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Optimization of Inventory Control for Supply Chain Management using Novel Techniques of Regression: a Case Study

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Abstract: This research paper presents the optimization of inventory control for supply chain management (SCM) by using techniques of regression. Parameters like blooms quantity (mt), ordering cost per order (O_C), carrying cost (C_C), and purchase order per unit are considered for the analysis. Common used technique for calculation of inventory control parameters is the economic order quantity (EOQ) and the same parameters have been predicted by the different techniques of regression. Comparison is made between standard EOQ model, and values predicted by different regression techniques. Analysis reveals that the regression has shown strong correlation with the standard values for predicting the inventory control parameters and the accuracy varies between 96.65% to 99.85%.

Keywords: Inventory Control, Supply Chain Management, Regression Analysis, Economic Order Quantity Model.

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I. INTRODUCTION

SCM practices as a set of actions undertaken in a group to support effective management system which includes supply and material management issues, information technology, operations, customer service and information sharing [1,2]. Components such as inventory management, technology, cost, competitiveness and external regulations need to be managed efficiently to attain the business goals of each members of SCM that leads to value formation to end customers. Organizations are parts of supply chains that link the process of acquiring raw materials, manufacturing, assemblage and delivery to end customer [3]. Success of company depend on its internal performance its collaborating partners. Competency of producing business associations with suppliers, customers and other strategic partners is based on trust and longtime assurance that becomes a vital competitive parameter [4]. Enhancement of vertical incorporation requires increased coordination of wealth and activities, which in turn results in greater complication in management and control. Increasingly, supply chain management is being expected as the management of key business processes across the system of organizations that practices supply chain. On the other hand many organizations have recognizable benefits of SCM. Most of the organizations are unclear about the processes and sub-processes to be utilized for better SCM and activities to be controlled to interrelate with the traditional methods [5]. To maintain competitive advantage over the rivals the organizations pay continuously attention in responding to the customer demand and focuses on material, information and cash flows from vendors to customers or vice-versa [6,7]. Hence, SCM is considered as the most popular operations strategic tool for improving organizational competitiveness in the 21stcentury [8]. SCM is an integral process in which manufacturer strategically collaborates with its supply chain partners and collaboratively manages intra and inters organizational activities to achieve effective and efficient flow of products, money and information to maximize the value addition to customer [9]. In SCM all parties which are directly or indirectly involves in fulfilling the customer's demand and hence the key issue of SCM is customer focus and satisfaction [10]. From the customer's point of view the quality of product, value for money & post sales facilities are key features and hence the success or failure of SCM is ultimately determined in the marketplace by the end user i.e. consumer [11]. Demanding competition in today's markets, introduction of products with short life cycles, and the discriminating expectations of customers have forced organizations to invest and focus attention on SCM as system which is affected by the globally competitive environment making SCM an inevitable challenge to most of the organization [12, 13].

In business world, inventory is one of the most expensive assets and good inventory management being crucial aspect to reduce cost of inventory [14]. One of the major objectives of SCM is to maintain balance between inventory investment and customer service as shortage of items in the market leads dissatisfaction of customer [15]. To achieve low-cost strategy good SCM is necessary. Small Medium Enterprises are divided into

three sectors which are agriculture, manufacturing and service. Inventories contribute to second largest asset category for manufacturing companies, next to plant and equipment with a share of 15% to 30% of total cost. Given substantial investment in inventories, the importance of inventory management cannot be overemphasized [16, 17].

Inventory management and SCM are the inevitable part of any business operations and application of different software for inventory management has made significant changes with the expansion of technology and availability of process [18]. The performance of a SCM can be enhanced by judging its ability to remain market-sensitive without losing the integration of chain. Other challenges in designing and analyzing a supply chain is its processes which governed by its strategic attributes. [19,20]. Along with the emergence of business era that embraces change as one of the major characteristics, manufacturing success and survival are becoming more and more difficult to ensure thus there is need of addressing the market proactively [21, 22]. EOQ is well-known technique used by engineers and managers in engineering economics, industrial engineering, operational and financial courses. EOQ formulas have practical and exact applications in defining concepts of cost tradeoffs and inventory control [23, 24, and 25].

EOQ model is considered as the exchange between ordering cost and storage cost for selecting the quantity to be used for restoring item inventories. This model can also be defined as the Cost Minimizing Order quantity [26]. EOQ helps in identifying optimal quantity of orders that minimizes total variable costs which is required to order and hold inventory. This is well known EOQ model as it recognizes the most profitable size of order to be place [27]. This model is one of the oldest classical production scheduling models which is used in the current study. The present study is intended to determine the industry practice in inventory management and to evaluate management performance in this regard. In order to evaluate the performance of the inventory management referring the annual reports of the organization the required data has been collected. This research attempts to fill the gap between manual calculations of inventory control by software analysis using techniques of regression.

II. RESEARCH METHODOLOGY

The data was provided by Indo Auto Tech Limited, Faridabad to calculate EOQ for single product. EOQ model has been used to minimize inventory and find the optimal order quantity with an objective of minimizing total cost associated with single product. Additional data was collected for research method to calculate the EOQ, ordering cost (C_O), number of orders (N), total annual cost (T_C), carrying cost (C_C), order size (S) and average inventory (I_A) per year for single product. Provided data was utilized to calculate the above parameters to selected the optimum combination among them in terms of cost reduction. Average Inventory per year was calculated in order to compare the estimated cost from current method applied by the company and the research method. Common decisions faced by operations managers is "how much to order" or "how many times to order" to satisfy external or internal requirements for item. Mostly, this decision is made with little knowledge related to cost. Figure 1 shows the flow chart of methodology applied for obtaining optimum solution

Following assumptions have been used in adopted model:

- Demand is constant and continuous over the time.
- The lead-time is constant.
- There is no limit on order size to stores capacity.
- The cost of placing an order is independent of size of order.
- The cost of holding a unit of stock does not depend on the quantity in stock.

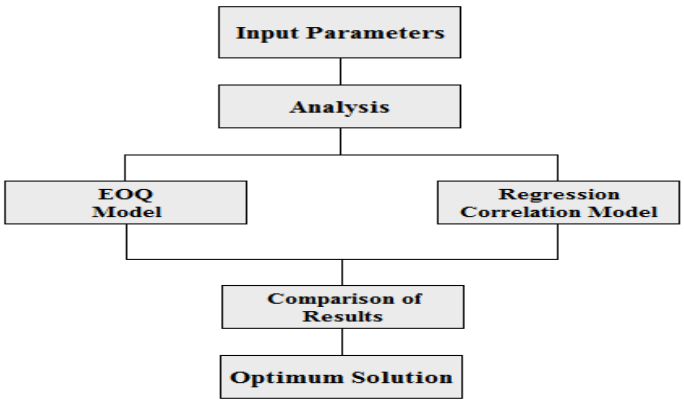


Figure1. Research Methodology

This model is the easiest way for calculating Inventory. EOQ may be calculated as:

$$EOQ = \sqrt{2AO_C/C_O} \quad (1)$$
$$C_O = O_C * N \quad (2)$$
$$N = A/EOQ \quad (3)$$
$$T_C = C_C + C_O \quad (4)$$
$$C_C = S * I_A \quad (5)$$
$$S = A/N \quad (6)$$
$$I_A = S/2 \quad (7)$$

Equations (1) to (7) have been implemented for calculating the EOQ, C_C,C_O,T_C, I_AN, and S respectively.

Table 1: Actual values received as input parameters from Indo AutoTech Limited, Faridabad

Items	Units	2017	2016	2015	2014	2013
Billets/Blooms Qty	mt	134538	106066	123596	28889	26987
Ordering Cost per Order	INR	2600	2400	2200	2000	1800
Carrying Cost	%	10	10	10	10	10
Purchase price per unit	INR	460	440	420	400	380

Table 2: Actual values received from Indo Auto Tech Limited, Faridabad as output parameters for inventory control

Items	Units	2017	2016	2015	2014	2013
EOQ	INR	3850	3600	3805.4	1885	1615
Ordering Cost (C_O)	INR	79000	77500	78000	35580	32850
Average Inventory (I_A)	INR	2000	1800	1800	1200	1150
Total Annual Cost (T_C)	INR	834765	5737635	7344567	1600000	1460000
Carrying Cost (C_C)	INR	8647239	6348443	7552467	1666000	1530000
Items						
Number of Order (N)	No	40	34	39	20	18
Order Size (S)	No	3800	3400	3700	1850	1775

III. RESULTS AND DISCUSSION

Statistics plays an important role in business, because it provides the quantitative basis for arriving at decisions in all matters. Moreover, without education of statistics, business management is incomplete. According to Danish physicist and Nobel laureate, Niels Bohr, nothing exists until it is experimental. This is very much relevant in the present times for creation of knowledge, just as steel is the raw material for manufacturing automobiles. The use of computers in teaching statistics can make an impact in two ways. First, it can affect the amount and rate of learning of statistics. Second, it can affect one's attitude towards computers such as SPSS, SYSTAT, SAS, MINITAB, etc. The regression analysis is the statistical technique that identifies the relationship between two or more quantitative variables: a dependent variable, whose value is to be predicted, and an independent or explanatory variable (or variables), which is known. The goal of regression analysis is to determine the values of parameters for a function that cause the function to best fit a set of data observations that you provide. A simple regression analysis can show that the relation an independent variable X and a dependent variable Y is linear, using the simple linear regression equation: $Y = a + b X$ (Where a and b are constants).Multiple regressions will provide an equation that predicts one variable from two or more independent variables: $Y = a + bX_1 + cX_2 + dX_3$ (Where a, b and c are constants).

By utilizing the available information such as billets/blooms quantity (mt), ordering cost per order (INR), carrying cost (INR), and purchase price per unit (INR) of different years. The different inventory control systems parameters are calculated through empirical correlations and the regression analysis. The different empirical correlations are given in equation 1 to 7 and the different regression equations are given from 8 to 14.

Following correlations are given by regression analysis:

EOQ (Rs.) = 963.156 + 0.0202768 Billets/Blooms Qty (mt) + 0.129256 Ordering Cost per Order (INR) (8)

Ordering Cost (INR) = 16846.5 + 0.4375 Billets/Blooms Qty (mt) + 3.17403 Ordering Cost per Order (INR) (9)

Number of Order (No.) = 15.8428 + 0.000208187 Billets/Blooms Qty (mt) - 0.00142441 Ordering Cost per Order (INRv) (10)

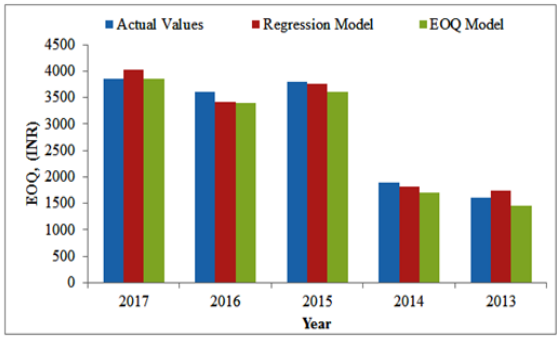
Total Annual Cost (Rs.) = -302368 + 61.1311 Billets/Blooms Qty (mt) + 29.9195 Ordering Cost per Order (INR) (11)

Carrying Cost (Rs.) = -1.15019e+006 + 61.0951 Billets/Blooms Qty (mt) + 530.046 Ordering Cost per Order (INR) (12)

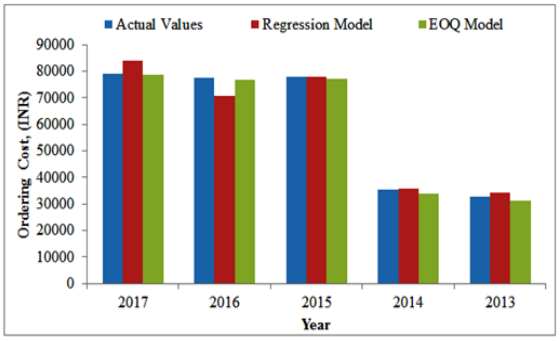
Order Size (No.) = 1439.01 + 0.0197649 Billets/Blooms Qty (mt) - 0.0884378 Ordering Cost per Order (INR) (13)

Average Inventory (Rs.) = 374.105 + 0.00553327 Billets/Blooms Qty (mt) + 0.341371 Ordering Cost per Order (INR) (14)

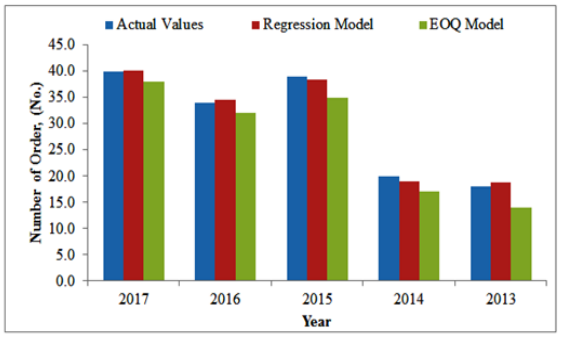
Parameters like billets/blooms quantity (mt) and ordering cost per order (INR) shows significant affect on inventory control compared to carrying cost (INR), and purchase price per unit (INR). The Figure 2(a-h) shows the information of financial years versus inventory control parameters for actual, EOQ model and regression correlation analysis. In comparison it has been seen that the values predicted by regression analysis are same as that of actual values and the values predicted by EOQ model are varying from actual values. Figure 3 shows the deviation in percentage for different parameters from actual values and values obtained from regression and empirical correlation. The deviation in percentage between actual values and values predicted by EOQ model is the range of 8.370 % to31.5 %. And deviation in percentage between actual values and values predicted by regression correlation is in the range of 8.550 % and 8.989% respectively.



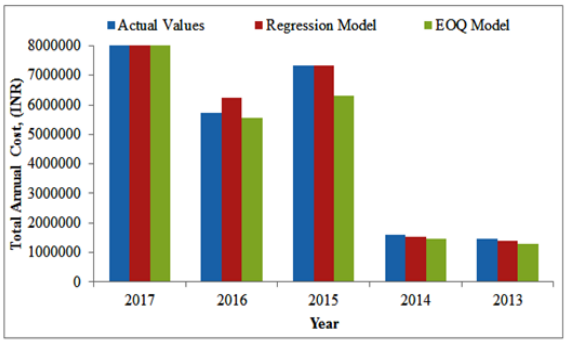
(a) EOQ versus Financial year



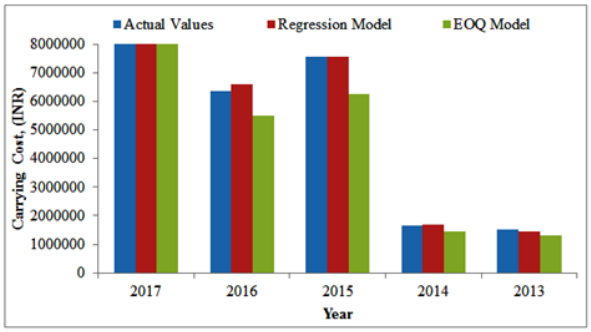
(b) Ordering Cost versus Financial year



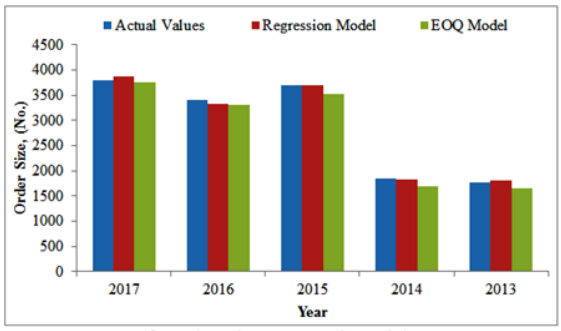
(c) Number of Orders versus Financial year



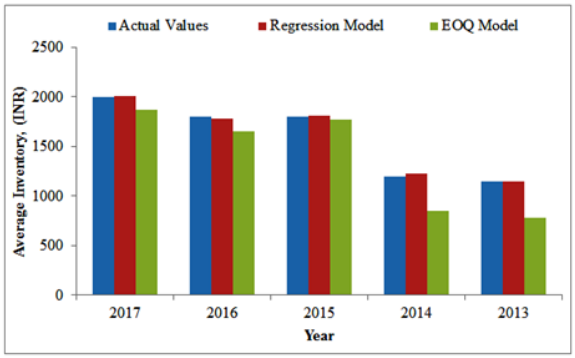
(d) Total Annual Cost versus Financial year



(e) Carrying Cost versus Financial year



(f) Order Size versus Financial year



(g) Average Inventory versus Financial year

Figure 2 (a-g): Financial year versus various inventory control parameters

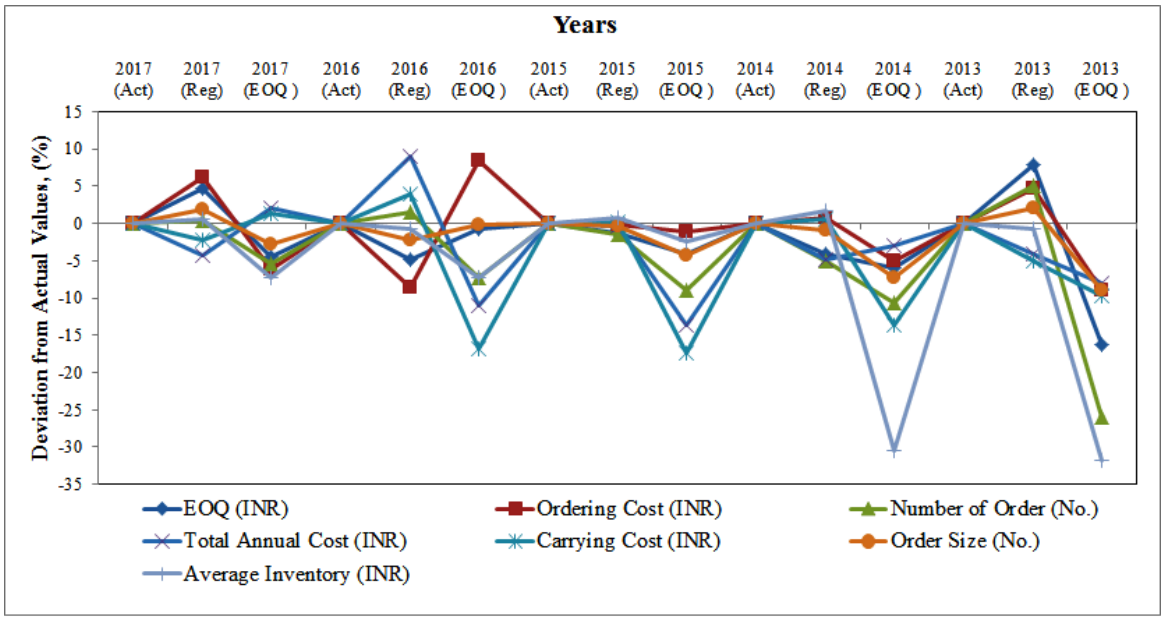


Figure3. Deviation in percentage between Actual, EOQ and Regression Correlation

IV. CONCLUSIONS

Inventory control problems are either too big or too small but inefficient inventory control system leads to failure of business. If an organization experiences stock-out of a critical inventory item, production halts could result or if too much stock remains present the inventory cost increases. Various techniques are available for calculating inventory but it is recommended to use statistical technique for prediction of different parameters that affects the SCM. Finally the study revealed that the regression has shown strong correlation with the actual values and for predicting the inventory control parameters, the accuracy of regression correlations varies from 96.65% to 99.85%. It can be concluded that values of inventory control parameters predicted by regression correlation has shown best results compared to actual values and EOQ model.

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Abbreviations	**Full forms**
Act	Actual Values
Reg	Regression Values
Res	Research Values
%	Percentage
A	Total units required
Q_t	In-transit Inventory
Q_b	Surplus inventory
T_c	Total Annual Cost
C_c	Carrying Cost
C_o	Ordering Cost
O_c	Cost per Order
S	Order Size
N	Number of Orders for the year
sI_A	Average Inventory
mt	Metric Ton
INR	Indian Rupees

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