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LEAD TIME UNCERTAINTIES, AVERAGE INVENTORY AND SCHEDULING PRACTICE ON MANUFACTURING FIRMS IN NIGERIA

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ABSTRACT: *This study examined lead time uncertainties, average inventory and scheduling practice on manufacturing firms in Nigeria. A survey design was adopted, where we identify the population of manufacturing firms and by a purposive sampling procedure, we used twenty (20) manufacturing firms in Port Harcourt, Nigeria. The research instruments used were the questionnaire and oral interview of key personnel in the production, marketing and material management departments. We collected 16 completed questionnaires that give an 80% response rate. The data were analysed in presenting answers to the research questions. We used the statistical tools of the mean, standard deviation, covariance in determining lead time and the weighted mean percentage inventory (WMPI) and weighted mean percentage stock out (WMPS) in determining the inventory profile and the incidence of stock out respectively in both the uniform and fluctuating schedules of product manufacture.From the findings; the calculated WMP1 and the calculated WMPS are higher in fluctuating schedules with 8% and 9% respectively as compared to the low inventory and stock out levels in uniform schedules of calculated WMPI and WMPS of 9% and 6% respectively. Thus production scheduling plays a chief role in improving the overall performance of any company in regards of increased output improved on time delivery and also improved balancing of the production line. Due to the economic view of inventory costs to the overall production activity, we recommend from the results that a uniform production schedule fined tune to holding a small manageable inventory is preferred.*

KEYWORDS: Scheduling, Lead Time, Demand Uncertainty, Inventory Management

INTRODUCTION

Manufacturing companies are often dynamic and complex systems. Right from its origin the manufacturing facilities have tried to organize and control their production process by making use of practical and efficient methods (Hermann, 2004). Most of the manufacturing firms present their production schedule as a plan that outlines the activities that can be controlled to be carried out. Production scheduling is a very important factor in decision making in any company as it also has a valuable role in manufacturing and the service industries. Production Scheduling deals with the proper sequence of job, tasks, orders, and individual operations.

According to Bagshaw (2014) production scheduling pertains to establishing the timing of the use of specific resources in a firm. This relates with the overall production scheduling plan for the production process within some given period to give an idea to management as to what quantity of materials and other resources are to be procured and when, so that the total cost of operations of the organization is kept to the minimum over the period.

The scope and complexity of scheduling problems are continuously increasing due to the more established and efficient solution technologies and increased popularity and need to improve

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the profitability of industrial production (Liro and Reinhard, 2014). In manufacturing, the purpose of scheduling is to minimize the production time and costs, by programing a production facility on when to make, with which staff, and on which equipment in other to maximize the efficiency of the operation and reduce costs (Nahid, 2014). Also, a good schedule should be design in sucha way as to meet the demands of the product and also to achieve a level of output where wastage of time, material and human effort is low with an inbuilt capacity to adapt to changing demands in the market. The essence of production scheduling is fundamentally to avoid increased costs on production by having a scheduled programme that fits the production planning for a given period accommodating the uncertainties in product demand.

Planning, scheduling and controlling production in the face of uncertain market conditions that result in fluctuating demand is a tasking responsibility on the management of manufacturing organisation. How this can be achieved is a function of the interplay of variables among which are forecasted demands, production schedule, and finished goods inventory level. Use of a stable production schedule also permits the use of back-flushing to manage inventory where an end item's bill of materials is periodically exploded to calculate the usage quantities of the various components that were used to make the item, eliminating the need to collect detailed usage information on the shop floor (Baitler, 2010).

Hence the ultimate goal of production scheduling is to eliminate such activities so as to streamline all activities towards creating value in the product.

Demand for the product varies widely over time and the practice is to schedule production to create inventory levels above the current demands. This precautionary inventory is built to the scheduled production to compensate for inevitable occurrence higher than average demand. In lower demand periods, the stock will accumulate and this excess inventory will be used to meet future sales requirements.

Inventory can mask or cover a lot of problems within a manufacturing system. These problems may include machine breakdowns, long set-up times, long lead times, quality defects, problems associated with scheduling and even problems associated with the selling and marketing of products (Ignatio et al, 2013). However in very competitive markets reducing uncertainties by holding more inventories might prove not to be a valid remedy as inventory holding costs may become prohibitive. Too much or too little inventory leaves an organisation at a competitive (or cost) disadvantage to competitors.

The existence of inventories makes it possible to develop production schedules relatively independent of demands. The economic significance of an effective scheduling practice vis-à-vis the inventory system is very important. How to balance these activities in the turbulent market environment is worrisome. The effects of such difficulty are still apparent and oftentimes the solution to these difficulties seems afar. However, there are particular interactions of variables such as lead-time, stock out incidence, average inventory levels, scheduling techniques and rules in the production schedule - inventory management interface. To what extent are these interaction appreciated and exploited in the Nigeria manufacturing environment is the focus of this study.

The purpose of this study is to examine the features of the production scheduling/inventory management interface in a number of Nigerian manufacturing organisation and hence to

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identify the underlying interplay of variables that make for improved levels of organisational effectiveness and efficiency.

Research Questions

1) Between fluctuating scheduling and uniform scheduling, which one is a preferred practice vis-à-vis the sales forecast of the firm's product(s)?

2) What is the effect of lead time uncertainties on scheduling practice?

3) To what extent does the choice of scheduling practice influence the average inventory and the incidence of stock out?

LITERATURE REVIEW

Inventories constitute one of the largest and most tangible investments of any retailer or manufacturing organization. Intelligent inventory management strategies can not only help boost profit but they can mean the difference between a business thriving or barely surviving. Holding inventories at the lowest possible cost and giving the objectives to ensure uninterrupted supplies for on-going operations is the aim of inventory management (Ogbo et al, 2014). They further defined inventory as the availability of any stock or resources used in an organization.

An inventory system is the set of policies that controls and monitors inventory level and determine what level should be maintained, how large orders should be made and when stock should be replenished. Also, Ghosh and Kumar (2003) opined that inventory is a stock of goods that is maintained by a business in anticipation of some future demand. Inventory management has a significant impact on a company´s performance because it can influence all of the three key factors of competitiveness: quality, time (or flexibility) and costs (Denisa, 2014).

Management is concerned with the role of inventories in business cycles that will lead to lower inventory and production cost in meeting the demands for the product(s). The inventory here is termed average inventory of the raw materials, work-in-process and finished goods (King-Scott, 1971). He then gave mathematical presentation of achieving the economic production lot size as:

$$Cm = \frac{Ad}{q} + \frac{q}{2}\,\frac{(1-d)}{p}$$

where, p is production run

Cm	=	total variable cost of production
A	=	inventory cost
d	=	expected demand
q	=	quantity to be produce per production run
1	=	per unit cost of quantity produced

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Therefore, the economic production lot size model is written as:

$$EPQ = \sqrt{\frac{2Ad}{(1 - d/p)i)}}$$

Because costs are involved, management decision to operate at a certain production level must be related to the inventory investment vis-à-vis an efficient and effective production schedule.

In this situation, we are mainly concerned with inventory of finished goods in relation to the schedule practice in the production process as to meet fluctuations in product demand. The goals underlying production planning, scheduling and related inventory management problems involve balancing of conflicting objectives such as: minimum purchases or production cost, minimum storage and distribution cost, and minimum inventory investment, while maintaining maximum service to the customers (Buffa and Taubert, 1972).

According to Chase and Aquilano (1977), a stock of finished goods on inventory is kept to satisfy the following:

1) *To maintain independence of Operations*

2) *To maintain variation in product demand*

3) *To allow flexibility in production scheduling.*

The two main inventory systems are: Fixed order quantity system and, fixed-order period system (Chase and Aquilano 1977). The fixed order quantity system is quantity or 'event triggered' that is, once the level of inventory falls to the level below the fixed quantity, a new replenishment is made to inventory.

The fixed period system is 'time triggered', it implies a given period (time frame) to which inventory is replenished once that time period elapses, say every one month. These approaches are adopted to maintain the desired inventory level for stock of finished goods or other inventories to avoid unforeseen circumstances.

According to Banjoko (2002), production plan is subjected to a proper sales forecast, which is tied to unpredictable demands for the product. Inventories therefore serve to absorb the shocks of the demand — forecast errors, and to permit effective production process.

However, demand fluctuations occur and therefore production is independent on demand. In such a situation, there is a deliberate policy of management to have inventory of finished goods that will cushion the ups and down effect of demand fluctuation on production levels and this inventory level is called the 'safety stock'. Thus, if there is an increase in the demand for an item, more than the production outputs, then stock out will be avoided by drawing from the safety stock to satisfy the additional demand. It also follows that if the lead time is greater than expected such that delivery cannot be made at the appropriate time, the safety stock will be used to meet such demands.

Forecasting Demand for Production Scheduling:

A forecasting exercise is usually carried out in order to provide an aid to decision-making and in planning the future. Typically all such exercises work on the premise that if we can predict

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what the future will be like we can modify our behavior now to be in a better position, than we otherwise would have been, when the future arrives (Surjeet, Vivet and Kamal, 2014).

Fildes, Goodwin, Lawrence, and Nikolopoulos (2009) stated that demand forecasting is the crucial aspect of a planning process in production. It implies taking historical data and projecting them into the future, using mathematical models and methods or intuition (Zoran and Mirko, 2015).

Numerous factors are related to the sales forecast according to Chopra and Meindl (2007) which includes past sales, product lead time, planned advertising or marketing efforts, state of the economy, planned price discounts, competitors' actions.Also, Nenni, Giustiniano and Pirolo (2013) established that poor forecasting affects result in stock outs or high inventory, low service level, rush orders, inefficient resource utilization and bullwhip propagating through the upstream supply chain.

The organisation's output capacity is determined by the amount of goods and services it is capable of producing: the level of this output capacity is to be determined to achieve the best result for the firm. If the quantity produced is below the total actual demand for the firm's goods, the results is lost customer orders. If the quantity is more than the actual demand, the result is higher costs of inventory.

The management of the firm must be able to predict the demand for the firm's products as to enable it schedule its resources to achieve maximum capacity utilisation in meeting up the demand. Sales forecasting of such expected demand is necessary as a planning tool in the scheduling process (Lockyer, 1983).

The planning procedures are made effective in knowing the demand for the product(s) at each time during some future period. This is necessary because, if demand varies significantly from one period to another, factor of production requirements will also vary significantly from such periods. The sales forecast must hence show such difference in demand per period as to reveal fluctuations in the future demand for the product(s). This leads to preparing different schedules in terms of a daily demand, a weakly demand, a monthly demand or an annual demand depending on the demand patterns as per the forecast made.

The production lead time and demand forecasts are essential ingredients in determining the production schedule. This will bring about an appropriate material requirement planning as per the capacity utilisation and due date of delivery of the product(s) in achieving an economic lot size that satisfies customer demands and maximise the firm's resources. This brings about a detailed scheduling of production, where the task is to programme sales and work out dispatch schedule to meet up the planned production — inventory level relationship that will accommodate a safe stock level plus the deliveries for the product demand.

The fundamental aim of forecasting in production scheduling is to ensure that the product is available to the customer at the right quantity, price, time and place. Accurately forecasted demand may lead to increased customer satisfaction, reduced stock outs, efficient production, reduced product obsolescence, and better managed shipping, superior negotiation terms with the supplier and more informed pricing as well as promotion decisions (Stock and Lambert, 2001). The demand forecast identifies requirements for which the supply chain must schedule inventory and operational resources. Accurate forecasting should be a major focus for situations where long replenishment lead times and large economies of scale are both present (Bowersox et al. 2010).

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Making decisions under uncertainty is less than optimal and allocating resources among logistics activities without knowing what product will be needed is extremely difficult. Because of this it is imperative for organizations to undertake some type of demand forecasting after which they communicate the results to different departments that need to know precisely how much product will be required (Jenni, 2014). Forecasts of future demand affect the promotional strategies, allocation of sales force, pricing and market research activities. Additionally the forecasts also determine production schedules, purchasing and acquisition strategies (Stock and Lambert, 2001).

Production Order for Stock:

Inventory management seeks to answer questions such as when to order, how much to order and how much stock to keep as safety stock (Silva 2009). According to Wanke (2011a), inventory management involves a set of decisions that aim at matching existing demand with the supply of products and materials over space and time in order to achieve specified cost and service level objectives, observing product, operation, and demand characteristics.

Every organisation has inventories of some type and the economics and techniques of inventory management are critical for efficient operation, profitability and survival; especially in a highly competitive environment (Kros, Falasca and Nadler, 2006).

According to Sharif (2011) inventory management basically aims at providing both internal and external customers with the required service levels in terms of quality, quantity and order fill rate, to ascertain present and future requirements for all types of inventory to avoid overstocking while avoiding bottleneck in production and to keep costs to a minimum.

The provision of safety stock on the other hand is a kind of insurance and is largely influenced by the lead time required to procure the materials. It is obvious that any improvement in the lead time would necessitate a decrease in the volume of safety stock and thereby reduce overall capital lock-up in inventory (Olusakin, 2014).

The principal goal of inventory management involves having to balance the conflicting economics of not wanting to hold too much stock,thereby having to tie up capital so as to guide against the incurring of costs such as storage, spoilage, pilferage and obsolescence and, the desire to make items or goods available when and where required (quality and quantity wise) so as to avert the cost of not meeting such requirement.

On the other hand, having enough finished (or semi-finished) products in stock helps to react more flexible on customer´s demand what positively influences the quality of provided services and delivery times (Denisa, 2014).

METHODOLOGY

A survey design was adopted, where we identify the population of manufacturing firms and by a purposive sampling procedure, we used twenty (20) manufacturing firms in Port Harcourt, Nigeria. The research instruments used were the questionnaire and oral interview of key personnel in the production, marketing and material management departments, though we observed that not all the manufacturing firms have a materials management department. We collected 16 completed questionnaires that give an 80% response rate. The data were analysed

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in presenting answers to the research questions. We used the statistical tools of the mean, standard deviation, covariance in determining lead time and the weighted mean percentage inventory (WMPI) and weighted mean percentage stock out (WMPS) in determining the inventory profile and the incidence of stock out respectively in both the uniform and fluctuating schedules of product manufacture.

ANALYSIS OF FINDINGS AND DISCUSSIONS

We adopted here and in subsequent analysis, a letter-figure arrangement (Al,A2, A3, A4, ...Dl, D2, D3, D4) with the firm represented by a letter and the product type represented by a figure. Typical product types from the sample manufacturing firmsorganisations have been used here.

Sales Forecast and Scheduling Practice:

From the research data, we have obtained the total forecast for the year, the gross output for the year and the Pearson's coefficient of correlation for each product type with the associated scheduling practice as presented below.

Table 1: Sales Forecast and Product Output

PRODUCT	TOTAL SALES FORECAST (X)	TOTAL PRODUCT OUTPUT (Y)	CORR. COEFFICIENT (r)	SCHEDULING PRACTICE
A1 A2	166626 181116	155366 180175	0.61 0.53	FLUCTUATING SCHEDULING
B1 B2	262087 15482	260658 14252	0.85 0.29	
C1 C2	19971 112671	19744 112332	0.58' 0.45	
D1 D2	25094 339271	22786 344122	0.83 0.46	
A3 A4	147200 233850	148000 240000	0.97 0.00	UNIFORM SCHEDULING
B3 B4	5130 226380	5100 222000	1.00 0.99	
C3 C4	200400 13500	199500 13200	1.00 1.00	
D3 D4	3900 325000	3900 324000	1.00 0.89	

Source: Research Data, 2015.

From the rules, 0 < r < 1 shows the degree of relationship between the scheduling practice and the sales forecast. The uniform schedule practice adopted within the sales forecasts shows a correlation (r) from 0.89 to 1.0, except in one product (A4) where there is no linear correlation between the scheduled production and the sales forecast. It infers that there is a high relationship in product output to sales forecast in the uniform schedules, than the observed product output in the fluctuating schedule.In the fluctuating schedules there is a varying degree

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of relationship where the calculated correlation values range from 0.29 — 0.85, indicating moderate to high relationship between the schedule practice and the sales forecast.

Lead Time Uncertainties and Scheduling Practice:

The lead time is the time between processing of orders made and the delivery of such orders. This time period is sometimes seen as a reflection of the manufacturing cycle time. It is the interval between the perception and the fulfilment of a need. There is always some interval between the time that the need for material is determined and order placed and the time this material is actually manufactured and delivered. This gap period is the lead time (Mohammad, 2014).

In his findings, JING-sheng (1994) opined that stochastically larger lead times may not necessarily lead to higher optimal average costs as a result of the dominance of the variability effect. Similarly a more variable lead time always leads to a higher optimal average cost and vice-versa. However, the effect of lead-time variability on optimal average cost is a factor of inventory cost structure. This demonstration that reduced lead times and their variability is a key factor in the processes involvement which is the nerve centre of production scheduling. Also, Bagshaw (2014) established that scheduling is an important aspect of operations control in both manufacturing and service firms with increased emphasis on output levels, lead time in meeting demand and in satisfying the customer. Efficient scheduling plays increasing emphasis in ensuring the effective management of demand uncertainties. Higher total levels of inventory increases production lead times and thus negatively influence delivery performance.

Moreover, the longer the lead time, the more time is required to get the results of production and vice versa. Inventories rise when lead time increases to maintain plant operations. However, no safety stocks would be required, if lead time is zero, as replenishment of the stock can be done immediately without any problem. In case the lead time is longer, it is more difficult to predict the usage or consumption, while the order is open. If the procurement is zero, it would be necessary to make any predictions (Mohammad, 2014). Lysons and Farrington (2012) asserted that delivery lead times can be reduced through close cooperation with suppliers and possibly by inducing or having suppliers located closer to the factory. Therefore, for production scheduling to be successful lead time must be zero or reduced to the minimum. Reducing lead-time can improve competitive advantage.

Furthermore, lead-time reductions allow the order decision to be made based on an updated demand forecast. Thus, the forecast evolution process affects the marginal value of time. Gallego and Özer (2001) present a model that quantifies the value of receiving demand information further in advance of the delivery date, showing that the performance of the system improves as order information is received earlier. Thus, the value of lead-time reduction decreases when firms have other alternatives to obtain demand information.

The lead time affects the production pattern as there are uncertainties to which the manufacturing process responds. These uncertainties are occasioned by inter-organisational perception of needs, technical exigencies of the manufacturing process, inventory factors and even customer behaviour. Evolving of an appropriate scheduling practice thus appears to be a logical attempt at smoothening out the effect of lead time uncertainties, with a view to meeting the expected needs in terms of right quality and quantity at the required time.

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From data on production runs, we have obtained a measure of average lead time per unit of output for the different products, and consequent on this the mean, standard deviation and coefficient of variation of lead times have been calculated.

The results are presented below:

Table 2 **Calculated values of Mean, Standard deviations and Coefficient of variation of Lead-time.**

PRODUCT	MEAN LEAD-TIME (Hour)	STANDARD DEVIATION (Hours)	CO. VARIATION (%)	TYPES OF SCHEDULING
A1	3.26	3.278	100.30	FLUCTUATING SCHEDULING
A2	2.15	2.33	108.37	
B1	1.88	1.59	84.8	
B2	0.97	0.898	93.05	
C1	1.24	0.84	65.12	
C2	2.83	2.03	71.73	
D1	2.501	1.56	62.4	
D2	3.0	2.0	66.14	
A3	2.50	0.71	28.4	UNIFORM SCHEDULING
A4	3.71	0.97	26.14	
B3	3.33	1.33	45.94	
B4	3.0	1.41	47.0	
C3	3.79	1.50	39.58	
C4	4.88	2.72	55.74	
D3	5.78	2.73	47.23	
D4	1.42	0.68	47.88	

Source: Research Data, 2015

The data presented above indicate a higher percentage variation in lead time in products with fluctuating scheduling than that of those under the uniform schedules.This indicates that there are higher lead time uncertainties associated with fluctuating scheduling up to as high as 100% which can be referred as very uncertain. However, there are degrees of uncertainty in lead time both in products under the fluctuating or uniform schedules.

Using the coefficient of variation as a comparative measure of the degree of variability, products have been categorized as being characterized by different levels of variability in lead-time — highly uncertain, moderately uncertain, predictable and very certain.

The results are presented below having been classified as follows:

Above 100%	-	very uncertain
81% - 100%	-	highly uncertain
61% - 80%	-	moderately uncertain
41% - 60%	-	low uncertain
31% - 40%.	-	Predictable
21% - 30%	-	very certain

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Table 3 **Lead Time Variability Indicating the Coefficient of Variation as Level of Variability**

Product.	Very Uncertain	High Uncertain	Moderately Uncertain	Low Uncertain	Predict-able	Very Certain
A1 A2	13373 14506					
B1 B2		22758 1349				
C1 C2			1683 9493			
D1 D2			2380 27661			
	27879 (29.91%)	24107 (25.87%)	41217 (44.22%)			
A3 A4						12306 19859
B3 B4				420 18437		
C3 C4				 11239	16242	
D3 D4				325 2687		
				57308 (54.21%)	16242 (15.36%)	32165 30.43%

Source: Research Data, 2015.

From the lead time variability under the different schedules, products Al, A2 under the fluctuating schedules show very uncertain lead time; Bi, B2 as highly uncertain and C1, C2, Dl, D2 shows moderate uncertainty. In all, the whole of the products under the fluctuating production schedule runs are of moderate to high uncertainty with 30% by product volume as very uncertain; 26% as highly uncertain and 44% moderately uncertain. The products under the uniform schedule show 54% by product volume under low uncertainty, 15% as predictable and 30% as very certain in lead time.

Thus, under the different lead time variations, the highly uncertain conditions influence as adoption of fluctuating schedule, this we believe is an adaptation procedure to the uncertain environment turbulence affecting the period between the perception of the need and the fulfilment of that need.

These environmental jolts (consumer behaviour affecting the demand for the product, organisational systems effectiveness in issues of inventory control such as the time taken in the order ‘for raw materials and the production of finished goods to the control of such inventory levels affecting production) all contribute in creating an atmosphere of uncertainty that necessitate a fluctuating schedule when the lead time is very uncertain and to a uniform schedule when the lead time is very certain and the manufacturing environment stable.

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Scheduling Practice and Average Inventory:

Inventory management is a science based art of ensuring that just enough inventory stock is held by an organization to meet demand (Jay and Barry, 2006). Possessing high amount of inventory for long periods of time is not usually good for a business because of inventory storage, obsolescence, and expiry, spoilage costs. On the other hand, the possessing of too little inventory isn't good either, because the business can face the risk of losing out on potential sales and potential market share as well. Undoubtedly more business failures are caused by an overstocked or under stocked inventory than any other factor (Mohammad, 2014).

Inventories are basically stocks of resources held for the purpose of future production and/or sales. Inventories may be viewed as an idle resource which has an economic value. Better management of inventories would release capital for use elsewhere productively, (Ghosh and Kumar, 2003). Hence inventory control implies the coordination of materials accessibility, controlling, utilization and procuring of material. The direction of activity with the purpose of getting the right inventory in the right place at the right time and in the right quantity is inventory control and it is directly linked to production scheduling of any organization. This implies that profitability of any organization directly and indirectly is affected by the inventory management system operated (Miller, 2010).

The production activity results in the output of finished goods that are put in inventory. The scheduling practice affects the size of inventory and therefore efforts are geared towards maintaining optimal levels in inventories. This will involve how best to select the proper scheduling of production runs as to lower inventories and production costs in meeting the demand for the product.Scheduling practice is directed at the maintaining of minimal levels of average inventory (the average of the sum of the beginning inventory and the ending inventory) on the one hand, and minimizing the incidence of stock out on the other.

From the inventory profile for the different products, we have obtained the mean monthly output, the mean monthly average inventory, the mean monthly stock out, the percentage inventory and the percentage stock out as follows:

(a) Mean monthly output = (monthly output) $= \dfrac{\sum(monthly\ output)}{12}$

(b) Mean monthly Average inventory $= \dfrac{\sum(monthly\ average\ inventory)}{12}$

(c) Mean monthly stockout = Z (monthly stockout) $= \dfrac{\sum(monthly\ stockout)}{12}$

(d) Percentage inventory $= \dfrac{Mean\ monthly\ Average\ Inventory}{Mean\ monthly\ output} x\, 100$

(e) Percentage stockout $= \dfrac{Mean\ monthly\ Stockout}{Mean\ monthly\ Average\ Inventory} x\, 100$

The results are presented below:

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Table 4 Inventory Profile of the Different Product Types

Product	Mean(x) Monthly Output	Mean (x) Monthly Avg. Invt.	Mean (x) Monthly Stockout	Percentages (%) Inventory	Percentage (%) Stockout	TYPES OF SCHEDULING
A1 A2	12947 15015	6324 4889	30 -	48.84 32.56	0.05	FLUCTUATING SCHEDULING
B1 B2	21722 1188	3300 413	938 178	12.19 34.76	28.42 42.98	
C1 C2	1630 9361	1185 2223	68 49	72.70 23.64	5.74 2.21	
D1 D2	1899 28978	1545 25350	81 -	81.36 88.40	5.24 -	
A3 A4	12333 20000	930 2703	63 -	7.54 13.52	6.77 -	UNIFORM SCHEDULING
B3 B4	426 18500	74 1306	- 33	17.41	- 2.53	
C3 C4	16500 1100	948 149	80 29	5.75 13.55	8.44 8.46	
D3 D4	325 27000	25 3007	- -	7.69 11.14	- -	

Source: Research Data, 2015.

Mean values are approximated to the nearest whole numbers

The mean monthly output was used as weights to obtain the weighted mean of percentage inventory under the different types of scheduling. This will give an indication of the relative size of average inventory incidental to the scheduling practice.. The weighted mean percentage inventory (WMPI) for a set of products may be derived from:

$$\text{WMPI} = \frac{\sum (\textit{Mean Monthly Output})(\textit{Percentage Inventory})}{\sum (\textit{Mean Monthly Output}}$$

Table 5(a) ForFluctuating Scheduling

PRODUCT	MEAN MONTHLY OUTPUT (X)	PERCENTAGE INVENTORY (Y)	(X) (Y)
A1 A2	12947 15015	48.84	632331.48 488888.40
B1 B2	21722 1188	15.19 34.76	329957.18 41294.88
C1 C2	1639 9361	72.70 23.64	118501.00 221294.04
D1 D2	1899 28678	81.36 88.40	154502.64 2535135.20
***Total:* =**	**92440**	**-**	**4521904.82**

Source: Research Data, 2015.

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$$\text{WMPI} = \frac{\sum (\textit{Mean Monthly Output})\,(\textit{Percentage Inventory})}{\sum (\textit{Mean Monthly Output}}$$

$$= \frac{4521904.82}{92440} = 48.92$$

Table 5(b) For Uniform Scheduling

PRODUCT	MEAN MONTHLY OUTPUT (X)	PERCENTAGE INVENTORY (Y)	(X) (Y)
A3 A4	12333 20000	7,54 13.52	92990.83 270400
B3 B4	425 18500	17.41 7.06	7399.25 130610
C3 C4	16500 1100	5.75 13.55	94875 14905
D3 D4	325 27000	7.69 11.14	2499.25 300780
***Total:* =**	**96183**		**914459.32**

Source: Research Data, 2015

$$\text{WMPI} = \frac{\sum (\textit{Mean Monthly Output})\,(\textit{Percentage Inventory})}{\sum (\textit{Mean Monthly Output}}$$

$$= \frac{914459.32}{96183} = 9.51$$

Also, we used the mean monthly average inventory as weights in calculating the weighted mean percentage stockouts under the different scheduling types. This will indicate the stockouts level associated with each scheduling type. The weighted mean percentage stockouts for the products (WMPS) are derived from the formula:

$$\text{WMPS} = \frac{\sum (\textit{Mean Monthly Output})\,(\textit{Percentage Inventory Output})}{\sum (\textit{Mean Monthly Output}}$$

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Table 5(c) For Fluctuating Scheduling

PRODUCT	MEAN MONTHLY INVENTORY (X)	PERCENTAGE INVENTORY (Y)	(X) (Y)
A1	6324	0.05	316.2
B1 B2	3300 413	28.42 42.98	93786 17759.74
C1 C2	1185 2213	5.74 2.21	6801.9 4890.73
D1	1545	5.24	8095.8
Total: =	**14980**	**-**	**131641.31**

Source: Research Data, 2015.

$$\text{WMPS} = \frac{131641.37}{14980} = 8.79$$

Table 5(d) For Uniform Scheduling

PRODUCT	MEAN MONTHLY AVERAGE INVENTORY (X)	PERCENTAGE STOCKOUT (Y)	(X) (Y)
A3	930	6.77	6296.1
B4	1306	2.53	3304.18
C3 C4	938 149	8.44 19.46	9001.12 2899.54
Total: =	**3333**		**20500.94**

Source: Research Data, 2015

$$\text{WMPS} = \frac{20500.95}{3333} = 6.15$$

The calculated weighted mean percentage inventory of 9.51 as in uniform scheduling of average inventory on production output indicate a low inventory profile.We have the assumption that the work-force is constant, and that the low inventory and the attendant low stockout of 6.15 is allowed to vary as a sea-saw from inventory to stockout as to maintain a stable schedule.

The inventory value (9.51) balances off as it were the stockout value (6.15) at a point where the inventory is allowed to offset excess of product demand over product output as to minimise the stockout that would have occurred.

Uniform scheduling attempts to reduce the inventory level to an accommodating stock is to hold on the variables of lead time and product demand in satisfying the customer.

In the fluctuating scheduling of average inventory to production output, the calculated weighted mean percentage inventory is 48.92. Also, the calculated weighted mean percentage stockout

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is 8.79. From the analysis, we had inventory build-ups in products Cl, Dl and D2, and more stockouts in Bl and B2, where percentage stockouts are higher than inventories.

We observed that in cases where inventory build-ups cannot be cleared within an expected time, the production centres are shutdown to allow the backlog of inventory to be cleared. This causes a loss in man-hour to the firm and wasted resources especially of work-in-process where there are no room for inter-convertibility of work station. Normally, causal workers are laid-off as they are under-utilised and resources pulled up to work stations where there are stockout to beef-up production outputs in such products.

CONCLUSION

With an increasing emphasis on the multiple objectives on delivery time, low inventory and product production quality, the management of the plant needs production scheduling for better system performance. Taking into cognisance lead time uncertainties and inventory level in scheduling is a necessary step to enhancing the reliability of work flow and subsequently, achieving high productivity and improved product quality. Thus production scheduling plays a chief role in improving the overall performance of any company in regards of increased output improved on time delivery and also improved balancing of the production line (Liro and Reinhard, 2014).

From the findings the calculated weighted mean percentage inventory (WMP1) and the calculated weighted mean percentage stockout (WMPS) are higher in fluctuating schedules with 49% and 9% respectively as compared to the low inventory and stockout levels in uniform schedules of calculated WMPI and WMPS of 10% and 6% respectively.

The incidence of high percentage inventory in products Al (49%), Cl (72%), Dl (81%) and D2 (88%) (Table 6a) under the fluctuating production schedules is worrisome.

RECOMMENDATION

We recommend a close monitoring of production levels vis-à-vis the product demand.Boundary personnel between marketing and production should be made to coordinate the activities in the functional areas so as to optimise inventory levels. Interchangeability of work-in-process should also be exploited to utilise process output from where product inventory levels are high to other product types of low inventory levels.

Due to the economic view of inventory costs to the overall production activity, we also recommend from the results that a uniform production schedule fined tune to holding a small manageable inventory is preferred.

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