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Discrete Economic Order Quantity (EOQ) and Quantity Reorder Point Inventory Control: Implication on Resource Optimization in Nigerian Manufacturing Companies

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Abstract:-

- ***Purpose***

The purpose of this study is to explore the implication of discrete Economic order Quantity (EOQ) and Recorder point on the optimization of resources in Nigeria manufacturing companies.

- ***Design/Methodology Approach***

A quantitative research design was employed of which secondary data obtained from the annual report and account of tern year period (2004-2013) from the studied firms were used. Data collected were estimated using Microsoft excel and exponential smoothing for each of the studied firms.

- ***Findings***

The economic order Quantity (EOQ) that is the quantity that minimizes total cost of raw material for each of the studied firms were determine discretely and by exponential smoothing. The results obtained, compared, we found that the result obtained by discrete EOQ were higher than the corresponding results obtained by exponential smoothing. The implication is that the discrete EOQ method over estimates resource optimization.

- ***Conclusion***

It is concluded that total cost of inventory is greatly reduced by the application of exponential smoothing method of EOQ and hence the essence of the method and the usefulness of this study.

***Keywords**:-* *Inventory, Economic Order Quantity, Q/R Operating System, Flour, Ordering Cost, Carrying Cost,*

I. INTRODUCTION

Effectiveness of economic order quantity and quantity re-order point inventory control system is a vital point in the manufacturing organization to be more competitive. Scott (2007) in Abara et al (2016) argued that organization exert considerable efforts in making pertinent decisions that border on inventory procurement and efficient allocation of resources in an attempt to meet the demands of the changing environment. Discrete optimization can be defined as a method of deriving the mathematically optimal solution to minimize cost and maximize profit at the lowest level of the material supply chain.

The reference model of static inventory management was formulated by (Wilson 1934) from (Harris 1913)'s work. According to Ghorbel et al (2014). Wilson is based on a simplistic model optimizing the cost of managing a stock during a fixed period of replenishment to be determined. The assumption is that the consumption per that time is certain and constant. According to Tiwari (2002), Gupta (2005) and NOUHA Ghorbel (2014), there are studies on supply chain, but there are not many that reflect the uncertainty of variables such as inventory management work. Kadir Ertogral (2005) analyzed a multi period inventory problem in which they consider that the replenishment interval of material are independent and identically distributed random variables for the case of periodic replenishments. They present pertinent solutions and analysis in uniform and exponential distributions.

Each material resource combination has its demand and supply history, biases and economic performance. Discrete optimization moves beyond general rule of intuition or rule of thumb such as "all raw material should have seventy-five percent (75%) service level of one week of safety stock"; and find the unique and best inventory strategy at a level that will lead to an optimized inventory system. In wrangling out the last drop of unproductive and excessive inventory in any manufacturing firms, supply chain, discrete optimization is critical.

As effective operating system is needed to allocate inventory resources, it is therefore expectant that operation managers especially in Nigeria flour manufacturing firms, have a basic understanding of the effectiveness of discrete economic order Quantity with respect to Quantity Reorder point inventory control system, its associated benefits as well as its related cost component in enhancing their economic performance.

Stock out are common in manufacturing firms (Mekel, Anantadjaya and Labindah2014), Adesuyi et al (2017) asserts that flour manufacturing companies in Nigeria run out of stock several times. They explained that most of the product manufactured experienced stock out at times which led to reduction in sales and a decrease in revenue. Using the theory of constraints as the theoretical underpinning for this study, we argue that firms with good inventory management technique have a competitive advantage over firms that do not. Further we argue that inventory is the proxy for information, the less information you have about demand and supply, the more inventory you need to buffer against uncertainty. Thus firms without a strong market orientation and EOQ will not be aware of the changes in demand which may result in understocking or over stocking of material resources that may jeopardize economic performance.

II. LITERATURE REVIEW

A. *Conceptual Framework*

- *Economic Order Quantity (EOQ)*

The First Inventory model was developed by Harris (1915). This model was further generalized by Wilson (1934), who derived the formula to obtain the economic order quantity (EOQ). According to Leonid et al (2018), Mc Gillivary and silver (1978) studied the first inventory model of substitutable items. They assert that all substitutable items were assured to have the same unit variable cost and shortage penalty.

The economic order quantity (EOQ) is the optimal quantity to order to replenish inventory with a trade-off between inventories and ordering cost. The optimal quantity q* to order, that is the order quantity that minimizes total cost is given as:

$$Q^* = \sqrt{2ad/h}$$

Where: d = Average demand
a = Ordering Cost
h = holding Cost of an item.

The above equation is for q* is known as the EOQ formula. The tradeoff between inventory and the variables costs is represented in the figure below.

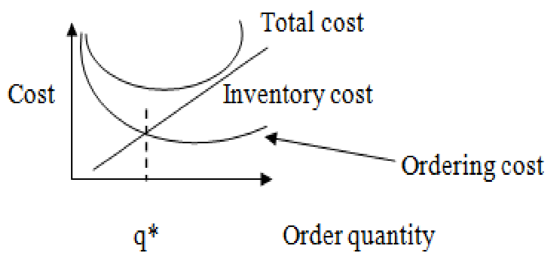

Fig 1:- Trade-Off between Inventory and Variable Cost

In this study we have acted some recent work that used the EOQ as basic model. Most importantly the study will assess the implication of the EOQ model on resources optimization in Nigeria manufacturing companies using the discrete EOQ by exponential smoothing.

B. *Theoretical Framework*

The theory of constraint upon which this study is based was propounded by Goldratt, (1984). This is a managerial philosophical theory that seeks to increase manufacturing, efficiency or system performance. It measured sales by identifying those processes that constrain manufacturing system (Goldrath, 2004). Kazin (2008) argued on the theory of constraints based on the principle that chain is as strong as the weakest link or constraint and the management of every firm must alleviate and manage the constraint. Goldratt (1984) noticed that every system has at least one constraint that limits its performance which he referred to as system's "weakest link". According to him, a system can have one constraint at a time while other areas of weakness may be termed "non-constraints" until they become weakest link also.

Goldratt (1984) identified five focusing steps as necessary conditions by which constraints can be overcome. The five steps are:

- Identifying the system's constraint, that prevent the organization from obtaining more than one goal at a time. Mabin (1990) opined that the identification of the constraint is paramount because it limits the overall performance of the firm which he contended that may be physical or constraint policy.
- Deciding how to exploit the system's constraint(s) as well as how to getting the most out of the constraint. Bates (2004) argued that there is no choice in the matter, if you fail to manage the constraint, the constraint will manage you! This is because the constraint determines the output of the system.
- Subordinating everything to the decisions above, aligning the whole system or to support the decisions made. According to Mabin (1999) operation managers are advised to link output of other operations that will reduce constraint and work flow so as to avoid buildup of work-in-process inventory. However, Anderson (1999) suggested that management should direct efforts toward improving performance of the constraining task that will directly affect production process.
- Elevate system constraint(s) and make up changes needed to increase the constraining capacity.
- Goldratt (1980) warned that if the previous step breaks a constraint, we should go back to the first step. However, organizations should not allow inertia to cause a system's constraint. Goldratt (1990) argued that the step is consistent with a process of ongoing improvement of the system.

Theory of constraint has the appealing quality of future sales by increasing quality, lowering response time and reducing operating cost. Goldratt (1984) stressed that the focus of the firm should be on discovering constraints and administer the five necessary steps in overcoming them.

C. Empirical Review

Abara et al (2016), Conducted a study on optimizing multiple- material inventory and Q/R operating Doctrine with respect to function in Enugu, Nigeria. The objective of their study was to optimize multiple material inventory control system for resource allocation in the plastic manufacturing industry. Their study employed a statistical design of which secondary production and cost data was used. Data collected were estimated using regression models while ordinary least sequence (OLS) formed the basis for estimation. The optimal (functional) valves of various material used in producing plastics were compared and contrasted from the discrete EOQ values. They found out that the EOQ values obtained using discrete method overestimated the optimal values. The implication of their study is that optimization method minimized the total cost of inventory relative to discrete economic order Quantity (EOQ).

Adesuyi et al (2017) conducted a study on enhancing economic performance of Nigerian manufacturing forms using Quantity- Recorder point inventory control system, flour manufacturing forms in Nigeria. In their methodology, a quantitative research design was employed of which secondary data obtained from annual report and account of ten years period (2004-2013) from studied firm was used .Data collected were estimated using regression models of which ordinary least square (OLS) forms the basis for estimation, using OLS. The various cost functions were estimated. The study found out that there is a significant positive relationship between profit and demand for material inventory. The study identified attributes of Quantity recorder point inventory control system as a technique that can enable manufacturing firms achieve economic performance.
Ernst and Kouvelis (1999) proposed an efficient numerical algorithm to determine optimization for their substitutable products. Talazadeh et al (2015) in their study developed a model that optimizes price replenishment frequency, replenishment cycle and production rate in a vendor-managed inventory system with deteriorating items.

Krommda et al (2015) salameh et al (2014); Rasonli and Nakhai Kamalabadi (2014) AND Gerehak and Grosfeld (1999) in Lennid et al (2018) developed inventory models that consider too substitutable items with deterministic demand, constant holding cost and fixed ordering cost. None of these studies considered the implication of the discrete EOQ on the optimization of the inventory resources. However Abara et al (2016) find out that the discrete EOQ over estimates inventory resources. It is in view of this that this study is undertaken to assess the implication of discrete EOQ on resources optimization and other optimization method.

D. Hypothesis

Adesuyi (2017) opened that the theory of constraint sees inventory as a resources that gives the firm the capability to generate intelligence related to customers' attitude changes in demand for goods and services. To enhance the availability of products and services to customers at all times is a function of a trade between holding cost, shortage cost and avoidability of stock out during replenishment order cycle. It is therefore against this backdrop that this study hypothesized that: The Economic Order Quantity (EOQ) of material inventory at the studied firms in a discrete manner does not over estimate their optimal values.

III. METHODOLOGY

The study employed quantitative research design. The focus of the study was on raw material (wheat) inventory and its cost and demand required at the three selected manufacturing firms. The cost associated with the raw material inventory is divided into two, carrying cost and ordering cost. The study employed discrete Economic Order Quantity (EOQ) and EOQ optimization by exponential smoothing for the material resource at the selected firms.

- *Discrete "optimization". The Economic Order Quantity (EOQ).*

The Economic Order Quantity (q^*) is the quantity that discretely minimize total cost is achieved when the ordering cost equals the carrying cost of inventory. This may be presented as:

$$\frac{C_0 d}{q} = \frac{C_c q}{2} \qquad (1)$$

This implies that $q^2 = \frac{2dC_c}{Cc}$ such that,

$$q^* = \sqrt{\frac{2dC_0}{Cc}} \qquad (2)$$

Where: q^* = economic order quantity
d = Annual demand
C_0 = Ordering cost
Cc= Carrying cost

Equation 2 was used to analyze discretely, the Economic Order Quantity (EOQ) and the Economic Order Quantity by Exponential Smoothing for each of the studied firms and the result compared.

IV. RESULTS

The results are as shown in tables 1 to 7

d	c_o	c_s	$c_c = 0.15c_s$	$2dc_o$	$\frac{2dc_o}{c_c}$	$f_o = \sqrt{\frac{2dc_o}{c_c}}$	$f_o - f_e$	$(f_o - f_e)^2$	$\frac{(f_o - f_e)^2}{f_e}$
140377.4	52020	6304490	945673.5	14604864696	15443.88	124.2734	76.13958	5797.236	120.44
43398.1	49830	6912730	1036910	4325054646	4171.101	64.58406	16.45025	270.6109	5.622054
34253	48320	10862148	1629322	3310209920	2031.648	45.07381	-3.06	9.363593	0.194533
16073.4	45000	13245102	1986765	1446606000	728.1212	26.98372	-21.1501	447.3262	9.293389
15972.1	45300	16345616	2451842	1447072260	590.1979	24.29399	-23.8398	568.3371	11.80744
279470	34916	37159301	5573895	19515949040	3501.313	59.17189	11.03808	121.8392	2.53126
25388	35380	47444473	7116671	1796454880	252.4291	15.88802	-32.2458	1039.791	21.60209
33150	37440	63108525	9466279	2482272000	262.2226	16.19329	-31.9405	1020.197	21.19502
10283.2	37800	70169638	10525446	777409920	73.86005	8.594187	-39.5396	1563.382	32.47991
12473.2	32000	75916975	11387546	798284800	70.10156	8.372668	-39.7611	1580.948	32.84486
						393.429			258.0106
						39.3429			

Table 1:- Analysis of Discrete EOQ for Wheat Inventory at Honey Well Flour Mills PLC
Source: Microsoft excel

$$f_e = \frac{\sum f_o}{n} = \frac{393.429}{10} = 39.3429$$

d	c_o	c_s	$c_c = 0.15c_s$	$2dc_o$	$\frac{2dc_o}{c_c}$	$f_o = \sqrt{\frac{2dc_o}{c_c}}$	$f_o - f_e$	$(f_o - f_e)^2$	$\frac{(f_o - f_e)^2}{f_e}$
958502.7	32000	198611642	29791746	61344172800	2059.1	45.3773	-2.75651	7.598333	0.157859
534372.8	37800	156992997	23548950	40398583680	1715.515	41.41878	-6.71503	45.09163	0.936797
398099.9	37440	108744832	16311725	29809720512	1827.503	42.7493	-5.38451	28.99295	0.602341
575417.1	35380	218559730	32783960	40716513996	1241.965	35.24152	-12.8923	166.2112	3.453108
708756.6	34916	91684824	13752724	49493890891	3598.843	59.99036	11.85655	140.5777	2.92056
456873.9	45300	133311104	19996666	41392775340	2069.984	45.49708	-2.63673	6.952369	0.144438
629950.3	45000	218702439	32805366	56695527000	1728.239	41.5721	-6.56171	43.05605	0.894507
720109.4	48320	141860123	21279018	69591372416	3270.422	57.1876	9.053795	81.9712	1.702986
755399.1	49830	162714347	24407152	75283074306	3084.468	55.53799	7.404175	54.82181	1.138946
940539.3	52020	202445764	30366865	97853708772	3222.384	56.76605	8.632239	74.51555	1.548092
						481.3381			13.49963
						48.13381			

Table 2:- Analysis of EOQ for Wheat Inventory at Flour Mills of Nigeria PLC
Source: Microsoft Excel

$$f_e = \frac{\sum f_o}{n} = \frac{481.3381}{10} = 48.1381$$

d	c_o	c_s	$c_c = 0.15c_s$	$2dc_o$	$\frac{2dc_o}{c_c}$	$f_o = \sqrt{\frac{2dc_o}{c_c}}$	$f_o - f_e$	$(f_o - f_e)^2$	$\frac{(f_o - f_e)^2}{f_e}$
3038553	32000	32544309	4881646	1.94467E+11	39836.44	199.5907	151.4569	22939.18	476.5711
6395624	37800	37859786	5678968	4.83509E+11	85140.33	291.7882	243.6543	59367.44	1233.383
6179911	37440	41899086	6284863	4.62752E+11	73629.57	271.3477	223.2139	49824.43	1035.123
8386006	35380	28011379	4201707	5.93394E+11	141226.8	375.8016	327.6678	107366.2	2230.577
5397449	34916	24078077	3611712	3.76915E+11	104359	323.0465	274.9126	75576.96	1570.143
3248788	45300	31842774	4776416	2.9434E+11	61623.65	248.2411	200.1073	40042.93	831.9086
2926685	45000	33659644	5048947	2.63402E+11	52169.62	228.4067	180.2729	32498.32	675.1661
4899136	48320	31737937	4760691	4.73453E+11	99450.38	315.3575	267.2237	71408.53	1483.542
7317448	49830	28740533	4311080	7.29257E+11	169158.7	411.2891	363.1553	131881.8	2739.899
7686291	52020	22728987	3409348	7.99682E+11	234555.6	484.3094	436.1756	190249.2	3952.506
						3149.178			16228.82
						314.9178			

Table 3:- Analysis of EOQ for Wheat Inventory at Dangote Flour Mills PLC
Source: Microsoft Excel

$$f_e = \frac{\sum f_o}{n} = \frac{3149.178}{10} = 314.9178$$

➢ *EOQ Optimization by Exponential Smoothing*

Exponential smoothing is a technique for smoothing time series data, with exponential window function. It is a procedure that can be applied for calculating or recalling value approximately, or for making determination based on poor assumptions by the user. It is commonly applied to smooth data as many window function are in signal processing in order to remove high frequency noise.

The data sequence is represented by (xt) at time t= 0

For the purpose of the work, the exponential smoothing is modeled as

$$f_t = (1-\alpha)\hat{f} + \alpha f$$

Where is the data smoothing factor, 0<α<1.

Therefore the EOQ for each of the studied firms can be estimated for optimization using exponential smoothing as shown in tables 4, 5 and 7 below.

Year	d	c_o	c_s	$c_c = 0.15c_s$	$2dc_o$	$f = \frac{2dc_o}{c_c}$	$f_t = (1-\alpha)\hat{f} + \alpha f$	$f_o = \sqrt{f_t}$	$f_o - f_e$	$(f_o - f_e)^2$	$\frac{(f_o - f_e)^2}{f_e}$
2004	958502.7	32000	198611642	29791746	61344172800	2059.1	-	-	-	-	-
2005	534372.8	37800	156992997	23548950	40398583680	1715.515	2059.1	45.37731	-2033.49	4135088	91126.79
2006	398099.9	37440	108744832	16311725	29809720512	1827.503	2024.742	44.99713	-2033.87	4136635	91931.08
2007	575417.1	35380	218559730	32783960	40716513996	1241.965	2005.018	44.77742	-2034.09	4137529	92402.11
2008	708756.6	34916	91684824	13752724	49493890891	3598.843	1928.712	43.91711	-2034.95	4141029	94291.94
2009	456873.9	45300	133311104	19996666	41392775340	2069.984	2095.725	45.77909	-2033.09	4133455	90291.32
2010	629950.3	45000	218702439	32805366	56695527000	1728.239	2093.151	45.75097	-2033.12	4133569	90349.32
2011	720109.4	48320	141860123	21279018	69591372416	3270.422	2056.66	45.35041	-2033.52	4135198	91183.24
2012	755399.1	49830	162714347	24407152	75283074306	3084.468	2178.036	46.66944	-2032.2	4129835	88491.21
2013	940539.3	52020	202445764	30366865	97853708772	3222.384	2268.679	47.63066	-2031.24	4125929	86623.4
							18709.82				**816690.4**
							2078.869				

Table 4:- Analysis of EOQ with Exponential Smoothening for Flour Mills of Nigeria PLC
Source: Microsoft Excel

$$f_e = \frac{\sum f_t}{n} = \frac{18709.82}{9} = 2078.869$$

Year	d	c_o	c_s	$c_c = 0.15c_s$	$2dc_o$	$f = \frac{2dc_o}{c_c}$	$f_t = (1-\alpha)\hat{f} + \alpha f$	$f_o = \sqrt{f_t}$	$f_o - f_e$	$(f_o - f_e)^2$	$\frac{(f_o - f_e)^2}{f_e}$
2004	3038553	32000	32544309	4881646	1.94467E+11	39836.44	-	-	-	-	-
2005	6395624	37800	37859786	5678968	4.83509E+11	85140.33	39836.44	199.5907	-56975.6	3246215478	16264364
2006	6179911	37440	41899086	6284863	4.62752E+11	73629.57	44366.82853	210.6343	-56986.6	3247474038	15417590
2007	8386006	35380	28011379	4201707	5.93394E+11	141226.8	47293.1024	217.4698	-56993.4	3248253140	14936573
2008	5397449	34916	24078077	3611712	3.76915E+11	104359	56686.47625	238.0892	-57014.1	3250603912	13652882
2009	3248788	45300	31842774	4776416	2.9434E+11	61623.65	61453.73009	247.8986	-57023.9	3251722557	13117146
2010	2926685	45000	33659644	5048947	2.63402E+11	52169.62	61470.72205	247.9329	-57023.9	3251726465	13115349
2011	4899136	48320	31737937	4760691	4.73453E+11	99450.38	60540.61233	246.05	-57022	3251511731	13214840
2012	7317448	49830	28740533	4311080	7.29257E+11	169158.7	64431.58949	253.8338	-57029.8	3252399483	12813107
2013	7686291	52020	22728987	3409348	7.99682E+11	234555.6	74904.3049	273.6865	-57049.7	3254664272	11891943
							510983.8061 56775.97845				**1.24E+08**

Table 5:- Analysis of EOQ with Exponential Smoothening for Dangote Flour Mills PLC
Source: Microsoft Excel

$$f_e = \frac{\sum f_t}{n} = \frac{510983.8061}{9} = 56775.97845$$

d	c_o	c_s	$c_c = 0.15c_s$	$2dc_o$	$f = \frac{2dc_o}{c_c}$	$f_t = (1-\alpha)\hat{f} + \alpha f$	$f_o = \sqrt{f_t}$	$f_o - f_e$	$(f_o - f_e)^2$	$\frac{(f_o - f_e)^2}{f_e}$
140377.4	52020	6304490	945673.5	1.46E+10	15443.88	-	-	-	-	-
43398.1	49830	6912730	1036910	4.33E+09	4171.101	2059.1	45.37731	-2033.49	4135088	91126.79
34253	48320	10862148	1629322	3.31E+09	2031.648	2270.3	47.64767	-2031.22	4125860	86591.02
16073.4	45000	13245102	1986765	1.45E+09	728.1212	2246.435	47.39657	-2031.47	4126880	87071.28
15972.1	45300	16345616	2451842	1.45E+09	590.1979	2094.604	45.76684	-2033.1	4133504	90316.58
279470	34916	37159301	5573895	1.95E+10	3501.313	1944.163	44.09266	-2034.78	4140315	93900.31
25388	35380	47444473	7116671	1.8E+09	252.4291	2099.878	45.82443	-2033.04	4133270	90197.97
33150	37440	63108525	9466279	2.48E+09	262.2226	1915.133	43.76223	-2035.11	4141660	94640.04
10283.2	37800	70169638	10525446	7.77E+08	73.86005	1749.842	41.83111	-2037.04	4149523	99197.06
12473.2	32000	75916975	11387546	7.98E+08	70.10156	1582.244	39.77743	-2039.09	4157894	104529
						17961.7				837570
						1995.744				

Table 6:- Analysis of EOQ with Exponential Smoothening for Honey Well Flour Mills PLC
Source: Microsoft Excel

The comparison between discreet EOQ and estimated optimal inventory level of wheat at the studied firm is as shown in table 36 below:

Name of firm	EOQ by exponential smoothing	EOQ Discrete.	Difference	Percentage reduction
Flour mill of Nig. Plc	410.29	481.338	71.04	14.76%
Honeywell flour Mill Plc	401.45	393.429	-8.05	-2.05%
Dangote flour Mill Plc	2135.11	3149.178	1014.07	32.2%

Table 7:- Comparison between Estimated EOQ, Discrete EOQ and EOQ by Exponential Smoothing
Source: Computed by the researcher

Table 7 above shows the result of the discreet EOQ and the optimal inventory by exponential smoothing. From the table, it is glaring that the estimated EOQ by exponential smoothing provide the optimal inventory level, while the discreet EOQ gives overestimated inventory level.

V. STRUCTURE ASSESSMENT

The structural results are presented in tables 1 to 7.Economic order Quantity by discrete optimization and economic order quantity by exponential smoothing provides information necessary to assess the significance of each of the methods used for resource optimization at the studied firms as shown above..

VI. CONCLUSION

A. Discussion of the Findings

The result shows that the discrete EOQ over estimates the inventory level while the estimated EOQ by exponential smoothing optimizes the inventory level. This is in agreement with findings of Abara et al (2016) that the EOQ values obtained using the discrete methods overestimated the optimal value of material inventory.

B. Limitation of the Study

Although the objectives of the study is accomplished; it is expedient to note the limitation of this research work. The sample for the study is from selected flour manufacturing firms in Nigeria. Replication with new sample from other manufacturing companies other than flour mills is necessary for generalizability of results.

C. Future Research

Additional research is necessary to validate the findings from this study that discrete EOQ overestimate material resource inventory of manufacturing organizations other than flour mills.

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