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ABC Analysis Strategy as a Cost Reduction Parameter in Building Projects Delivery, South-East Nigeria

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ABSTRACT

In building production management, the goal is to achieve project delivery within the contract cost, time and to ensure that specified scope and quality is met without compromising the health and safety of the operatives. Effective project delivery refers to realizing the building project within the scheduled time at the scheduled cost which equally meets the client's need. This is achievable adopting some cost reduction parameters. According to Arora and Bindra (2008), building materials account for 50 to 80 percent of the total value of construction; hence the ability to reduce wastage and improve productivity will have major cost and time benefits. For a project to be successfully delivered, Lock (2002), states that such project would seek to foresee or predict as many of the dangers and problems as possible and to plan, organize and control activities so that the project is completed as successfully as possible despite all the risks. This process starts before any resources are committed, and will continue until all work is finished. The aim is for the final result to satisfy the project sponsor or purchaser within the promised timescale and without using more money and other resources than those originally set aside or budgeted. It was observed that diligent building materials management; adoption of inventory models as cost reduction parameters in public building delivery significantly reduce time, waste and cost. In addition development of appropriate framework for Economic Order Quantity model which enables the ordering of the critical building materials as and when needed without overstocking and tying up capital assist to minimize total construction cost so that project will be realized on schedule in accordance to specified quality hence, eliminating the incidence of failed construction projects.

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Introduction

2.0 Conceptual and Theoretical Framework

2.1 Basic Theories in Materials Management

Most inventory models are usually developed on the principles of stochastic, deterministic, ABC analysis and queuing theories. Therefore, in order to lay the basis for the development of appropriate inventory models in this study, it will be necessary to examine the basic principles in these theories. According to Okereke (2002), inventory models could be stochastic (probabilistic) or deterministic (improbabilistic). The following theories find wide applications in materials management:

i. **Deterministic Theory** - A deterministic theory is one which assumes complete certainty. The values of all factors (e.g. demand, usage, lead time, carrying cost, etc) are known exactly and there is no element of risk and uncertainty, (Lucey 2002). According to Nworuh and Njoku (2005), Deterministic theory gives no room to chance. All the variables considered in the deterministic theory are known with certainty.

The model is used to explain some of the notation associated with inventory. It is easier to find an optimal solution to the deterministic model because of its simplicity, (<https://www.me.utexas.edu/forjensen05/30/02>)

The following are variants of Deterministic Theory:

a. **Deterministic Continuous Review** - This is the most common inventory situation faced by manufacturers, retailers,

and wholesalers. In this model, stock levels are depleted over time and then are replenished by the arrival of a batch of new units. A simple model representing this is the Economic Order Quantity model (EOQ). This is often referred to as the Economic Batch Quantity or the economic lot size model. (meetingsz.informs.org/Phoenix03/Sli...) The theory is used when the demand in future periods can be forecast with considerable precision. The assumption is that all forecast will always be accurate. This suggests that the demand level is known, (www.whitman.edu/zapponjz.pdf).

a. **Economic Order Quantity (EOQ)** - According to Okereke (2002), the Economic Ordering Quantity (EOQ) or Economic Batch Quantity (EBQ) is the optimal ordering quantity for an item of stock, which will minimize costs.

The assumptions used in the model are that:

- i. Demand is certain, constant and continuous over time.
- ii. The supply lead-time is constant and certain or else there is instantaneous re-supply.
- iii. Customers' orders cannot be held while replenishment stocks are awaited and current stocks are down to nothing.
- iv. No stock-outs are permitted.
- ii. All prices are constant and certain; there are no bulk purchase discounts.
- vi. The cost of holding stock is proportional to the quantity of stock held.

Items (i) to (iii) thus remove the precautionary motive for holding stocks, and item (iv) removes the speculative motive.

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In particular, there will be no bulk purchase discounts for larger order sizes. Therefore, the cost of materials will be the same for every item order, regardless of the size of the batches in which they are obtained. What emerges is a deterministic model in which no stock-outs are allowed.

b. Queuing Theory

Queuing theory is the mathematical study of waiting line or queues. With this theory, a model is constructed so that queue lengths and waiting times can be predicted, (Wikipedia, the free encyclopedia). According to Khinchin (1963), queuing theory is a mathematical discipline that studies system intended for servicing a random flow of requests (the moments at which the requests appear as well as the time for servicing them may be random) The purpose of the methods developed in the theory is to organize service reasonably so that a given quality/quantity of materials are ensured. The theory determines the corresponding characteristic of the quality of service. This determination is possible through analytical methods in a number of simpler cases or by means of Carlo method for complex cases. The waiting line or queue management is a critical part of service industry. It deals with issue of treatment of customers in a reduced time and improved service. The theory deals with cases where the customer's arrival is random; therefore, service rendered to them is also random. In complex building project sites (construction of a research centre) problems of queues of resources demands exist during construction operation. A queue can be a waiting line for service. For example, in an erection of structural element; pouring or assembling a floor; construction of walls; installation of HVAC (heating, ventilation and air conditioning) equipment; installation of plumbing; electric wiring; installation of science laboratory equipment that normally take place on a site. The roving inspector will have to go round for inspection. The various activities will have to wait until the inspector arrives to give approval to proceed to the next stage. Employing enough hands for inspection will eliminate time wastage. Also if workers spend appreciable portions of time waiting for particular tools or materials, costs increase and productivity declines. Ensuring adequate resources to serve expected demands is an important problem that should adequately be addressed during construction planning and field management.

A service organization such as an aluminum company can reduce cost and improve profitability by efficient queue management. A cost is associated with the customer waiting in line and there is also cost associated with adding new customers to reduce service time. Khinchin (1963), further opines that queuing theory is very useful in the manufacturing companies. The theory is a necessary element of flexible systems in which factors of production may be continually adjusted to handle periodic increase in demand for manufacturing capacity. Excess capacity in periods of low demand may be converted into other forms of working capital, rather than be forced to spend those periods as idle non-productive assets.

Customer selection is through first come first served method, random or last in first out. As a result, buyers or procurers leave if the queue is long or may even switch to faster service queue or some other companies.

The theory makes use of various scheduling policies at the queuing nodes. These include:

i. **First in first out:** This principle states that customers are served one at a time. Yet, the customer that has waited longest should be served first.

ii. **Last in first out:** This principle also serves customers one at a time. However, the customer with the shortest waiting time is served first.

iii. **Processor Sharing:** This policy encourages the service capacity to be shared equally between customers. The customers with high priority are served first.

iv. **Shortest job first:** This is a situation where the next job/order to be met/or supply to be made is the one with the smallest size.

Queuing theory is used to develop more efficient systems that reduce customers waiting times and increase the number of customers that can be served, www.eventhelix.com.investopei.

3.0 Project Cost Performance

Construction cost is the total cost necessarily to procure a project. The major factors affecting construction cost in Nigeria according to Elinwa and Silas (1993), are thirty one in number. Project cost performance is measured by the extent of completion of a project within estimated budget. According to Chan and Tan (2000), cost performance can be measured in terms of unit cost, percentage of net variation over final cost. (Odusami 2001), posits that project cost performance is measured by cost overrun. Ali and Rahmat (2010), see cost variance as a very important factor in measuring project performance because it indicates how much the project is delivered over or under budget.

Elements of cost (cost vectors) are the quantities and cost of materials, labour, plant and overheads that will be required to plan, design, organize and control a project from inception to completion, within the agreed time, and quality performance parameter, (Nwachukwu 2000). An estimate is a cost statement or computation which is prepared before commencement of work and reviewed at the various stages of the project cycle to show the likely cost of doing the work, (Duta 1993). From the foregoing, this cost is either estimate or final cost. UK.aswer.yahoo.com/question/index... maintained that estimate cost is based on the most accurate information one has at the moment for cost of materials, labour, often times unforeseen variables are included. The elements include the cost of materials; the number of man-hours and the amount of equipment necessary. Final estimate is arrived at after due reduction or enlargement of the actual cost of materials and the actual man-hours. Cost control and monitor come into play during final cost.

Lock (2002), opines that there is a direct and very important relationship between time and cost (money). If the planned time-scale is exceeded, the original cost estimates and budgets are almost certain to be exceeded too. A project costs money during every day of its existence. The cost could be categorized as direct cost, indirect (overhead) costs, costs of financing, cost of penalties. All these time/cost considerations mean that delays on a large project can easily cause additional cost.

Manified et al (1994), opines that the key variables causing cost overruns are price fluctuation, inaccurate estimate, delay, and additional work. Kaming et al (1997), identify the factors influencing high rise of building projects in Indonesia. The following variables were some of the factors responsible for cost overruns: materials cost increased by inflation, inaccurate quality take offs, lack of experience for project type and location. According to Johnson (1981), a comprehensive study of cost overrun in Boston found that nine out of ten construction projects had underestimated costs.

Table 4.1. The Requirement of Different Building Materials for the Construction of a Shopping Plaza, their units and unit cost /rate and their total cost.

S/N	Item of Materials	Unit	Quantity	Rate	Amount Cost
1.	Sandcrete blocks (6 ¹ ,9 ¹)	M ²	56,340	2,200	123,948,000
2.	Reinforced bars 8-25mm Ø High yield bar	Kg	82,080	270	22,161,600
3.	Cement (50kg/bag)	M ³	9,366	1,850	17,327,100
4.	Chippings	M ³	1,483	10,295	15,267,485
5.	Floor tiles (Vitrified)	M ²	6,193	1,450	8,979,850
6.	Broken blocks/Hardcore	M ³	827	9,280	7,674,560
7.	0.45mm gauge Longspan Aluminum roofing sheets	M ³	3935	1,250	4,918,750
8.	Structural timber, treated hardwood	No	4,030	3300	2,703,900
9.	Paint (Emulsion & Oil Paint)	M ²	11,468	220	2,522,960
10.	25x300x3600mm softwood for form work	No	1,675	1,200	2,010,000
11.	Sand	M ³	859	2,320	1,992,880
12.	PVC ceiling	M ²	3,280	556	1,803,879
13.	Laterite	M ³	992	1,740	1,726,560
14.	Burglar proof to windows	No	66	18,000	1,188,000
15.	Round steel pipe for hand r	No	66	12,000	792,000
16.	25x300x3600mm Hard wood for scaffold	No	200	1,400	280,000
17.	Ditto Aluminum fascia 0.45mm gauge/long span	M	382	700	267,400
18.	Aluminum ridge cap	M	178	700	124,600
19.	50x75x3600mm hardwood for scaffold	No	150	450	67,500
20.	0.45mm gauge/long span Aluminum valley/gutter	M	24	700	16,800
Total					215773824

Source of Data: Author's Fieldwork, August 2014 through January 2015.

Table 4.2. Cumulative Cost and Cumulative Percentage of the Materials.

S/N	Item of Materials	Amount Cost	Cumulative cost	Cumulative percentage cost	Cumulative rate percentage
1.	Sandcrete blocks (6 ¹ ,9 ¹)	123,948,000	123,94800	57.44	
2.	Reinforced bars 8-25mm Ø High yield bar	22,161,600	1461,09600	67.71	10.27
3.	Cement (50kg/bag)	17,327,100	163436700	75.74	8.03
4.	Chippings	15,267,485	178704185	82.82	7.08
5.	Floor tiles (Vitrified)	8,979,850	187684035	86.98	4.16
6.	Broken blocks/Hardcore	7,674,560	195358595	90.54	3.56
7.	0.45mm gauge Longspan Aluminum roofing sheets	4,918,750	200277345	92.82	2.28
8.	Structural timber, treated hardwood	2,703,900	202981245	94.07	1.25
9.	Paint (Emulsion & Oil Paint)	2,522,960	205504205	95.24	1.17
10.	25x300x3600mm softwood for form work	2,010,000	207514205	96.17	0.93
11.	Sand	1,992,880	209507085	97.10	0.92
12.	PVC ceiling	1,803,879	211310964	97.93	0.84
13.	Laterite	1,726,560	213037524	98.73	0.80
14.	Burglar proof to windows	1,188,000	214225524	99.28	0.55
15.	Round steel pipe for hand r	792,000	215017524	99.65	0.37
16.	25x300x3600mm Hard wood for scaffold	280,000	215297524	99.78	0.13
17.	Ditto Aluminum fascia 0.45mm gauge longspan	267,400	215564924	99.90	0.12
18.	Aluminum ridge cap	124,600	215689524	99.96	0.058
19.	50x75x3600mm hardwood for scaffold	67,500	215757024	99.99	0.031
20.	0.45mm gauge longspan Aluminum valley/gutter	16,800	215773824	100	0.0078
Total		215773824			

Source of Data: Author's Fieldwork. August 2014 through January 2015

Overrun of 50 to 100 percent were common. Therefore, budgeted construction cost should be strictly adhered to and as much as possible reduce additional allocation of funds to the project.

4.0 Developing a Framework for Effective Inventory Planning and Control

1. ABC Analysis

a. List of Materials Requirements and the Rearrangement of Cost of the Items in Descending Order
In Table 4.1 are shown the Materials Requirement for the Construction of a Shopping Plaza in Abakaliki, Ebonyi State.

The field survey carried out revealed that the construction of a shopping plaza is estimated to require some of these materials listed in Table 4.1 and the rearrangement of the items in descending order of cost of individual item to arrive at cumulative cost.

b. Identification of Cumulative Percentage Cost and Cumulative Rate Percentage of the Material

Table 4.2 identified the regular stock items with their project usage value, classified in ascending order. The cumulative cost is also expressed in terms of percentage of the total cost

and ranked based on their cumulative percentage using ABC analysis technique. The cumulative cost is also expressed in terms of percentage of the total cost.

c. Grouping the items under ABC categories

In Table 4.3 are shown material items according to their ABC grouping. This grouping allows the identification of those items of the materials that have direct effect in tying up project capital and thus will require tighter control in deciding how and when they would be purchased. Those in A group will require tighter control than those in B and C.

Table 4.3. Material Items A, B & C.

S/N	A	B	C
1.	(5-9)%	(10-15)%	(35-58)%
2.	Chippings (7.08%) Cement (50kg) 8.03%	Reinforced bars 8-25mm Ø High yield bar (10.27%)	Sandcrete blocks (150,225) mm (57.4%)

Source of Data: Author's Fieldwork, August 2014 through January 2015

From field survey carried out using ABC analysis, chipping and cement are the major A items and shall be purchased with tighter control while B item (Reinforced bars and High yield bars) need fairly tight control. C-items need moderate control and would not tie up the capital; neither will it be controlled infrequently and at large quantities as compared to the total requirement, (Nagarajan 2012). Other items are deemed to be insignificant.

Economic Order Quantity model was applied to the A-items to decide the reorder quantity level and the reorder time cycle so as to affect economy in cost of purchasing and holding inventory. This section also determined the respective materials consumption of concrete for different public building projects in the study area.

d. The Steps to determine ABC Analysis in Materials Management using Table 4.1- 4.3.

- i. Articulate the different building materials for the Construction of a Public Building Project (not more than 20 items).
- ii. State the unit of measurement, quantities required, rate/unit cost and cost of each of the selected materials.
- iii. Rearrange the items in descending order of cost of individual items.
- iv. Determine the cumulative cost (this is obtained by retaining the first cost and adding the next cost to the previous total).
- v. Derive the cumulative percentage cost. This is expressed in terms of percentage of the total cost;

$$\frac{\text{Cumulative Cost} \times 100}{\text{Total Cost}} \quad 1 \quad \dots 1$$

- vi. Derive the cumulative rate percentage based on their cumulative percentage cost;

$$\frac{\text{Amount/Cost} \times 100}{\text{Total Cost}} \quad 1 \quad \dots 2$$

- vii. Rank the derived cumulative rate percentage in terms of importance.

e. Determination of Economic Order Quantity for the Procurement of Cement and Granite

This second stage in the framework for proper materials inventory planning and control is determined using the following EOQ model:

$$EOQ = \sqrt{\frac{2ab}{h}} \quad \dots 3$$

Substituting the respective values as obtained in the study as follows:

a = Annual Demand = 9,366 Units

b = Ordering Cost per Order = 1,850

h = Holding/Carrying cost per items per annum = N93, for unit cost of cement of N1,850 per bag;

2 = Constant

And the holding cost is assumed to be 5% of the unit price; thus

$$\frac{5}{8} \times 18500 = N93$$

Therefore;

$$EOQ = \sqrt{\frac{2 \times 9366 \times 1850}{93}}$$

$$EOQ = \sqrt{\frac{34,654,200}{93}}$$

$$EOQ = 610 \text{ bags}$$

f. The Steps for Economic Order Quantity (EOQ) in Materials Management.

Having determined the critical materials in a building project site through, ABC analysis, EOQ model was plunged into the critical items to determine the reorder quantity level and the reorder time cycle so as to affect economy in cost of purchasing and holding inventory. The following steps were adopted using Eq. (2) to arrive at an Economic Order Quantity (EOQ) of cement which is an A- item.

- i. From Table 4.1 on materials requirement; determine the annual demand 'a' of cement required to execute the shopping plaza project.
- ii. Document the ordering cost per order 'b' or unit price which was 1850 as at the period of this field survey.
- iii. Assume the holding /carrying cost 'h' of item per annum.
- iv. The holding cost is assumed to be 5 percent of the Unit Price.
- v. By applying the above parameters to Eq (2), the resultant is that each order should be placed for the procurement of 610 bag of cement which is the EOQ.
- vi. Determine the number of orders that should be placed in a day.
- vii. Divide the annual demand of cement 'a' by the EOQ to obtain the No. of bags of cement required daily.

The total No. of bags of cement for each activity would be obtained by multiplying the daily demand for cement by each project activity duration.

In order to proffer proper inventory planning, analysis and control, a frame work is developed as shown in Fig.4.1 This will assist project managers in public building projects to deliver effectively.

The diagrammatic framework shows the sequence of operation for effective materials management

5.0 Summary of Findings, Recommendations and Conclusion

This study examined how the adoption of appropriate cost reduction parameters contributes to effective building projects construction in South-East States of Nigeria.

5.1 Findings Resultant from Table 4.2 on Developing Frameworks for Effective Inventory Planning, analysis and Control

- (i) Items within (5-9) percent cumulative rate percentage are classified as A-Items.

(ii) Those within cumulative rate percent of (10-15) percent are B-item

(iii) While those items within (35-58) percent are C-items.

(iv) Economic order Quantity Model enables the ordering of the critical building materials as at when needed without overstocking them and tying up capitals.

(v) Economic Order Quantity Model also ensures successful timely completion of building projects, thereby eliminating project abandonment.

6.0 Recommendations

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

1. There should be universally accepted inventory model for every type of building project in the study area.

2. Management framework or procedures in materials management for building projects should have a regulatory body monitoring and moderating compliance.

3. The critical materials (A & B - items) in every project should be identified using ABC Analyses Technique, such critical materials, the A - items should be purchased with tighter control; while B - items need fairly tight control. C - Items need moderate control and should not tie up much capital.

7.0 Conclusion

The study has clearly examined the basic principles in the theories of materials management in order to lay the basis for the development of appropriate inventory models. It has significantly shown that cost, time, and specifications are very important valuables in materials management for effective public building projects delivery. When professionally and strategically administered enhance profitable public building delivery. Thus, the formulation of appropriate framework for effective combination of inventory models such as ABC analysis model and Economic Order Quantity (EOQ) will reduce construction cost; deliver projects on schedule thereby eliminate the incidence of stoppage of project midway or total abandonment.

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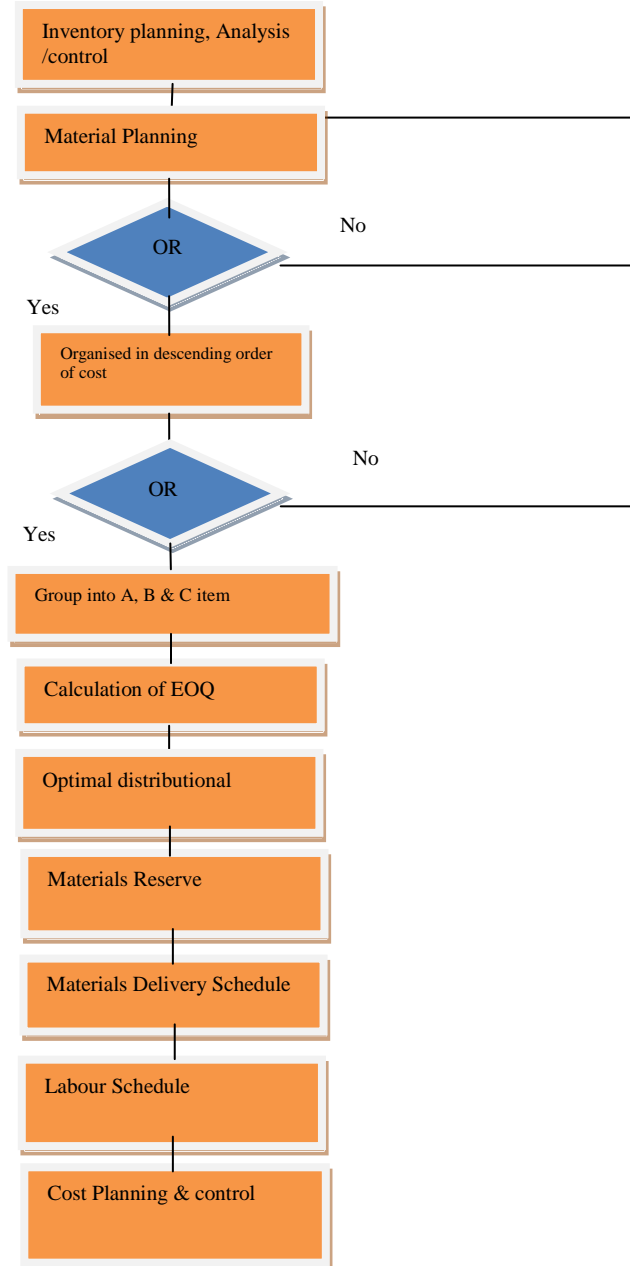


Fig. 4.1. Flow Chart Framework for Proper Inventory Planning, Analysis and control.