials, product prices, government polices etc. that create risk and uncertainty in inventory management. These risks and uncertainties are incorporated through their stochastic error terms and therefore yields more realistic (lower0 values of Economic Order Quantity (EOQ). Minimization of total cost is absolutely the basic tenet of effective inventory management policy, and should be the guiding operational principle for inventory resource allocation in any inventory-based manufacturing firm.

Conclusions

Based on the findings, the study concludes that optimality is the key to efficient and effective inventory resource allocation because it yields the expected Economic Order Quantity (EOQ) that minimizes the total inventory. In other words, when the total cost of inventory is minimized, it would reduce both the carrying costs (Cc), and Ordering Costs (Co) in their production runs which subsequently reduces per unit cost of producing Over-Head Tank of 700 meters. Therefore, just-in-Time (JIT) inventory control system does not only eliminate waste of inventory materials resulting from obsolescence, deterioration, pilferage etc. but ensures steady flow of materials in meeting the demands of the business environment.

Recommendations

Based on the findings of this study, the following recommendations are made:

The management of Plastic manufacturing Firms in Nigeria should groom their staff especially the personnel responsible for inventory management on the use of estimated optimal Economic Order Quantity (EOQ) for the procurement of inventory materials necessary for the production of Over-Head Tank of 700 meters, because it is the optimal order quantity (q*) that minimizes the total cost of inventory.

The organization should employ Just-in-Time (JIT) inventory control system in their operations in order to address the problem of over-stocking of inventory materials. The just-in-time approach to inventory control system is most desired in operations management especially giving the dynamic nature of business environment because, it is concerned with due-date performance.

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