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EVALUATION AND SELECTION OF INVENTORY POLICIES BY MCDM-MATRIX METHOD-A CASE STUDY FOR PASSENGER VEHICLES FOR AUTOMOTIVE INDUSTRY IN INDIA

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ABSTRACT

The inventory employs huge amount of annual revenue of any organization. The evaluation and selection of inventory policies one of the vital activities of business processes. As purchasing is quite critical for the manufacturer, seeking the right policy is absolutely significant for the company. Thus the inventory policy selection process has received considerable attention in the business management literature due to the key role of inventory policy performance on cost, quality and service in achieving the objectives. The selection of one of the best alternative from a set of potential alternatives depends upon the selection criteria. We have proposed a framework for selection of inventory policy using Matrix method based on selection criteria for Passenger vehicle manufacture automotive industry.

KEYWORDS: MCDM-Matrix Method, Selection Criteria, Ranking, Inventory Policies

INTRODUCTION

Industry is the production of economic goods or services. Each country has a common objective of economic development and industry plays a vital role in fulfilling this objective. Economic development is the growth in the production of the goods and services with the time. It is commonly evaluated as the percent rate of change in Gross Domestic Product (GDP). The industrial growth facilitates sustain economic development. The process of Evaluation and Selection of inventory policies is to locate the right policies which deliver the quality products, in the optimum quantity, at the lower cost and required time.

Purchasing is critical activity of any organization. It includes lots of activities: purchase of the raw materials, finished/semi-finished components, selection of inventory policies, price comparison and negotiation, degree of outsourcing, incoming material inspection, vendor development, vendor rating and identification, lot size, etc. The activities associated with it include selecting and evaluation of the right inventory policies, rating inventory policy performance, determining the optimum lead time, review period and reorder point, sourcing goods and services, timing purchases, selling terms of sale, evaluating the value received, predicting price, service and sometimes demand changes, specifying the form in which goods are to be received, etc.

The purpose of inventory policy selection process is primarily lower purchase risk with higher confidence between seller and buyer. The selection process would be quite simple if there is one criterion in the decision making but in real situations, purchasers have to consider a number of criteria. It converts ranking and selection of inventory policies a MCDM problem in which the firms need to identify the top priorities of selecting the best inventory policy based on type of industry and its own capabilities. In any automotive industry cost and Quality are conflicting criteria. In purchasing of a vehicle price, comfort, safety features and fuel economy are the criteria under consideration. It is not possible that the car having lower price may deliver high comfortable and safety [1].

In such cases, it becomes necessary to determine how each of the criteria influences the decision making process whether all are to be equally weigh or whether the influence varies according to the type of criteria [2]. Researchers have presented numerous MCDM techniques. The MCDM-Matrix technique is found to be appropriate to identify the best potential inventory policy for an automotive industry.

LITERATURE REVIEW

An automotive organization includes designing, developing, manufacturing, marketing and selling activities of the motor vehicles. With the time, the automotive industry becomes the cynosure of the economic growth [3]. Globalization has significantly altered the automotive-manufacturing scenario in India. The vendor selection and reorder level influence purchase strategic [4]. Kraljic (1983) recommended a procedure to employ supply chain management. Carlson’s (1990) empirical research employed case studies to focus on purchasing support of corporate strategy and long term strategic plans. Ellram and Carr (1994) described the role of the purchase activities in any organization strategy. In any manufacturing or distribution organization, the proper management of inventory is critical given that on average materials contribute to more than half a product’s cost. Proper inventory policy cannot only reduce the cost, but also reduce stock-outs and improve customer satisfaction. Thus, proper inventory methods/systems can improve the profitability and help in the survival of an organization [8].

Besides, long-run production associated with a high level of inventory conceals production problems (e.g., quality), which can damage a company's long term performance. Therefore, the primary goal of inventory management has been to maximize a company's profitability by minimizing the cost tied up with inventory and at the same time meeting the customer service requirements [9]. Most inventory management models are based upon rather restrictive assumptions, e.g. unit sized demands and the normal distribution for total demand during replenishment time. In a majority of inventory management systems, circumstances seem to allow these simplifications, and inventory policies based upon these assumptions yield satisfying results. However, in some particular cases, these simplifications differ fundamentally from the actual conditions and particle. Therefore, application of the models mentioned above can result in an overinvestment in inventory or in an unacceptable low service level [10].

Ranking of the inventory policies depends upon selection criteria. Therefore this problem becomes a Multi Criteria Decision Making (MCDM) problem in which the firms need to identify the top priorities of selecting the best inventory policy based on type of industry and its own capabilities. The researchers have presented widespread MCDM methods to provide a viable and effective solution to various real selection problems [11, 12, 13, 14, 15, 16, 17, 18, 19, 20 and 21].

MULTI CRITERIA DECISION MAKING-MATRIX METHOD (MCDM-MATRIX METHOD)

Inventory Policy Selection Criteria

Some criteria are associated with every inventory policy. Some criteria identified by Gupta et al. (2013) are:

- **Unit Cost**

  It is the price of raw material/semi finished or finished items purchased. This criterion is evaluated with reference to importance of the price dimensions in the purchaser inventory policy selection, total annual cost of raw material/semi finished or finished items purchased, discount on bulk purchase etc.

- **Holding Cost**

  It is cost required to hold all type of items e.g. setup cost, storages staff wages, insurance; rent, deprecation of all the stored items, maintenance or material handling and interest charges. This factor is evaluated with reference to its effect on annual inventory cost.

- **Shortage Cost**

  It is the sale lost due to non availability of product.

- **Procurement Cost**

  It is the cost of placing an order to seller.

- **Demand**

  It is the buyer wiliness to buy a product.

- **Review Period**

  It is the average time gap between two successive orders.

- **Lead Time**

  It is the average time gap between purchaser places an order and till it is received. Lead time factor is evaluated with reference to its effects on the delivery of required items and selection of the policy.

- **Reorder Period**

  It is the lowest inventory level at which order need to be placed to refill the stocks up to desired optimum level.

Inventory Policies

Several researchers have presented many inventory policies. Gandhi, 2003 has compared for inventory policies economic order quantity, monthly policy, just in time and vendor managed inventory under known lead time and variable demand. In this paper, we have considered these four inventory policies.

Matrix Method

This technique facilitates the selection of an appropriate inventory policy from numerous potential inventory policies on the basis of identified selection criteria. It considers all the selection criteria to evaluate the inventory policy using a reference suitability index. The inventory policy with the highest suitability index is ranked as #1, which with the second-highest suitability index as rank #2, and so on. This method is applied in two phases, namely criteria matrix and permanent function representation.

The aggregated assessment i.e. ratings of the inventory policies and the relative aggregated weights of all identified inventory policies selection criteria are stored in a ‘n x n’ matrix known as ‘Criteria Matrix’ where ‘n’ is the inventory policy selection criteria. The diagonal elements (aii’s or ai’s) of this matrix represent the aggregated ratings of different inventory policies while the off-diagonal elements (aij’s) give the relative importance weights of different selection criteria. The criteria matrix is an array of ‘Rating Matrix’ and ‘Criteria Relative Weight Matrix’.

Inventory Policies Rating Matrix

The diagonal element of this matrix represents the aggregated ratings of the inventory policies for different selection criteria.

$$\begin{bmatrix} a_{11} & 0 & 0 & \cdots & 0 \\ 0 & a_{22} & 0 & \cdots & 0 \\ \vdots & & & & \\ 0 & 0 & 0 & \cdots & a_{nn} \end{bmatrix} \qquad (1)$$

Criteria Relative Weight Matrix

The Criteria Relative Weight Matrix is formed on the basis of the aggregated weights of different criteria. The off diagonal elements of this matrix represent the aggregated weights of the criteria e.g. the element (a_{ij}) of this matrix will give the relative importance weight of jth criteria in respect of ith criteria. All diagonal elements of this matrix are zero because there is no significance of comparing a criterion with itself.

Mathematically, a_{ij} = weight of j^{th} criteria/ weight of i^{th}

The off diagonal elements of Criteria Relative Weight matrix are correspond to the aggregated weights of the selection criteria (a_{ij} = weight of j^{th} criteria/ weight of i^{th} criteria)

$$\begin{bmatrix} 0 & a_{12} & a_{13} & \cdots & a_{1n} \\ a_{21} & 0 & a_{23} & \cdots & a_{2n} \\ \vdots & & & & \\ a_{n1} & a_{n2} & a_{n3} & \cdots & 0 \end{bmatrix} \qquad (2)$$

The Criteria Matrix is:

$$\begin{bmatrix} a_{11} & a_{12} & a_{13} & \cdots & a_{1n} \\ a_{21} & a_{22} & a_{23} & \cdots & a_{2n} \\ \vdots & & & & \\ a_{n1} & a_{n2} & a_{n3} & \cdots & a_{nn} \end{bmatrix} \qquad (3)$$

Variable Permanent Function

Variable Permanent Function is employed for multi-criteria based evaluation and ranking of the systems [23]. The Permanent is calculated as the determinant of a matrix but there is no negative term.

DATA COLLECTION

Data requisite for the research work categories as primary and secondary. The primary data collected as much useful information as possible by conducting a series of structured and unstructured interviews, meaning that some interviews followed a formal question and answer process, whereas other interviews took the form of a more informal conversation. The interviews were conducted within the purchasing and other related departments which were involved in the inventory policy selection process, and with those who were familiar with the selection procedure. Telephone interviews were also conducted with those who were far away.

Secondary data have been collected by others earlier, or data which is not being collected for the first time and has been used by someone else for a different purpose. This data are generated by primary data gathering techniques e.g. any demographic and economic data generated by any government agency for whatever purpose they need, may be employed as secondary data for someone else [23]. The secondary data were collected from literature and scientific articles. The search engines were used to find scholarly articles and reliable information. The words as inventory /replenishment/ordering/procurement policy selection and evaluation, supply chain management, strategic purchasing, inventory/replenishment/ordering policy selection methods, etc. were used to find relevant information and articles.

Determination of Weights

A seven point scale is used to determine the priority weights of each inventory policy selection criteria and sub criteria. The respondents are from different companies who are involved directly or indirectly in inventory policy selection process in automotive industries in India, were selected as the questionnaire population. The personnel functions within the company are belongs to engineering, purchasing, production planning and control, production, quality, vendor management operation management and such others. The data is collected from 73 Experts from 15 automotive industries involved in the manufacturing of passenger vehicle. The aggregated weigh of each criteria are shown in the Table 1.

Table 1: Aggregated Weights of Selection Criteria

S. No.	Criterion	Aggregate Weight
1	Unit Cost	0.18186
2	Holding Cost	0.14338
3	Shortage cost	0.07997
4	Procurement Cost	0.12463
5	Demand	0.14591
6	Review Period	0.10969
7	Lead Time	0.12480
8	Reorder Level	0.08976

INVENTORY POLICY SELECTION USING MATRIX METHOD

The policy rating matrices are formed for each policy based on criteria are:

$$\text{Rating Matrix}\left[IP_1\right]=\begin{bmatrix} 0.49065 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0.66077 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0.23323 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0.43820 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0.51643 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0.45624 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0.52158 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.59549 \end{bmatrix}$$

$$\text{Rating Matrix}\left[IP_2\right]=\begin{bmatrix} 0.68336 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0.42457 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0.48405 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0.72462 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0.60476 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0.60930 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0.62360 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.64040 \end{bmatrix}$$

$$\text{Rating Matrix}\left[IP_3\right]=\begin{bmatrix} 0.76243 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0.27142 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0.61836 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0.42206 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0.69809 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0.76921 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0.58081 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.53303 \end{bmatrix}$$

$$\textit{Rating Matrix}\left[IP_4\right]=\begin{bmatrix} 0.35162 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0.63582 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0.14632 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0.44755 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0.22731 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0.56105 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0.34332 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.75474 \end{bmatrix}$$

Based on the priority weights, the relative weight of each criterion with respect to another criterion is determined. The criterion relative weight matrix obtained using relative weights of the criterion is written as:

$$\begin{bmatrix} \textit{Criteria Relative} \\ \textit{Weight Matrix} \end{bmatrix}=\begin{bmatrix} 0 & 0.78841 & 0.43973 & 0.68531 & 0.80232 & 0.60321 & 0.68619 & 0.49362 \\ 1.26838 & 0 & 0.55775 & 0.86923 & 1.01765 & 0.76510 & 0.87034 & 0.62610 \\ 2.27410 & 1.79292 & 0 & 1.55846 & 1.82456 & 1.37176 & 1.56046 & 1.12255 \\ 1.45920 & 1.15045 & 0.64166 & 0 & 1.17075 & 0.88021 & 1.00128 & 0.72029 \\ 1.24638 & 0.98266 & 0.54808 & 0.85416 & 0 & 0.75183 & 0.85525 & 0.61524 \\ 1.65779 & 1.30702 & 0.72899 & 1.13610 & 1.33008 & 0 & 1.13756 & 0.81832 \\ 1.45733 & 1.14897 & 0.64084 & 0.99872 & 1.16924 & 0.87908 & 0 & 0.71937 \\ 2.02584 & 1.59719 & 0.89083 & 1.38833 & 1.62538 & 1.22201 & 1.39011 & 0 \end{bmatrix}$$

The criteria matrices are constructed for each policy by combining the inventory policy rating matrix and criterion relative weight matrix. The criteria matrices, so constructed, for each policy are written as:

$$\textit{Criteria Matrix}\left[IP_1\right]=\begin{bmatrix} 0.49065 & 0.78841 & 0.43973 & 0.68531 & 0.80232 & 0.60321 & 0.68619 & 0.49362 \\ 1.26838 & 0.66077 & 0.55775 & 0.86923 & 1.01765 & 0.76510 & 0.87034 & 0.62610 \\ 2.27410 & 1.79292 & 0.23323 & 1.55846 & 1.82456 & 1.37176 & 1.56046 & 1.12255 \\ 1.45920 & 1.15045 & 0.64166 & 0.43820 & 1.17075 & 0.88021 & 1.00128 & 0.72029 \\ 1.24638 & 0.98266 & 0.54808 & 0.85416 & 0.51643 & 0.75183 & 0.85525 & 0.61524 \\ 1.65779 & 1.30702 & 0.72899 & 1.13610 & 1.33008 & 0.45624 & 1.13756 & 0.81832 \\ 1.45733 & 1.14897 & 0.64084 & 0.99872 & 1.16924 & 0.87908 & 0.52158 & 0.71937 \\ 2.02584 & 1.59719 & 0.89083 & 1.38833 & 1.62538 & 1.22201 & 1.39011 & 0.59549 \end{bmatrix}$$

$$Criteria\,Matrix[IP_2]=\begin{bmatrix} 0.68336 & 0.78841 & 0.43973 & 0.68531 & 0.80232 & 0.60321 & 0.68619 & 0.49362 \\ 1.26838 & 0.42457 & 0.55775 & 0.86923 & 1.01765 & 0.76510 & 0.87034 & 0.62610 \\ 2.27410 & 1.79292 & 0.48405 & 1.55846 & 1.82456 & 1.37176 & 1.56046 & 1.12255 \\ 1.45920 & 1.15045 & 0.64166 & 0.72462 & 1.17075 & 0.88021 & 1.00128 & 0.72029 \\ 1.24638 & 0.98266 & 0.54808 & 0.85416 & 0.60476 & 0.75183 & 0.85525 & 0.61524 \\ 1.65779 & 1.30702 & 0.72899 & 1.13610 & 1.33008 & 0.60930 & 1.13756 & 0.81832 \\ 1.45733 & 1.14897 & 0.64084 & 0.99872 & 1.16924 & 0.87908 & 0.62360 & 0.71937 \\ 2.02584 & 1.59719 & 0.89083 & 1.38833 & 1.62538 & 1.22201 & 1.39011 & 0.64040 \end{bmatrix}$$

$$Criteria\,Matrix[IP_3]=\begin{bmatrix} 0.76243 & 0.78841 & 0.43973 & 0.68531 & 0.80232 & 0.60321 & 0.68619 & 0.49362 \\ 1.26838 & 0.27142 & 0.55775 & 0.86923 & 1.01765 & 0.76510 & 0.87034 & 0.62610 \\ 2.27410 & 1.79292 & 0.61836 & 1.55846 & 1.82456 & 1.37176 & 1.56046 & 1.12255 \\ 1.45920 & 1.15045 & 0.64166 & 0.42206 & 1.17075 & 0.88021 & 1.00128 & 0.72029 \\ 1.24638 & 0.98266 & 0.54808 & 0.85416 & 0.69809 & 0.75183 & 0.85525 & 0.61524 \\ 1.65779 & 1.30702 & 0.72899 & 1.13610 & 1.33008 & 0.76921 & 1.13756 & 0.81832 \\ 1.45733 & 1.14897 & 0.64084 & 0.99872 & 1.16924 & 0.87908 & 0.58081 & 0.71937 \\ 2.02584 & 1.59719 & 0.89083 & 1.38833 & 1.62538 & 1.22201 & 1.39011 & 0.53303 \end{bmatrix}$$

$$Criteria\,Matrix[IP_4]=\begin{bmatrix} 0.35162 & 0.78841 & 0.43973 & 0.68531 & 0.80232 & 0.60321 & 0.68619 & 0.49362 \\ 1.26838 & 0.63582 & 0.55775 & 0.86923 & 1.01765 & 0.76510 & 0.87034 & 0.62610 \\ 2.27410 & 1.79292 & 0.14632 & 1.55846 & 1.82456 & 1.37176 & 1.56046 & 1.12255 \\ 1.45920 & 1.15045 & 0.64166 & 0.44755 & 1.17075 & 0.88021 & 1.00128 & 0.72029 \\ 1.24638 & 0.98266 & 0.54808 & 0.85416 & 0.22731 & 0.75183 & 0.85525 & 0.61524 \\ 1.65779 & 1.30702 & 0.72899 & 1.13610 & 1.33008 & 0.56105 & 1.13756 & 0.81832 \\ 1.45733 & 1.14897 & 0.64084 & 0.99872 & 1.16924 & 0.87908 & 0.34332 & 0.71937 \\ 2.02584 & 1.59719 & 0.89083 & 1.38833 & 1.62538 & 1.22201 & 1.39011 & 0.75474 \end{bmatrix}$$

Table 2 represents the “Permanent” and the ranking of each policy based on selection criteria. The policy with highest value of the suitability index is ranked as #1, second highest value as rank #2 and so on and the policy with minimum value of the suitability index is ranked last.

Table 2: Ranking of Inventory Policies Based on Criteria by Matrix Method

Inventory Policy	Permanent	Rank #
Economic Order Quantity (IP_1)	24164.9049	3
Just In Time (IP_2)	26992.6564	1
Vendor Managed Inventory (IP_3)	26493.6633	2
Monthly Policy (IP_4)	22819.7228	4

CONCLUSIONS

No single inventory policy is best for any industry specifically for automotive industry. The preference of any policy depends upon the weights of selection criteria. Thus there is a need to develop a multi criteria approach for the selection of inventory policy. In this paper, we have employed matrix method for inventory policy selection. This approach not only assists the inventory personnel in decision making but also reduces the chance of error as well as eases this tedious job. Unit cost is the most important criterion having aggregate weight 0.18186 followed by demand having aggregate weight 0.14591. The present scenario demands the end product at lower cost with higher customer satisfaction. The ranking of inventory policies based on the weight and rating assigned by experts. The ranking of policies are presented in Table 2.

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