OVERVIEW OF THE CLASSIC ECONOMIC ORDER QUANTITY APPROACH TO INVENTORY MANAGEMENT

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Abstract

The paper provides an overview of the basicEconomic Order Quantity (EOQ) model designed to enhance efficient management in modern organizations. The dearth of research into the classic EOQ in favour of the more sophisticated versions of the model is explained. The relevance of the fundamentals of the EOQ particularly in the public-sector organizations of less-developed economies such as those of Asia and sub-Saharan Africa is discussed. Using exploratory research design, the data including the model's basic assumptions, formula, procedure, were sourced primarily from recent survey of concerning literature and interviews with management teachers and practitioners. Numerical examples and computer-aided sensitivity analysis are used to demonstrate simple and effective solutions to basic inventory control problems. *Practical challenges are acknowledged, but the capacity of basic spread sheet package to simplify EOQ application process without losing much information quality at departmental and corporate levels are also noted. The paper's pedagogic value and implications for strategic management education, particularly in the context of the developing economies like Nigeria where quantitative management approaches are not yet fully entrenched are presented. Suggestions for future research scope are also highlighted.*

Keywords:Carrying cost, Management education, Production management, Public-sector, Spreadsheet package.

JEL Codes: *A2, D04, F61, L23*

I. INTRODUCTION

The classic Economic Order Quantity (EOQ) model is perhaps the best known and most fundamental inventory decision model. The model hallmarks management science methods geared towards improving the timing of inventory delivery and streamlining overall production or service delivery process. The use of basic EOQ enables a store manager to better understand the challenges. Although this model has been criticised for being over-simplified to represent most real world situation, it is nonetheless an excellent starting point from which todevelop complex and more realistic inventory decision models. As is the case with all models, the validity of the EOQ model depends on a number of assumptions highlighted in this presentation. The EOQ model, supply chain management and Just-in-Time (JIT) represent some of the common and oldest classical production scheduling models and efficient inventory management tools. The EOQ equation in particular helps in identifying the level of inventory which allows for uninterrupted operations while minimizing reordering costs and hence enhances cash flow. Recent research suggests the possibility of a 20 percent reduction in the total variable costs by using the EOQ model (Kumar &Prajapati, 2015).

The basic EOQ is the order quantity that minimizes total inventory holding costs and ordering costs. The model was developed by Ford W. Harris in 1913, but R. H. Wilson, a consultant who applied it extensively, is given credit for its in-depth analysis (Hax&Candea, 1984). The model aims at determining the optimal number of units to order so that management can minimize the total cost associated with the purchase, delivery and storage of a product. In other words, the classic EOQ is the amount of inventory to be ordered per time for purposes of minimizing annual inventory cost. In broad terms, the optimal order quantity at a given time must be determined by balancing two factors: (i) the cost of possessing or carrying the product and (ii) the cost of acquiring or ordering materials. Purchasing larger quantities may reduce the unit cost of acquisition, but the saving may not offset the cost of carrying the product in inventory for a longer period of time. The more specific variables required for the solution are (i) the total demand for the year, (ii) the purchase cost for each item, (iii) the fixed cost to place the order (not the cost of the goods) and (iv) the storage or carrying cost (warehouse space, refrigeration, insurance, security, etc.) for each item per year.

The basic function of EOQ is thus to identify the optimum order with the lowest cost parameter. The EOQ formula can be modified to determine production levels or order interval lengths. As will be observed in subsequent sections of this paper, the basic EOQtechnique is relatively a simple mathematical approach. Big organisations across the world, especially those with large supply chains and high variable costs per unit of production use the model to make their stock management system more efficient; this means keeping wastages to the barest minimum, while seeking to achieve operational corporate goals and objectives.

While the literature is dense on the EOQ model as an inventory management approach, past studies appear to be more focused on the diverse areas of its applications with increasing suggestions for model adjustments so as to fit multiple realities, notably, randomness or fluctuations in inventory demand. Admittedly, more and more sophisticated mathematical tools and computational algorithms are constantly being discovered such that the field is increasingly field with a wide variety of modernised EOQ techniques, but there remains very few academic papers

that have provided significant holistic assessment of the classic EOQ itself. Perhaps, the reason for this lack of research interest in the basic EOQ model is a mistaken belief that the student and practitioner arealready familiar with the basic EOQ approach, hence the research concentration on sophisticated EOQ model modifiers. In effect, research seems to have stopped looking at the basic EOQ model itself which still has a lot of relevance in less-developed economies such as those of Asia and sub-Saharan Africa, hence the need for further overview of the model to reinforce teaching and learning of the technique.

There are various perspectives to the problem of inventory control in developing economies like Nigeria, which should compel further research on classic EOQ (CEOQ) model. Developing economies like Nigeria are currently faced with the challenges of maintaining socio-economic progress amidst unprecedented plunge in crude oil prices and tightening of global financial conditions that had led to sharply reduced export earnings and government revenues. It is therefore imperative to use inventory management techniques like the CEOQ model to complement on-going campaigns towards attaining operational efficiency in both public and private sector organizations, sealing leakages in revenue and wastages in expenditure, especially unnecessary inventories.

Notably, the key challenge inventory control in the country has been attributable to the failure, on the part of the top management officials, to give a deserved attention to the function of warehouses and stores as well as their inability to employ the services of as well qualified store officers to take charge of inventory supervision and management. There seems to be a mistaken impression that inventory operation is a non-strategic function. Besides, there is the related issue of the dearth of storage facilities and the habit of stores procedure violation by various cadre personnel in many organisations, whether private or public (Yusuf, 2003). Thus, the practice of inventory management in Nigeria today requires significant improvement, given the poor level of computerization, non-determination of stock level, the involvement of illiterates and unskilled personnel in the management of inventory (Akindipe, 2014), but beyond all the generic issues, certain questions on the CEOQ model are of immediate interest in the context of operational management learning and practice in the developing economies.What are the underlying assumptions of the CEOQ model that inventory managers from the developing world should clearly understand? What are the model's vital variables and formula? How can today's store manager especially in the developing world be assisted to use the computer technology to achieve optimal inventory management using the CEOQ model? What are the aspects of the model that needs to be improved upon in order to accommodate real-world realities? What are the likely inventory management policy and research implications from the above enquiries?

These issues are germane not only to sustainable operational management practice, but also to development of strategic management and human capital development across economic sectors. In this paper, an attempt is made to explore the extent to which a panoramic review of the CEOQ model and a pedagogic contribution to its literature can help to address some of these issues.

Significance of the Study

The need for the present study can be viewed from two perspectives. First, the results from this study are expected to educate management students and executives on the benefits of robust CEOQ-aided inventory management policy to modern organizations. While the literature is awash withsilos of inventory control techniques in the field, to the best of our knowledge, sparse research to date has been focused on the general knowledge and utility of the CEOQ model. Thus, this pedagogic paper could serve as a resource base to students, scholars and researchers interested in carrying out further, more precise research in inventory management, in terms of increasing researchers' familiarity with the basic scope of the EOQ model, and providing a systematic guide/framework towards successful implementation of practice-oriented research agenda in CEOQ-based inventory management.

Secondly, enhanced awareness of the CEOQ model in a more holistic manner is expected to result in superior organizational performance through wider measurement perspectives and more informed recognition of risk and uncertainty in inventory management. Beneficiaries across the sectors, operations managers, senior management, state actors, and other stakeholders, can take advantage of the spreadsheet tools to build advanced inventory solutions faster than the competition, and to complement efforts towards significantly improving operational efficiency across economic sectors, whether public or private. Thus, revisiting the CEOQ model holistically and pedagogically as attempted in this paper may provide some starting point towards integrated thinking as a way of dealing with complexities in modern inventory control (Hindle, 2008).

This paper consists of five broad sections. The paper begins with this introduction including the imperatives for the present contribution. The second section reviews the general literature and highlights some of the significant contemporary studies carried out on the subject globally. The third section deals with the methodology adopted for the research, while the fourth section presents the results of the pedagogic study and a summary of the findings. The paper ends with a few policy implications and some suggestions for future studies

II. Literature Review

Conceptual overview

Drawn from basic literature (Oxford Advanced Learner's Dictionary, 2005; Parasuraman, 2014), the following definition of key terms is apposite for their instructional value:

Economic:	Something is 'economic' when it aligns with the rules of good management.
Order:	An 'order' is a request for something to be supplied.
Quantity:	'Quantity' refers to an amount or number.
Optimal:	The most favourable amount, point, or degree of something.

Economic Order Quantity: This is also known as Economic Batch Quantity (EBS) or Economic Lot Size (ELS). This is a calculated ordering quantity that minimizes the balance of costs between inventory holding cost and re-order cost.

CEOQ: Classic EOQ without modifications or adjustments for transactional differences such as trade credit, inventory rejects, and works-in-process.

Stock Management: Stock Managementis concerned with efficient control of the inventory mix of an organisation having regard to the different levels of demand on that inventory. There are external and internal factors that can exert demand for materials in a given period. A robust stock management tries to balance the situation by creating purchase orders that keep supplies at an optimal or prescribed level.

Efficient: An 'efficient' thing, person or system works productively with no waste of money or effort.

Brief survey of related empirical studies

A noticeable trend in the EOQ research is the increased emphasis on modifications to the classical EOQ model and extensive use of numerical examples so as to accommodate as much multiple operational management realties as possible for robust financial management. For instance, Manna and Chandri (2014) presented a modified EOQ for dealing with a deteriorating inventory item with quadratic time-varying demand and partially backlogged shortages. Similarly, several studies, notably, Swami *et al* (2015), Shah *et al* (2014) and Tripathi (2013) tried to address EOQ model's assumptionof immediate payment for inventories by proposing an integrated inventory policy for vendor-buyer in situations when demand is stock-dependent and trade credit is associated with order quantity. Through mathematical models, differential calculus, along with numerical examples and sensitivity analysis, these studies were able to demonstrate that joint total profit could be maximized through the modified EOQ approach.

Modifications of the EOQ model have been investigated in several studies, namely, Kannan*et al* (2013) with respect to pharmaceutical vendor-managed inventory contracts, Ullah and Chang (2014) dealing with inventory rejects, Elyasi*et al* (2014), Guangshu*et al* (2015), and others.

Toptal*et al* (2014) attempted to extend analytically extend the CEOQ model to consider carbon emissions reduction (and by extension, operational costs) and investment availability under carbon cap, tax, and cap-and-trade policies. This should be of interest to market regulators with respect to taming the effects of global warming in line with the dictates of green technology.

Umamaheswai et al (2014) examined the use of EOQ model for crafting economic purchasing strategy. The author tried to justify optimal ordering policy by maximizing the difference between the classical EOQ cost and discounted price quantity during the same sample period. This means that the CEOQ is versatile enough to permit some appreciable level of operational flexibility or disaggregation to meet business realities. Hence, more recently, Kumar and Prajapati

(2015) found the EOQ model useful for computing inventory turnover ratio and for optimizing inventory costs.

Research Gap

What is clear from the foregoing literature review is the prevalence of a multiplicity of perspectives on the EOQ model globally, but there is paucity of contributions on comprehensive assessment of the model, in its original, classical form, and its utility in modern organizations of the developing world. As earlier noted, research has focused more and more on sophisticated mathematical tools and computational algorithms, but there remain very few academic papers that have provided significant holistic contribution to the classic EOQ itself, hence the need for more pedagogical overview of the model so as to reinforce model teaching and learning.

Thus, the main purpose of the paper is to provide an overview of the classic Economic Order Quantity (EOQ) model as an overarching inventory management concept taught in many Business Schools over the years and therefore viewed as crucial for executive management education globally. The specific objectives are:

i. To review the underlying assumptions of the basic EOQ model for the improved understanding of modern inventory managers.
ii. To describe the model's vital variables and formula in its foundational, classic format.
iii. To introduce the spreadsheet applications of the basic EOQ model.
iv. To identify some emerging aspects of the classic EOQ model where some modifications may be needed in the context of the developing economies.

The paper is also expected to add some discussion on the likely inventory management policy and research implications from the study.

Research Questions

The following research questions were raised specifically for the purpose of the study:

i. What are the underlying assumptions of the basic EOQ model that inventory managers should clearly understand?
ii. What are the EOQ model's basic variables and formula?
iii. How can today's store manager especially in the developing world be assisted to use the computer technology to achieve optimal inventory management using the EOQ model?
iv. What are the aspects of the classic EOQ model that needs to be improved upon in order to accommodate real-world realities?

III. METHODOLOGY

Methodology of the study consists of exploratory survey of relevant literatureand analysis of a case organization for enhancement of knowledge on the subject-matter (Kothari & Garg, 2014). Online and offline sources were searched for academic papers, conference proceedings, and websites and books that dealt with various EOQ inventory management techniques. Scholars and researchers mainly in Nigeria and India were consulted to obtain contemporary perspectives on the subject. Additionally, further helpful insights were obtained from one of the author's participation at Nigerian Customs Service Training programme on effective store-keeping techniques held at the Public Service Institute of Nigeria Abuja, on 19th May 2015, hence, given the limitations of time, manpower, money, and other logistical issues, information in this paper regarding several aspects of the EOQ model that need to be improved upon in order to accommodate real-world realities were sourced from this seminar.

The present study stresses the public service context because, ultimately, it is the civil administrators who are responsible for ensuring effective implementation of government programmes and policies that affect the citizenry including the private sector (Olaopa, 2015).

This paper thus also seeks to contribute to the management literature by including simple numerical examples and sensitivity analysis using the MS Excel spread sheet to show how students and practitioners may easily apply the basic EOQ to solve simple inventory control problems effectively and efficiently.

IV. Results and Discussion

A. On the basic assumptions of classic EOQ model

The EOQ is a measure used to find the optimal quantity that needs to be ordered at a given point in time, given the cost of placing the order and the storage cost, as well as the amount required (Parasuraman, 2014). In order to properly appreciate modern stock management's role and the basic assumptions of the EOQ model, the concerning literature stress the importance of an effective inventory control system. Considering that an organisation's inventory represents money, the control of inventory has serious financial implications for the organisation. If the stock is controlled inefficiently, this is likely to result into the result in high storage cost, obsolescence and reduction in working capital. Hence, the manager concerned should ensure that inventory is controlled very carefully. In many private-sector enterprises, the actual level of business profit may depend on the success of inventory management. It must be stressed that while good customer service is the principal objective of the store manager's function, it is obviously desirable to provide that service economically and optimally. The key issue here is to always maintain the value of the inventory at the lowest-cost practicable level so as to economize on working capital and storage costs.

It can be noted from the foregoing paragraph that there would be some conflict between the need to give a good service at all times and the imperative of economizing stockholding. On one hand, the more stock you have, the easier it is to maintain ready availability of the items.

Contrariwise, the more stocks held the higher the level of the cost incurred. It is therefore crucial to find and operate a satisfactory compromise between these two opposing forces and this is where EOQ model comes in as a veritable optimization tool for store managers.

Thus, it is not necessarily correct or efficient practice to buy materials purely on the basis that they are being purchased at the lowest price obtainable(Yusuf, 2003). The object of effective inventory management is to purchase materials up to the amount which secures an uninterrupted supply of the commodity at the *least* ultimate costs (Joseph, 2014; Adebayo *et al,* 2012; Wilson, 1934). It is the *real* cost of the materials issued to the using department that is critically important, not just the invoiced cost of the goods when received from the supplier.

At this point, it is important to highlight the underlying assumptions for the EOQ model, so that the manager will be able to know when and how to apply the EOQ formula for realizing his or her stock management goals. As noted by Enikanselu (2008), Adebayo *et al* (2012),Akinsulire (2014), and others, the basic assumptions for applying EOQ are as follows:

- Demand is deterministic
- Demand is constant and known; if seasonality is involved, EOQ must be modified accordingly.
- Instantaneous replenishment (i.e. lead time is zero; replenishment not in instalments)
- Instantaneous delivery
- Batch ordering and delivery
- Shortages are not allowed
- Cost of order is fixed
- Fixed unit price (i.e. no volatility or discounts applicable)
- No constraints on order size

In essence, the EOQ model is great for production / stock management process that is consistent, easy to forecast, the demand is fixed and lead times are both known and fixed. In other words, organisations that have a steady demand for an inventory item are the most suitable for the application of the EOQ technique. Therefore, the EOQ approach may not be applicable to every type of business and industry. It is typically used in a manufacturing, maintenance and distribution environment where the ordering of stock is constant and repetitive.

B. On the variables and formula of the classic EOQ model

The classic EOQ model aims at determining the optimal quantity of units to order so that we minimize the total cost associated with the purchase, delivery and storage of the item, and the model's metrics are well documented in the literature (Adebayo *et al*, 2012; Chand, 2015; Yusuf, 2003; Enikanselu, 2008; Scott, 2015; Parasuraman, 2014). Different formulas have been developed for the calculation of the CEOQ including graphical approaches. The requisite parameters to the solution are the total demand for the year (A), the cost to place a single order (S), and the annual storage/holding cost for the item (I). The following formula is therefore usually used for the calculation of the classic EOQ.

$$EOQ = \sqrt{\frac{2*A*S}{I}} \quad \ldots (1)$$

Where,

A is the demand for the year
S is the cost to place a single order
I is the cost to hold one unit inventory for a year

It will be noted that the classic EOQ model is a trade-off between ordering cost (S) and holding cost (I); purchase cost is not a relevant cost for determining the optimal order quantity. In essence, EOQ is a function of only A, S, and I. Ordering costs (S) will include such indirect cost activities as negotiating with vendors / suppliers, updating the database, issuing purchase orders and handling complaints. The manager will need to have good accessibility to these costs in order to justify the utility or effectiveness of the CEOQ model. Also, it should be noted that, beyond the mathematical model indicated in eqn. 1, there are other approaches for determining CEOQ: graphic approach, differentiation approach, and the tabular approach; these are all beyond the present scope of this paper. There are many online study and textbook materials on these approaches for the interested reader to explore further

C. On computer-based application of the EOQ model

As noted in the previous section, the basic EOQ model computation is based on constant system of ordering and holding costs, constant system of demand quantity, and instantaneous replenishment. In this regard, it should be recalled that the EOQ is a measure used to find the optimal quantity that needs to be ordered at a given point in time, given the cost of placing the order and the storage cost, as well as the amount required (Parasuraman, 2014).

Illustration

Assume that the annual demand for A4 photocopying papersin a government departmentis 16,000 reams. The annual holding cost per unit is ₦5, 000 and the cost to place an order is ₦1, 250.00. Calculate the Economic Order Quantity (EOQ). The manual computation is shown below:

$$EOQ = \sqrt{\frac{2*16{,}000*1{,}250}{5{,}000}} = \sqrt{8{,}000} = 89 \; reams \; per \; order$$

The computer spreadsheet result is shown in Table 1.

Table 1: Basic EOQ - The order quantity that minimizes total inventory holding costs and ordering costs

(i) Annual demand quantity, A	16,000
(ii) Handling cost to place one order, S	1,250
(iii) Annual holding cost per unit, I	5,000
2*A*S/I	8,000
EOQ	89

Source: Authors' computations using MS Excel software (2016)

Sensitivity analysis

Assume a scenario that the expected annual demand for the same item has doubled. Ordinarily, the tendency will be for the store manager to want to double the order quantity per time, but the basic EOQ model dictates otherwise as shown in the spreadsheet results in Table 2.

Table 2: EOQ scenario analysis: When inventory demand is doubled

(i) Annual demand quantity, A	32,000
(ii) Handling cost to place one order, S	1,250
(iii) Annual holding cost per unit, I	5,000
2*A*S/I	16,000
EOQ	126

Source: Authors' computations using MS Excel software (2016)

It can be observed from Table 2 that, ordinarily, the traditional order quantity should have been 178 reams per time but the EOQ model dictates just 70% (126 reams) of that quantity, meaning that, for purpose of economic efficiency, less than ordinary sense dictates is actually needed per order. From this simple illustration, it should be easy to see the inherent cost advantage of the EOQ model, thus revalidating the cost-reduction prospects of the model as observed in similar studies (Kumar &Prajapati, 2015).

Contrariwise, Table 3 displays the spreadsheet results of the EOQ when the expected inventory demand is reduced by 50 per cent. In this case, the conventional manager will simply want to reduce the order quantity by half, that is, (from Table 1), he /she would order for about 45 reams, but the EOQ model dictates fairly more (63 reams), as shown in Table 3.

Table 3: EOQ scenario analysis: When inventory demand is reduced by half

(i) Annual demand quantity, A	8,000
(ii) Handling cost to place one order, S	1,250
(iii) Annual holding cost per unit, I	5,000
2*A*S/I	4,000
EOQ	63

Source: Authors' computations using MS Excel software (2016)

A major benefit of the EOQ approach is that of its insensitivity to parameter errors, imprecise estimates, forecast, costs, because those errors are significantly minimized by the presence of the square root function in the EOQ formula. Thus, by being insensitive to parameter imprecision, EOQs can be rounded off without a significant loss in economies; order sizes can be increased or decreased to the nearest pack (minimum), and order intervals can be lengthened or shortened to the next interval.

The model is particularly beneficial to businesses that have multiple orders, specific release dates for their products and have requirements plan for their components. Organizations that deal with large volumes of inventorywill find the EOQ equation useful. Such organizations are likely to have a steady demand for stock of ingredients or inventory needed for maintenance, repair and operations, and thus find EOQ model handy. Retailers and high technology providers are the least likely to benefit from the model.

D. On aspects of the EOQ model that needs to be improved upon in order to accommodate real-world realities

The EOQ is perhaps the most widely used and traditional technique for determining how much should be economically ordered(the optimal order quantity) in a continuous system. Despite its shortcomings, the model remains a helpful analytical tool to managing inventory, despite the fact that some supply chain industry executives perceive it as “old school”. Part of the challenges with its applications may be attributable to lack of the practical parameters to robustly reflect some of the model’s highly restrictive / deterministic assumptions. For example, the company’s actual acquisition or ordering costs or yearly inventory carrying cost rate may be unknown, unless diligent and purposeful data-gathering and analysis are specifically undertaken or captured in the management information system (MIS). Some organisations might never have determined their cost of placing and processing purchase orders, such as the time and additional cost to send in an order for a material, receive it, handle the supplier’s invoice and pay for it. Purchase orders can be cumulatively substantial, when you add up handling processing and inbound freight charges that may be incurred for smaller and more frequently delivered orders. There are also related issues about trade credit (as opposed to the fixed unit price assumption), rejects, and works-in-process, among other current realities in order management.

Two other EOQ model assumptions arenoteworthy because of their practical implications. The first is about the model requirement that the buyer must settle the payment due immediately when items are received in the inventory system. In practice, these (fixed unit price / fixed order cost assumptions) may not be obtainable, as some vendors usually give trade credit, as in, for instance, when the buyer’s order quantity exceeds a certain threshold (Shah *et al,* 2014 & 2015).

The second aspect for model modification relates to the assumption that shortages are not allowed, meaning that, the order quantity produces good quality products or inventory items every time. This assumption is also hardly realistic in some cases, and this has led to the development of model modifiers to permit the effect of rework, rejects, and work-in-process inventory, as well as freshness-keeping (agricultural) contracts (Guangshu*et al,* 2015; Ullah& Chang, 2014).

Despite the aforementioned technical challenges, as earlier noted, the basic EOQ model remains good enough for production / stock management process that is consistent, easy to forecast, the demand is fixed and lead times are both known and fixed. Thus, organisations – such as those in the manufacturing, maintenance, service and distribution environment where the ordering of stock is constant and repetitive,that have a steady demand for an inventory - item will continue to benefit from intelligent application of the EOQ technique.

Summary of findings

1. The research results indicate that there are nine key assumptions of the basic EOQ model that inventory managers should clearly understand. Basically, the EOQ model is good for production / stock management process that is consistent, easy to forecast, the demand is fixed and lead times are both known and fixed. In other words, organisations that have a steady /deterministic system of demand for an inventory item are relatively suitable for the application of the EOQ technique.

2. There are three basic variables or questions that need to be answered in the basic EOQ model: (i) Howmany units of the items will be needed annually? (ii) How much will it cost to place a single order? (Recall that this is not necessarily the same as the item's purchase price); and (iii) How much will it cost to hold one unit inventory for a year?

3. Review of few numerical examples in optimal order quantity indicates the capacity of the spreadsheet technology to make things relatively easy for the discerning inventory manager.

4. Part of the challenges with classic EOQ applications may be due to lack of the practical parameters to properly reflect some of the model's highly restrictive / deterministic assumptions. For example, the company's actual acquisition costs to place an order or yearly inventory carrying cost rate may be unknown, unless diligent and purposeful data gathering and analysis are undertaken. This means that the classic EOQ approach may not be applicable to every type of business and industry, or the model will have to be tweaked in some more realistic ways to adapt to every business, including those, for instance, engaged in inventory management of perishable products.

V. Conclusion

In this paper, an attempt was made to provide an overview of the basicEconomic Order Quantity (EOQ) model as an overarching management technique for determining optimal order quantity of organizational inventories. The underlying assumptions of the basic EOQ model were revisited and nine vital aspects identified and highlighted for the benefit of the students and practitioners. The computational results from the numerical examples presented in this paper go some way in reinforcing the cost-effectiveness of the EOQ model as observed in a number of recent studies, notably, Kumar &Prajapati (2015). Evidently, the development of computer technologies and their applications to theEOQ approach to inventory management will continue to refine its utility in practice.

Hopefully, this pedagogical work in the context of the classical EOQmodelhas brought again to the fore the primary objective of stores function which is to provide optimal service to operationalmanagement function and this should be fully appreciated by all discerning organisations, whether or not they are faced with revenue pressures. It is therefore important for organisations to see their stores department as crucial parts of the productive system, as most of items kept in the stores represent capital that, if not well-managed using tools like the EOQ model, can strangulate the organization and bring it to a halt.Admittedly, some of the information that the

manager needs for seamless CEOQ applications may not be readily available. In this regard, the following suggestions are apposite:

1. Computing many new measurements as critical components of the tripartite A, S, and I, variables that make up the model.
2. Bigger organizations and government agencies can hire external consultants who are routine experts in EOQ modelling to help them get a computerised system up and running.
3. Large organisations could have to run a pilot scheme prior to full introduction / implementation of fundamental EOQ system.

Overall, it is hoped that the holistic dimensions of the basic EOQ presented in this paper would give managers and researchers multiple options in addressing inventory management challenges, especially in optimizing inventory costs, given today's increasingly keener competitive environment and tightening financial conditions globally.

Scope for future research

Inventory management is complex and remains beyond the full capture of any singular model, notwithstanding years of continuous thorough research, data, theory, and innovative thinking for better understanding. For this reason, there is still a lot of distance to cover on the subject, notably:i. The next level of research may need to look at complementing the present results by conducting empirical analysis to providemore numerical examples / cases of real-world application of the model among public and private enterprises, particularly cases of bonded warehouses such as those containing customs agency-seized goods in the Nigerian context.ii. Development of more robust EOQ models that can handle fluctuations in demand for inventories will also continue to be an interesting research concern.

Endnotes

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References

Akindipe, O. S. (2014). Inventory management: A tool for optimal use of resources and overall efficiency in manufacturing SMEs. *Journal of Entrepreneurship and Innovation (JEMI), 10*, (44), 93-113.

Akinsulire, O. (2014). *Financial management, 8thedn*. Lagos: El-Toda Ventures Ltd.

Chand, S (2015). Most important techniques of inventory control system. http://www.yourarticlelibrary.com/inventory-control/6-most-important-techniques-of-inventory-control-system/26159/, [13th April 2015].

Adebayo, O. I., Enikanselu, S. A., &Oyende, A. I. (2012).*Fundamentals of Production Management.* Lagos: Enykon Consult.

Elyasi, M., Khoshalhan, F., and Khanmirzaee, M. (2014).Modified economic order quantity (EOQ) model for items with imperfect quality: game-theoretical approaches.*International Journal of Industrial Engineering Computations, 5*, (2), 211-222.

Enikanselu, S. A. (2008). *Introduction to business.* Lagos: Enykon Consult.

Guangshu, X., Jie, Z., Chao, W., and Hualing, S. (2015). Research on supermarket fresh agricultural products ordering based on freshness-keeping contract. *International Journal of Engineering & Industries, 6,* (1), 12-19.

Harris, F. W. (1915). Operations cost (Factory Management Series). Chicago: Shaw.

A. C. Hax, A. C., and D. Candea, D. (1984).*Production and Inventory Management*. NJ: Prentice-Hall, Englewood Cliffs.

Hindle, T. (2008).*Guide to management ideas and gurus*. London: The Economist Newspaper Limited.

Kannan, G., Grigore, M. C., Devika, K., and Senthikumar, A. (2013).An analysis of the general benefits of a centralized VMI system based on the EOQ model.*InternationalJournal of Production Research, 51,* (1), 172-188.

Joseph, L. (2014, March). Inventory management techniques and their importance.https://blog.udemy.com/inventory-management-techniques/, [13th march 2015].

Kothari, C. R., & Garg, G (2014). *Research methodology: Methods and techniques. Third Edition.* New Delhi: New Age International (P) Limited, Publishers.

Kumar, D., and Prajapati, D. R. (2015).Determination of inventory turnover ratios and cost savings by using basic EOQ model.*International Journal of Management, IT, & Engineering, 5,* (9), 80-92.

Manna, S. K., and Chaudhuri, K. (2014).An order level inventory model for a deteriorating item with quadratic time-varying demand, shortage and partial backlogging.*Journal of Engineering and Applied Sciences, 9,* (5), 692-698.

Olaopa, T. (2015). Change agenda: The devil in the details of execution. Presentation at the Nigerian Economic Summit.https://www.ngrguardiannews.com [25th October, 2015].

Oxford Advanced Learner's Dictionary (2005) 7th edition.Oxford University Press.

Parasuraman, N. R. (2014). *Financial management: A step-by-step approach.* Delhi: Cengage Learning India Pvt. Ltd.

Reference Suite. Chicago: Encyclopædia Britannica.

Shah, N. H., Jani, M. Y., and Shah, D. B. (2015). Economic order quantity model under trade credit and customer returns for price-sensitive quadratic demand. *InvestigacionOperacional, 36,* (3), 240-248.

Shah, N. H., Patel, D., and Shah, D. B. (2014). Optimal integrated inventory policy for stock-dependent demand when trade credit is linked to order quantity. *InvestigacionOperacional, 35,* (2), 130-140.

Scott, S. (2015). *Top ten ways to manage inventory.http://smallbusiness.chron.com/top-ten-ways-manage-inventory-11099.html*, [13th April 2015].

Swami, A., Pareek, S., Singh, S. R., and Yadav, A. S. (2015).Inventory model for decaying items with multivariate demand and variable holding cost under the facility of trade credit.*International Journal of Computer Applications, 113,* (1-19), 18-28.

Toptal, A., Ozlu, H., and Konur, D. (2014).Joint decisions on inventory replenishment and emission reduction investment under different emission regulations.*International Journal of Production Research, 52,* (1), 243-269.

Tripathy, R. P. (2013). Inventory model with different demand rate and different holding cost. *International Journal of Industrial Engineering Computations, 4,* (1), 437-446.

Ullah, M., and Kang, C. W. (2014).Effect of rework, rejects, and inspection on lot size with work-in-process inventory.*International Journal of Production Research, 52,* (8), 2448-2460.

Umamaheswari, S., Chandrasekeran, E., and Vijayalakshmi, C. (2014).Implementation of optimum inventory model for deteriorating items with economic purchasing strategy.*International Journal of Applied Engineering Research, 9,* (24), 25905-25917.

Wilson, R. H. (1934). A scientific routine for stock control.*Harvard Business Review, 13,* 116 – 128.

Yusuf, A. M. (2003). *Inventory and Economic Order Quantity in National Electric Power Authority (NEPA).* PhD Thesis, St Clements University.

Online Resources

https://www.customs.gov.ng/Publications/publications_details.php?callpage=/Publications/other_publications.php&page=0&id=107

https://en.wikipedia.org/wiki/Economic_order_quantity