Varying Lot-Sizing Models for Optimum Quantity-Determination in Material Requirement Planning System

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***Abstract*—Lot sizing is one of the three input components of material requirements planning (MRP). In practice, lot-sizing models (LSM) are not often utilised to solve real-life scenarios due to different assumptions, limits, and the extent to which these conditions are valid. Therefore, for many practitioners, a way out is to adjust some traditional method to their present situation rather than vary different lot-sizing models. This study was designed to develop a standalone lot-sizing module (LST-MOD) with a graphic user interface (GUI) to determine the most suitable ordering policy.**

Six (6) LSM were analysed based on relevance and complexity. Since lot-sizing is an exogenous decision, the lot-sizing component of the material requirement planning system (MRP) was decoupled. This resulted in the development of a standalone module using Python programming language. Thereafter, using an end product and its sub-items, the LST-MOD was used to obtain total inventory cost.

By varying different lot-sizing models, those with high flexibility performed better than those with little or no flexibility. This approach showed that for an organisation with little financial strength, it is possible to develop in-house lot-sizing module to vary simultaneously several ordering policies under multiple conditions. The output will assist management in their decision planning process and ultimately contribute to the actualisation of their strategic goals.

***Index Terms*— material requirement planning, lot sizing techniques, inventory planning, enterprise systems**

I. Introduction

LOT sizing (or ordering policy) is one of the three input components of material requirements planning (MRP). The aim of the policy is to determine the sizeable lots to purchase or produce. On MRP (invented by Joseph Orlicky in 1970's), this is a computer-based information system which translates master schedule requirements for end items into time-phased requirements of dependent-demand inventory such as sub-assemblies, components, and raw material [19]. Although MRP system can provide assistance on how much to order based on different cost factors, anticipated demand, and stock situation. Chase and Aquilano [6] cautioned that the process of obtaining optimal order quantity in the MRP system is complicated and difficult. This problem can be attributed to (i) complicated planning periods and, (ii) production stages associated with many production processes.

Atamturk and Küçükyavwz [1] defined the lot-sizing problem (LSP) as a decision-making process aimed at determining the quantity of an item to order (given the demand) in each period (lot timing) over a finite discrete time horizon. From the viewpoint of the economics of scale, Steinberg and Napier [18] expressed LSP as an attempt to balance ordering and holding cost. Therefore, they advised that strategies aimed at resolving the lot-sizing problem should be carefully selected. This is necessary because such decisions will influence the performance of the inventory system (a combination of ordering, holding and shortage costs).

In practice, LSP are usually resolved using an appropriate lot-sizing model (LSM). However, due to different assumptions, limits, and the extent to which conditions associated with using LSM are valid, these techniques are often not utilised to solve the majority of real-life LSP scenarios. Therefore, for many practitioners and organisations, a way out is to adjust some known and established lot-sizing models (e.g. Economic Order Quantity) to their present situation rather than vary different models [2]. In contrast, the decision to use a particular LSM due to its popularity might result in substantial variation in inventory levels (and associated costs), a situation which can affect the performance of an inventory system [18].

With rapid advancement in technology, increased globalisation, competitive manufacturing environment and the need to meet consumers' expectations; organisations with financial resources prefer to acquire agile, efficient and integrated manufacturing software to cater for inventory management. One of such software according to Chase and Aquilano in [6] is the advanced, new generation MRP-TYPE system which the Gartner Group called enterprise resource planning (ERP). ERP system integrates business processes so that resources can be managed productively and proactively [14]. This integration eliminates silo effect

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(data duplication and redundancy) associated with functional organisation structure [12]. ERP also being referred to as enterprise systems (ES) have reshaped how business processes are being carried out around the world [7].

In the enterprise system (ES) evolution, ERP is the third phase while material requirement planning (MRP) and manufacturing resource planning (MRP II) are the first and second phase respectively. One of the capabilities of an ERP system is the ability to choose and compares different LSM before determining optimum material plans [4], [15], [16]. Therefore, as expected in most small, medium size and multi-national companies with financial resources, the client-server-based multi-application ERP system has dominated production planning and inventory control [9].

In Nigeria, the benefits of ERP are yet to be exploited by small and medium scale enterprises (SMEs) due to the financial implications associated with the acquisition and usage of this proprietary tool [15], [17]. Specifically, Oladokun and Olaitan in [17] identified lack of affordable and user-friendly inventory control tool as one of several challenges limiting the performance of most Nigerian manufacturing companies. Despite this challenge, companies must have a decision support process for dependent-demand inventory. This is because such decisions are required during inventory planning which ultimately will contribute to the actualisation of the organisation's strategic goals.

Since lot sizing is an exogenous decision in the MRP system; invariably, the decision on which ordering policy to adopt can be made outside of the MRP. This implies that the process of determining the appropriate policy can be achieved through the development of a standalone module (decision support tool) to assist inventory managers. Baculinao, Wee and Chow in [5] opined that such module should be independent and user-centric with the capability to vary multiple LSM under different conditions. With this module, an organisation can decide on the most suitable ordering policy and make it available as input into an existing MRP system or the decision support system available for generating schedule requirements.

In this research, the objective is to develop a standalone lot-sizing technique module (LST-MOD) to vary six (6) lot-sizing techniques. The remainder of this paper is structured as follows. A brief discussion on LST is the focus of section 2 while the development of the LST-MOD with an illustrative example is the focus of section 3. The research is concluded in section 4.

II. RELATED LITERATURE

Lot-sizing models can be classified into two, static and time-varying [3], [8]. Before a static lot sizing model can be applied, the following features must be evident in the problem; these are, constant demand, continuous planning period, accumulation of on-hand inventory, and zero safety stock [3], [18]. These characteristics of static LSP are too idealistic for real-life situations. Nevertheless, the use of static LSM (e.g. EOQ) have tremendously helped to gain new insights and break new grounds in inventory planning and control. EOQ is widely used in many industries to minimise a firm's total inventory costs.

In most real-life LSP, the problem is characterised by the following (i) integer valued planning period, (ii) demand varying with time, (iii) holding cost is proportional to the number of integer periods items are held, (iv) ordering cost is independent of the lot size and, (v) delivery of quantity ordered can only take place at the end (inventory on hand must be zero) of the previous period [3]. Solving LSP with time-varying demands involves the use of heuristics procedures such as Lot for lot ordering (LFL), Periodic Order Quantity (POQ), Silver-Meal Heuristics (SMA), Part Period Algorithm (PPA) and Incremental Part Period Algorithm (Incremental PPA).

III. METHODOLOGY

The methodology adopted in developing the standalone lot- sizing module (LST-MOD) involved the following steps: a) System Analysis b) System Development c) System Testing, and d) System Deployment [13], [17].

A. System Analysis

Index

i - Index for planning period, i = 1,...,n

m - Index for order period *m* = 1,..,M

Notation and Definitions

IRF	Inventory record file
IOH*i*	Inventory on hand at period *i*
IOHi-$_1$	Inventory on hand carried from previous period *i*
I*i*	Inventory left at period *i*
I*i*-$_1$	Inventory left and carried from previous period *i*
SR*i*	Scheduled receipt at period *i*
GR*i*	Gross requirements at period *i*
NR*i*	Net requirements at period *i*
NR*m*	Net requirements at m period for selected lot-sizing model
D_{avg}	Average Demand
N	Number of periods
L	Average lot size
M	Order period
F	Required quantity when using FOQ
Q*i*	Quantity ordered at period i
K(m)	Cost per m periods when using SMH
A	Ordering cost
H	Holding cost
PP (m)	Part Period for m periods when using PPB
LFL	Lot-for-lot
FOQ	Fixed order quantity
POQ	Periodic order quantity
SMH	Silver-Meal Heuristics
MOQ	Multiple order quantity
PPB	Part period balancing

B. System Development

The codes for the solution algorithm for the 6 (six) different lot-sizing algorithms were written in Python programming language. The choice of the language was motivated by the fact that it is an object-oriented language. Although, its execution speed may not be compared with compiled language such as C and C++, the use of python in this research was as a result of its readability, uniformity, good choice for graphic user interface (GUI) programming and its ability in implementing standalone programs [11].

The graphic user interface is the communication mechanism between the user and different functions of the LST-MOD. For the LST-MOD, the start-up interface is the first page the user interacts with; thereafter, the user can select a model to determine order quantities without violating the conditions associated with its usage. The interface has six (6) different types of lot sizing models available for selection; namely, lot-for-lot (LFL), periodic order quantity (POQ), silver-meal heuristics (SMH), multiple order quantity (MOQ), part-period balancing (PPB) and fixed order quantity (FOQ). The help button guides the user in the usage of the interface. For the full details of the codes written in Python, refer to Ladokun in [10]. The flow chart of the Lot sizing module is presented in Fig 1.

C. *System Testing and Results*

The LST-MOD interfaces are presented in Fig. 2 and 3 respectively.

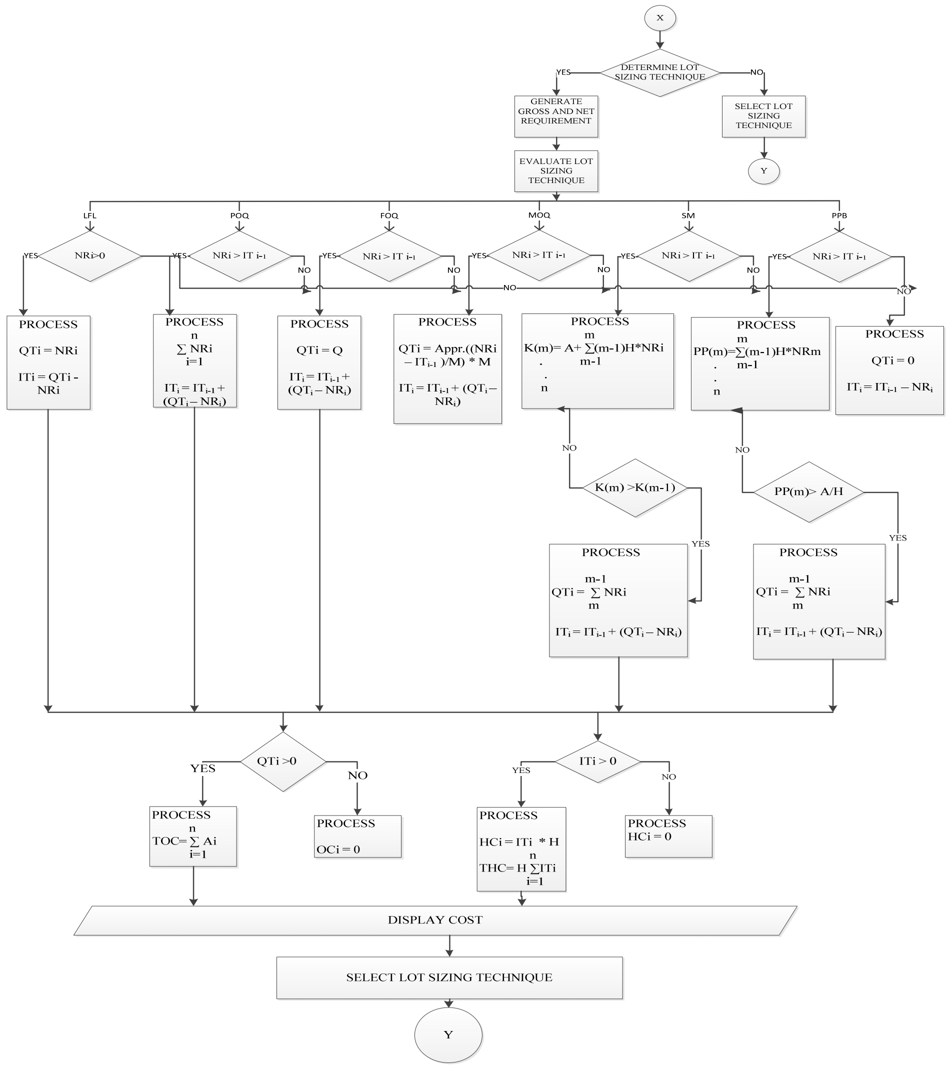

Fig. I. Flowchart of Standalone Lot-sizing Module (LST-MOD)

Fig. 2. LST-MOD Start Interface

Fig. 3. LST-MOD Lot Sizing Selection Interface

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TABLE I
COST IMPLICATION OF EACH LOT-SIZING MODEL (LSM)

LSM	Cost of Order in Naira (₦)				
	Table	Table Legs	Table Platform	Leg Cushion	Drawer
LFL	12000	3000	4200	600	2940
PPB	12000	2880	4200	576	1928
POQ	41700	3348	5670	669.6	2277
FOQ	52,200	4798	10470	601.6	3012
MOQ	12,200	3008	4220	1167.6	2942
SMH	12,000	2980	4200	596	1928

D. LST-MOD Application

To ascertain the integrity of the module, its accuracy was tested using an end item (table assembly). The six (6) lot sizing techniques were used to evaluate the inventory costs for the end item and its sub-items, which are table legs, platform, drawer and the leg cushion.

The cost implications of using any of the six LSM were varied and the method with the least cost was selected to generate order-requirements. Summary of the results are presented in Table I. In Table I, PPB proved to be more effective than SMH and LFL in evaluating total inventory cost for table legs and leg cushion. SMH was observed to be equally efficient as PPB when the total inventory cost was evaluated for the drawer. However, due to factors such as no of periods and a fixed quantity of orders, the total inventory cost for the end item using POQ, FOQ and MOQ were high. Obviously, the excess inventory that spanned from one period to another using these LSM resulted in high inventory cost, most especially for sub-items with high holding costs. These results corroborated Vollman, Beery and Whybark conclusions in [20] on the use of different lot-sizing models for different levels of the bill of materials (BOM).

IV. CONCLUSION

In this research, the decision on which ordering policy to adopt was achieved through the development of a standalone module (decision support tool) to assist inventory managers. With this module, an organisation can decide on the most suitable ordering policy and make it available as input into an existing MRP system. Further research efforts will be on the development of MRP (Material Requirement Planning) framework with opportunity to vary different LSM in order to properly domesticate enterprise resource planning software for local Nigerian SMEs.

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