# Analysis Of Economic Order Quantity (EOQ) & Lean Manufacturing Using Regression Method

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**Abstract:-**
To determine the Economic Order Quantity (EOQ) of the two goods, ordering cost, average inventory, carrying cost, and total annual cost, regression analysis is utilized to establish correlations. The report claims that a comparative analysis demonstrated how using the EOQ/Regression model significantly decreased the two items' combined costs. When comparing the two products' costs using the company's present procedures to the regression model that was suggested, the former was more expensive. The savings varied by year, from roughly 2% to 10%.

**Keywords:-**EOQ, Regression method, JIT, Annual cost, etc.

**INTRODUCTION:-**
The inventory control system's independent (input) parameters, such as raw material quantity, per order ordering cost, purchase price per unit, material cost, and carrying cost, are correlated statistically to determine economic order quantity (EOQ), ordering cost, average inventory, carrying cost, and total annual cost. The EOQ approach was first implemented using independent factors to determine EOQ and other dependent (output) characteristics. The same was approximated in a later stage by building a regression model. Comparison plots are made between the parameters of the Regression model and the EOQ model. The regression model displays any R2 values against the equation number and for several components deemed to be dependent (output) parameters.
Ford develops the EOQ model. This model was extensively applied by R. H. Wilson, W. Harris in 1913, and K. Andeler who provided in-depth analysis. This model's goal is to reduce the overall cost of inventory, which takes into account factors like average inventory, order size, carrying costs, number of orders, order quantity, and ordering costs [31–34]. When defining the EOQ model, the following factors are taken into account: the demand for the goods is known with certainty; the demand will not change over the study period; material shortages are not permitted; the lead time for the purchase will not change; the order quantity ordered once will be delivered in a single delivery, etc.
Based on the collected data, an EOQ model has been applied to maximize total cost of ownership for a single product while optimizing inventory and determining the ideal order quantity. Further information was gathered in order to develop a research methodology that computed the following variables for a single product: average inventory per year, total annual cost, carrying cost, number of orders, order size, and economic order quantity. The number of orders placed annually, the average inventory per year, the carrying cost, the ordering cost, the economic order quantity, the total annual cost, the order size 20, and the ordering cost were among the additional data gathered. Using this information, the following metrics were calculated: Economic Order Quantity, Ordering Cost, Number of Orders, Total Annual Cost, Carrying Cost, Order Size, and Average Inventory per year in order to compare the Cost estimates.

**Literature review: -**
Marcc J. et al., (2000) developed a production economics comparison model that incorporates just-in-time (JIT) and quantity discount for inventory expenses under EOQ. He has concluded that combining EOQ and JIT can help when making decisions about inventory ordering and purchase.
Yasuohiro Monden, (2002) claimed that it is more advantageous to use a Just-In-Time (JIT) production system in conjunction with a micro profit center than a stand-alone one, and that this is how most Japanese manufacturing companies operate. Employees are fundamentally made profit conscious and driven by the micro profit-center structure, even though the JIT technique aims to promote continual improvement.
Jaya Singheal et al. (2002) discussed how SCM is used during the design and development of new products. Methodologies centered on experts and consumers work hand in hand with product development. During the entire product innovation lifecycle, a method is created that simultaneously takes the product, process, and supply chain into account.
Mahmaoud M. Yasin et al., (2003) evaluated the JIT concept's performance across a number of US-based industries and service providers. Additionally, they examined the effectiveness of the various JIT-adopted practices within the organizations. Survey data is collected for 130 manufacturing organizations and 61 service organizations, respectively. Manufacturing and service companies are adjusting by training operators and management to fortify relationships with suppliers prior to implementing the JIT concept within the organization. Such prior training makes it easier to apply JI effectively.

Anshuman Gupta,ramkumar et al. (2003) Investigations were conducted into "how an uncertain demand can be incorporated in multisite supply chains' midterm planning." The study also reveals the planning procedure utilizing a developed model based on a methodical programming-based approach. The model proposed by the study shows how adaptable it is to demand realizations that unfold over a predefined period of time. The model defines the trade-off between production costs and customer satisfaction and models the decisions made during the manufacturing process as "here-and-now" decisions. By critically analyzing assets, the aforementioned model's proposal sought to manage them in a way that preserved inventory levels.

Vonderyembse et al. (2004) provided a blend of developed typology, theoretical developments on SCM, and existing literature. They also made a questionnaire so they could carry out more research. This type of approach helps with supply chain planning so that the product is developed, manufactured, and supplied in a way that meets the needs of the client. The study also reports on the three product categories—standard, innovative, and hybrid—based on their functions and the ways in which supply chains can support them.

Kawetummachai et al. (2005) there have been several reports on the ordering process's effects on the industry's performance. Based on the supply chain, the research study considers the multiple supplier aspect. Additionally, his research demonstrates that supply chain considerations are taken into account when making decisions and that minimizing input costs is the primary objective of a well-functioning supply chain management system. For the study, an algorithm was developed and tested to evaluate the efficacy in terms of the overall purchasing costs and service level of the company.

Eric Sucky (2005) provided a model for negotiating using the production policies of the supplier. The primary focus of the study, as seen from the inventory management perspective, is SCM. Achieving equilibrium between buyers and suppliers is crucial when it comes to production policies and ordering sizes. Should the buyer choose to determine the EOQ on their own, the supplier may not gain any advantages. Thus, a cooperative order and production policy will offer several advantages. Because of this, there is a bargaining model that the buyer and supplier can use to resolve disagreements over EOQ.

Peter Trkman et al., (2008) studied the relationship between analytical capabilities in supply chain management's planning, sourcing, and delivery domains using business process orientation and information support systems as moderators. To develop a mathematical equation, 310 unique samples were selected from China, Brazil, Canada, Europe, and the United States. Understanding the potential applications of business analytics is made easier by the established correlations.

TonyHou et al., (2010) showed that a number of ideas, including JIT and the Kanban System, had been successfully applied. An integrated multiple-objective genetic algorithm (MOGA) based system was proposed in the study to determine the Pareto-Optimal Kanban number and size. The proposed model was applied in a JIT-focused business to further demonstrate its feasibility.

Masaharu Iwase et al., (2011) explored the variations in the manufacturing industries' use of single-item, multi-stage, serial JIT systems with stochastic demand and production capacities. It was reported in the study that the M/G/1-type Markov chain is used to model JIT as a function of discrete time.

Inman et al. (2012) created the manufacturing industry's structural model, which included testing and agile manufacturing. The fundamental elements of Just-In-Time (JIT) procurement and production are included in the model for analytical purposes. Production and operations managers provided information so that equations could be modeled. They demonstrated the exact correlation between agile manufacturing and just-in-time (JIT) procurement.

**Methodology adopted: -**

**Regression method: -**

In the fields of finance, investing, and other statistics, regression is a statistical technique that seeks to ascertain the nature and strength of the relationship between a set of independent variables (referred to as variables other than the dependent variable, or Y) and a single dependent variable.

While it is an effective method for identifying correlations between variables in data, regression analysis is not a good way to show causality. In business, finance, and economics, it is employed in a variety of settings. For example, it assists investment managers in valuing assets and comprehending the connections between variables like commodity prices and the stocks of companies that deal in those commodities.

Simple linear regression:

$$Y = a + bX + u$$

Multiple linear regression:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + \ldots + b_tX_t + u$$

where:

$Y$ = The dependent variable you are trying to predict or explain

$X$ = The explanatory (independent) variable(s) you are using to predict or associate with Y

$a$ = The y-intercept

$b$ = (beta coefficient) is the slope of the explanatory variable(s)

$u$ = The regression residual or error term

**TEST OF REGRESSION MODEL FOR THE 2020-21:-**

| **Items** | **Units** | **2020-21** |
|---|---|---|
| Raw Materials Qty | Kg | 1400602 |
| Ordering Cost per Order | INR | 23583 |
| Purchase price per unit | INR | 49 |
| Material Cost | INR | 68629498 |
| Carrying Cost | % | 4.25 |

- Regression Correlations EOQ =800949 - 0.8764 Raw Materials Qty + 311.4 Ordering Cost per Order - 54353 Purchase price per unit + 0.06456 Material Cost
- Ordering Cost = -115581 + 0.08127 Raw Materials Qty + 1.646 Ordering Cost per Order + 3512 Purchase price per unit - 0.000403 Material Cost
- Average Inventory = 44796 - 0.001300 Raw Materials Qty + 3.655 Ordering Cost per Order - 1418 Purchase price per unit + 0.000481 Material Cost
- Carrying Cost = -4674981 + 3.040 Raw Materials Qty + 19.90 Ordering Cost per Order + 142777 Purchase price per unit - 0.1014 Material Cost
- Total Annual Cost = -4790562 + 3.121 Raw Materials Qty + 21.54 Ordering Cost per Order + 146289 Purchase price per unit - 0.1018 Material Cost

| **Items** | **Units** | **EOQ Model** | **Regression Model** | **Absolute Error** |
|---|---|---|---|---|
| EOQ | INR | 8727243 | 8727109 | 0.00002 |
| Ordering Cost | INR | 188664 | 188663 | 0.00001 |
| Average Inventory | INR | 89054 | 89052 | 0.00002 |
| Carrying Cost | INR | 185453 | 185446 | 0.00008 |
| Total Annual Cost | INR | 374117 | 374108 | 0.00003 |

**Table No2: Table for dependent (output) parameters for comparison of model**

| Items | Units | EOQ Model | Regression Model | % Error |
|---|---|---|---|---|
| EOQ | INR | 100 | 99.99846542 | 0.001534578 |
| Ordering Cost | INR | 100 | 99.99937251 | 0.000627494 |
| Average Inventory | INR | 100 | 99.9978672 | 0.002132801 |
| Carrying Cost | INR | 100 | 99.99249642 | 0.007503582 |
| Total Annual Cost | INR | 100 | 99.99707171 | 0.002928287 |

**Table No 3: Percentage Variations in dependent (output) parameters**

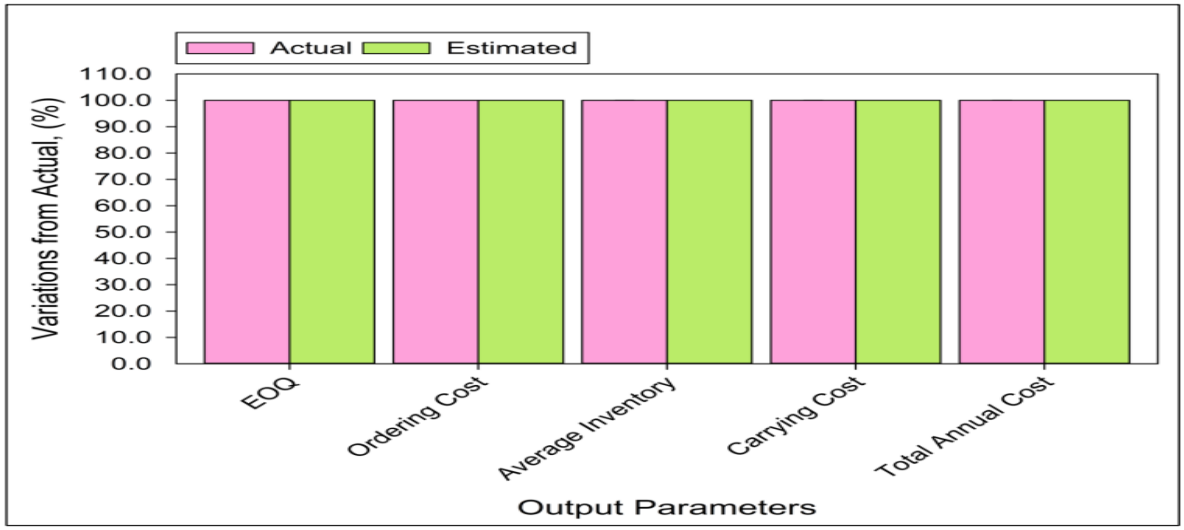


**Figure1: Output Parameters versus % Variations from Actual Values**

**COST SAVING BY ADOPTION OF EOQ/ REGRESSION MODEL:-**

Tables 2 and 3 contrast the expenses of the two products with the regression model proposed in this thesis, using the company Indo Auto Tech Ltd's present methods. The comparison shows that the two products' overall prices might be greatly lowered by utilizing the EOQ/Regression model. The savings varied by year, from roughly 2% to 10%.

| Cost comparison with existing system for Product 1 | | | | | |
|---|---|---|---|---|---|
| Year | **2013-14** | **2014-15** | **2015-16** | **2016-17** | **2017-18** |
| Cost with Existing System | 1167779 | 1172904 | 843123 | 912591 | 1324236 |
| Cost with Regression Model | 1046624 | 1141258 | 776000 | 860400 | 1272879 |
| Yearly Savings in INR | 121155 | 31645 | 67124 | 52192 | 51357 |
| % Saving | 10.375 | 2.698 | 7.961 | 5.719 | 3.878 |

| Cost comparison with existing system for Product 2 | | | | | |
|---|---|---|---|---|---|
| Year | **2013-14** | **2014-15** | **2015-16** | **2016-17** | **2017-18** |
| Cost with Existing System | 933728 | 1460072 | 943004 | 845882 | 1238080 |
| Cost with Regression Model | 880112 | 1433245 | 880488 | 776692 | 1124349 |
| Yearly Savings in INR | 53616 | 26827 | 62516 | 69190 | 113732 |
| % Saving | 5.742 | 1.837 | 6.629 | 8.180 | 9.186 |

**Conclusion:-**

The study also found that a rise in lean procurement practices will lead to higher firm performance rankings when all other independent factors are set to zero. The ultimate conclusion of the study shows a considerable correlation between large-scale manufacturing businesses' performance and lean manufacturing strategies.

Concepts for Further Investigation The primary focus of this study was on the performance of businesses in the large-scale manufacturing sector and lean manufacturing methodologies. The investigator proposes to carry out supplementary investigations on the identical topic, both nationally and globally, but in establishments apart from manufacturing businesses. This can help ascertain whether the same consequences will apply to businesses unrelated to manufacturing as well as to other parts of the country. This will also assist by providing precise facts from which reliable conclusions could be made.

**REFERENCES:-**


1. Abdulmalek, F., Rajgopal, J., and Needy. K., (2006). A Classification scheme for the process industry to guide the implementation of lean. Engineering Management Journal, 18(2). Bhasin, S & Burcher, P., (2006).
2. Lean viewed as a philosophy. Journal of Manufacturing Technology Management 17, 57-72. Billesbach, T. (2006).
3. A study of the implementation of just in time in the United States. Production and Inventory Management Journal 32(3), 1-4. Chandran, M. (2003).
4. Educational Research: Contemporary Issues and Practical Approaches. London: Continuum. Cook, R. & Rogowski, R. (2008).
5. Applying JIT principles to continuous process manufacturing supply chain.
6. Production and Inventory Management Journal, Third Quarter, 12-17. Cua, K. (2011).
7. The impact of total productive maintenance practices on manufacturing performance. Journal of Operations Management. 19(1), pp. 39-58. Czabke, J., Hansen, E. & Doolen, T. (2008).
8. A multisite field study of lean thinking in US and German secondary wood products manufacturers, Forest Products Journal, 58(9), 77-85.
9. Agarwal, S. (2014) Economic Order Quantity Model: A Review. VSRD International Journal of Mechanical, Civil, Automobile and Production Engineering 4, 12, pp. 233–236.
10. AL-Dulaime W.Emar W. (2019). Analysis of Inventory Management by Using Economic Order Quantity Model -A Case Study. International Journal of Scientific & Technology Research Vol. 8(10):3 766-3774.
11. Anantadjaya, S. P., Nawangwulan, I. M., Irhamsyah, M., & Carmelita, P. W. (2021).
12. Supply Chain management, inventory management & financial performance: evidence from manufacturing firms. Linguistics and Culture Review, 5(S1), 781-794.
13. Al-Momani H., Al Meanazel O. T., Kwaldeh E., Alaween A., Khasaleh A., Qamar A., (2020).
14. The efficiency of using a tailored inventory management system in the military aviation industry, Heliyon, Volume 6, Issue 7, 04424.
15. Birbil, S.˙I. Bulbul K., Frenk, J.B.G. Mulder H.M., (2015).
16. On EOQ Cost Models with Arbitrary Purchase and Transportation Costs, Journal of Industrial and Management Optimisation, October 11, No. 4, 1211 – 1245, doi: 10.3934/jimo.2015.11.1211.
17. Cárdenas-Barrón L. E. (2012), A complement to 'A comprehensive note on: AN economic order quantity with imperfect quality and quantity discounts'. Applied Mathematical Modelling 36(12):6338–6340, DOI 10.1016/j.apm.2012.02.021
18. Cárdenas-Barrón L. E., Shaikh A. A., Tiwari S., Treviño-Garza G. (2020). An EOQ inventory model with nonlinear stock dependent holding cost, nonlinear stock dependent demand and trade credit, Computers & Industrial Engineering, Volume 139, 105557.
19. Carter, J.R and B.G. Ferrin (1996). Transportation costs and inventory management: Why transportation costs matter. Production and Inventory Management Journal, Vol. 37, No. 3, 58–62.
20. Chang H-Ch. (2011), A comprehensive note on: An economic order quantity with imperfect quality and quantity discounts,Applied Mathematical Modelling 35(10):5208-5216, DOI 10.1016/j.apm.2011.03.039
21. Dash, R.K., Nguyen, T.N., Cengiz, K. et al. (2021).
22. A Proposed Approach to Extend the Economic Order Quantity(EOQ) Model Using Discrete Event Simulation, IFIP Advances in Information and Communication Technology 384:45-53. Đorđević, L., Antić, S., Čangalović, M. et al. (2017).
23. A metaheuristic approach to solving a multiproduct EOQ-based inventory problem with storage space constraints. OptimLett 11, 1137–1154. doi:10.1007/s11590-016-1009-5
24. Journal Pre-prDellino G., Kleijnen J. P.C., Meloni C. (2010). Robust optimization in simulation: Taguchi and Response Surface Methodology. International Journal of Production Economics, Volume 125, Issue 1, 52-59.