Ranking of Inventory Policies Using Distance Based Approach Method

Gupta Amit, Kumar Ramesh, Tewari P. C.

Abstract—Globalization is putting enormous pressure on the business organizations specially manufacturing one to rethink the supply chain in innovative manners. Inventory consumes major portion of total sale revenue. Effective and efficient inventory management plays a vital role for the successful functioning of any organization. Selection of inventory policy is one of the important purchasing activities. This paper focuses on selection and ranking of alternative inventory policies. A deterministic quantitative model based on Distance Based Approach (DBA) method has been developed for evaluation and ranking of inventory policies. We have employed this concept first time for this type of the selection problem. Four inventory policies economic order quantity (EOQ), just in time (JIT), vendor managed inventory (VMI) and monthly policy are considered. Improper selection could affect a company's competitiveness in terms of the productivity of its facilities and quality of its products. The ranking of inventory policies is a multi-criteria problem. There is a need to first identify the selection criteria and then processes the information with reference to relative importance of attributes for comparison. Criteria values for each inventory policy can be obtained either analytically or by using a simulation technique or they are linguistic subjective judgments defined by fuzzy sets, like, for example, the values of criteria. A methodology is developed and applied to rank the inventory policies.

Keywords—Inventory Policy, Ranking, DBA, Selection criteria.

I. INTRODUCTION

INFORMATION technology has wide application in the entire area of routine life such as in operation of cars, phones, medical diagnostics equipments, military weapons, television sets and for specific activities like banking, purchasing, planning, forecasting etc. Now customers can buy any product from anywhere across the globe. Because of this global competition and introduction of computer and internet, enterprises are forced to reorganize their supply chain to gain competitive lead by effective and efficient management of supply chain. Globalization stress product and service providers to review the traditional supply chain for effectively meeting customer requirements such as low costs, high product variety and short lead times [1].

A well-designed and implemented supply chain management (SCM) is an important tool under the globalization of economic markets and the development of information technology [2].

The inventory personnel have to answer the basic question "How much stock should have?" All the purchasing activities move around this question and include decisions related to control inventory costs, determine lot size and inventory level. Inventory costs comprise of two components: controllable e.g. lot-size, frequency of order, review period and reorder level and uncontrollable e.g. holding costs, setup costs, ordering costs, demand and shortage costs. These decisions have a thorough effect on inventory performance in terms of inventory cost.

Earlier inventory has been recognized as asset but JIT philosophy considered waste as it enhances the inventory cost without any contribution to the value of the end product. Inventory hides many problems and hence causes a hindrance to never-ending improvement [3]. Extreme inventory on either side i.e. too high or little cause problematic situation. Higher inventory provides protection against uncertainty in demand as well provide bulk purchase discount. This type of system is relatively easy to manage but the holding cost is higher. While having very little inventory, holding cost are much lower, but it is difficult to manage the system as compared to earlier one.

For the survival of any organization, it is crucial to select optimum inventory policy which can provide high quality goods at least cost with minimum lead time and maximum customer satisfaction. Therefore inventory policy selection is an important constituent of the organization decision making and is one of the most critical activities of purchasing management which has gained great importance in the supply chain management. The selection of inventory policy for a particular application from large number of available inventory policies or models is very difficult.

Succeeding to Wilson's formulae in 1930's, there are a number of reported studies concerning with the problem of how to determine the control variables of different inventory policies reported by researchers, engineers, scientists and experts dealing with inventory. Experts specify inventory criteria based on the experience. When the inventory control variables are determined, whether optimal or not, a number of inventory performance measures can be calculated [4]. Various inventory policies or model have been proposed in the recent past. As the inventory models have significant effect on the functioning of an organization their selection needs a careful evaluation of the requirements and economics.

Numerous researchers, scientist and experts actively engaged in research activities in various fields have proposed

Amit Gupta is research scholar with the National Institute of Technology, Kurukshetra, Haryana, 136119, India (corresponding author to provide phone: +91-999-6632877; e-mail: eramit81@yahoo.co.in).

Ramesh Kumar (R. K. Garg) is with Mechanical Engineering Department of Eenbandhu Chhotu Ram University of Science and Technology, Murthal, Sonepat, Haryana, 131039, India (e-mail: romeshkgarg@gmail.com).

P. C. Tewari is with the Mechanical Engineering Department, National Institute of Technology, Kurukshetra, Haryana, 136119, India (e-mail: pctewari1@rediffmail.com).

World Academy of Science, Engineering and Technology
International Journal of Mechanical and Mechatronics Engineering
Vol:8, No:2, 2014

various multi criteria decision making techniques to solve the different types of real life problems, [5]–[14].

Numerous models have been developed based on "Optimization of some performance measure of the Production System. Such systems have not widely accepted as per the complexity involved defining the various decision variables. Various MCDM methods have been proposed earlier such as the analytic hierarchy process and multi-attribute decision making methods which reflect that the benefit of considering criteria for the selection of alternatives on the basic of the relative importance [15]. Inventory policy selection is multi-criteria dependent decision making problem. A multi-criteria decision making (MCDM) problem incorporate a trade off among conflicting criteria model has been developed to identify the important criteria for inventory policy selection and selecting the optimum inventory policy for automotive industry.

It is one of the most important and widespread industries in the world. The current turnover of the automobile industry is around Euro 2 trillion and is equivalent to the size of 6th largest economy in the world. The global automotive industry has been evolving through different phases characterized by its own developments. Over a period of time, the industry has witnessed several ups and downs, only to emerge stronger and better equipped to take on the challenges [16].

The formulation of mathematical model for a multi-attributes decision problem includes lots of complexity. In this research paper, we have proposed new methodology using Distance Based Approach (DBA) method for evaluation and ranking of potential inventory policies. This methodology employs simple mathematical computation and is able for decision making problem. The paper is organized as: Section II presents DBA method. The selection criteria are explained in Section III. Inventory policies are outlined in Section IV. Section V demonstrates the model with a descriptive example considering various selection criterions to rank the inventory policies. The summary of the work is concluded in Section VI.

II. DISTANCE BASED APPROACH

Distance based approach defines the optimal state of the overall objective and presents the ideally good values of elements of the process. In this work, the optimal state is optimal inventory model. The vector AP $(a_1, a_2, ..., a_n)$ is the set of optimal attributes value. Optimal values of the attribute are defined as best values which exist within the range of values of attributes. An optimal inventory policy should have best values of attributes which is nearly impossible. The optimal one is not the practicable alternative but it is a reference for evaluation of possible alternatives. The numerical difference based on comparison use to evaluate the various alternatives to achieve the optimal state. The decision problem is to find a solution closed to the optimal point P.

The objective function can be formulated as:

Minimize δ {Alt (a), Optimal}

Where

{Alt (a)} alternate inventory policies

δ - Distance from the optimal point

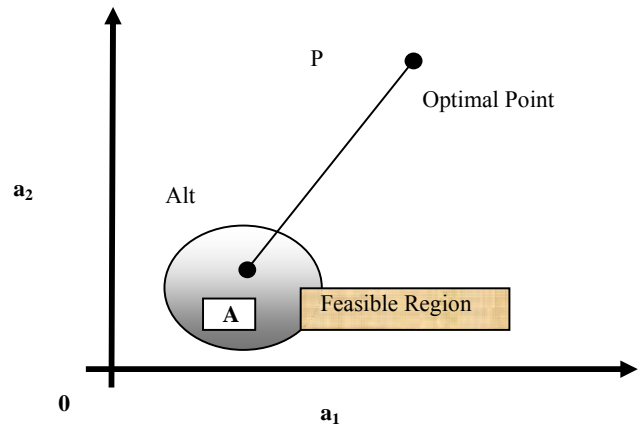Fig. 1 represents the solution function where A is the feasible region and P is the optimal point.

Fig. 1 Distance based approach

The DBA method determines the point in A region which is the closest to the optimal point and is graphically explained in Fig. 2 for two dimensional cases.
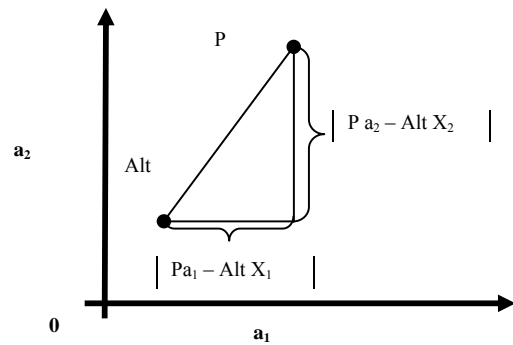

Fig. 2 Distance of real vector

In general case:

$$\delta = [(P_{ij} - Alt_{ij})^2]^{1/2}$$

where

i = 1, 2, 3,…., n alternative inventory policies

j = 1, 2, 3,…., n decision attributes

Consider 1,2,3,….,n alternative inventory policies, and 1, 2, 3,….,m attributes corresponding to each alternative, Alt_1 $(a_{11}, a_{12},….a_{1m})$, Alt_2 $(a_{21}, a_{22},…. a_{2m})$ and Alt_n $(a_{n1}, a_{n2},….a_{nm})$ and the OPTIMAL($a_{b1}, a_{b2},…. a_{bm}$),

where a_{bm} = the best value of attribute m. All the alternatives can be represented as:

World Academy of Science, Engineering and Technology
International Journal of Mechanical and Mechatronics Engineering
Vol:8, No:2, 2014

$$\begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1m} \\ a_{21} & a_{22} & \cdots & a_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nm} \\ a_{b1} & a_{b2} & \cdots & a_{bm} \end{bmatrix} \quad (1)$$

To eliminate the influence of different units of measurement, the matrix is standardized using Z formula as:

$$Z_{ij} = \frac{a_{ij} - \overline{a_j}}{s_j} \quad (2)$$

$$\overline{a_j} = \frac{1}{n}\sum_{i=1}^{n} a_{ij} \quad (3)$$

$$s_j = \left[\frac{1}{n}\sum_{i=1}^{n}(a_{ij} - \overline{a_j})^2\right]^{1/2} \quad (4)$$

where:
i = 1, 2, 3, 4,......, n
m= number of attributes
n = number of inventory policies
a_{ij} = Indictor value of alternative policy i for attribute j
s_j = Standard Deviation of attribute j
The standardized matrix is give as

$$\begin{pmatrix} Z_{11} & Z_{12} & \cdots & Z_{1m} \\ Z_{21} & Z_{22} & \cdots & Z_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ Z_{n1} & Z_{n2} & \cdots & Z_{nm} \\ Z_{P1} & Z_{P2} & \cdots & Z_{Pm} \end{pmatrix} \quad (5)$$

where

$$Z_{11} = \frac{a_{11} - \overline{a_1}}{s_1}, Z_{12} = \frac{a_{12} - \overline{a_2}}{s_2}, ..., Z_{12} = \frac{a_{12} - \overline{a_2}}{s_2}$$

The next step is to obtain the difference or distance from each alternative to the reference point, the OPTIMAL, by subtracting each element of optimal by correspondence element in the alternative set. This results in an interim matrix:

$$\begin{pmatrix} Z_{P1} - Z_{11} & Z_{P2} - Z_{12} & \cdots & Z_{Pm} - Z_{1m} \\ Z_{P1} - Z_{21} & Z_{P2} - Z_{22} & \cdots & Z_{Pm} - Z_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ Z_{P1} - Z_{n1} & Z_{P2} - Z_{n2} & \cdots & Z_{Pm} - Z_{nm} \end{pmatrix} \quad (6)$$

The next step is to introduce the aggregated preference weights for each selection criteria i.e. attribute. If the aggregated preference weight for any selection criteria j is denoted by Wj then this will result in another interim matrix:

$$\begin{pmatrix} (Z_{P1} - Z_{11})W_1 & (Z_{P2} - Z_{12})W_2 & \cdots & (Z_{Pm} - Z_{1m})W_m \\ (Z_{P1} - Z_{21})W_1 & (Z_{P2} - Z_{22})W_2 & \cdots & (Z_{Pm} - Z_{1m})W_m \\ \vdots & \vdots & \vdots & \vdots \\ (Z_{P1} - Z_{n1})W_n & (Z_{P2} - Z_{n2})W_2 & \cdots & (Z_{Pm} - Z_{1m})W_m \end{pmatrix} \quad (7)$$

Finally the Euclidean composite distance, CD, between each alternative models to the optimal state OPTIMAL, is derived from the following formula:

$$CD_{OPAlt} = \left[\sum_{j=1}^{m}\left\{(Z_{Pj} - Zij)W_j\right\}^2\right]^{1/2} \quad (8)$$

The distance of each alternative to every other is a composite distance which is employed to compare all the inventory policies.

III. INVENTORY POLICIES (IP$_S$)

The role of inventory policy in the present scenario is very critical. Inventory personnel deal with an important basic question of right quantity at right time at right place. Because of the dynamic nature of the demand, the enterprise cannot forecast the exact amount of inventory. But they tend to maintain close to exact inventory level. Selection of Inventory policy is one of the important functions of purchasing activities. As it involve various type of costs and its effects further on the purchasing, production processes and finally on the demand of the product. In this paper we have focused on four inventory policies:

A. Economic Order Quantity (IP$_1$)

The right inventory level depends upon the relevant inventory costs which consist of the holding costs, the procurement costs (which include fixed and variable components), and the penalty/shortage costs. The optimal inventory policy for a company is determined by balancing these costs. Fig. 3 explains the relationship between these costs, and the total cost curve which is the sum of the holding cost and the ordering cost.
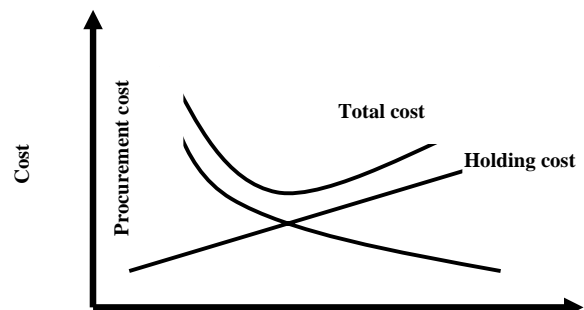

Fig. 3 Total inventory cost

B. Just In Time (IP$_2$)

It a pull system in which inventory is required just start of a process. It involves variable ordering amounts to satisfy fixed

World Academy of Science, Engineering and Technology
International Journal of Mechanical and Mechatronics Engineering
Vol:8, No:2, 2014

beginning inventory level requirements.

C. Vendor Managed Inventory (IP₃)

In vendor Managed Inventory supplier fulfils the customer's requirement as per demand information. The inventory is reviewed more frequently and reduces the delay in the information flow. VMI demand high confidence and trust between the customers and supplier as customer need to share the information with the supplier.

D. Monthly Policy (IP₄)

It a pull system in which inventory is required just start of a process. It involves variable ordering amounts to satisfy fixed beginning inventory level requirements.

IV. SELECTION CRITERIA

The overall goal of inventory policy selection process is to decrease purchase risk, increase overall value to the customer in terms of close and long-term relationships between supplier and customer, customer satisfaction at lowest possible price.

Inventory policy selection is one of the significant tasks of purchasing department. The selection process would be simple if only one criterion is used in the decision making process, however, in many situations, purchasers have to consider a number of criteria in decision making. In such cases, it becomes necessary to determine how each criterion influences the decision making process, whether all are to be equally weighted or whether the influence varies according to the type of criteria [17].

Inventory policy selection and evaluation is the process of finding the appropriate policy which are able to provide the buyer with the right quality products and/or services at the right price, in the right quantities and at the right time. Purchasing activities involves buying the raw materials, supplies, and components for the organization. The activities associated with it include selecting and evaluation of right inventory policies, rating inventory policy performance, determining the optimum lead time, review period and reorder point, sourcing goods and service, 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. Inventory selection criteria along-with classification scheme are proposed [18], which are used in the present research paper for ranking of inventory policies using DBA. These criteria are presented in Table I.

V. MODEL DEMONSTRATION

This section presents a procedure combining various attributes relevant to inventory policies, so that the policies could be evaluated and ranked. The objective of this section is to demonstrate the model with help of illustrative example. In this work, we consider the four inventory policies IP₁, IP₂, IP₃ and IP₄ as mentioned in Section III considering the attributes C₁, C₂, ..., C₈ as mentioned in Section IV. The summary of the attributes for alternate policies is presented in Table I. This methodology is not compressive and further may be

extended to include other attributes depending upon the application and the decision maker preference(s). Here, the objective is to analyze the applicability of the model.

The distance based approximation method is applied first time for evaluation, selection and ranking of the inventory policies for an automotive industry.

The preference weights of the attributes and the respective ratings of the inventory policies are given in Tables II and III.

TABLE I
SELECTION CRITERIA

	CRITERIA	MEANING
C₁	Unit Cost	It is the purchase cost of raw material/semi finished or finished items purchased. The unit cost factor is measured, on the basis of importance of the cost /price dimensions in the buying firm's inventory policy selection i.e. total cost, the vendor willingness and ability to share cost data, discount rate per unit and discount rate on annually purchased units etc.
C₂	Holding Cost	Holding or carrying cost include cost of set up required to hold all the items, storages staff wages, insurance; rent, deprecation of all the stored items, maintenance or material handling and interest charges. The holding cost factor is measured, in terms of its effect on total inventory cost.
C₃	Shortage Cost	When a customer seeks the product and finds the inventory empty, the demand can either go unfulfilled or be satisfied later when the product becomes available. The former case is called a lost sale, and the latter is called a backorder.
C₄	Procurement Cost	When a customer seeks the product and finds the inventory empty, the demand can either go unfulfilled or be satisfied later when the product becomes available. The former case is called a lost sale, and the latter is called a backorder.
C₅	Demand	It is the expected futuristic demand of product. It includes the effect of nature, uncertainty, time dependent in the selection of an inventory policy.
C₆	Review Period	It is time between consecutive inventory replenishments.
C₇	Lead Time	It is the average actual time gap between the customers places an order and till it is received by the customer. It includes the effect of role of lead time in the selection of an inventory policy.
C₈	Reorder Level	It is the inventory level at which information of requirement of items is dispatch to purchasing department.

TABLE II
SELECTION CRITERIA WEIGHT

Criteria	Weight	Criteria	Weight
C₁	0.18186	C₅	0.14591
C₂	0.14338	C₆	0.10969
C₃	0.07997	C₇	0.12480
C₄	0.12463	C₈	0.08976

TABLE III
RATINGS FOR EACH INVENTORY POLICIES

Criteria	IP₁	IP₂	IP₃	IP₄
C₁	0.4906	0.6834	0.7624	0.3516
C₂	0.6608	0.4246	0.2714	0.6358
C₃	0.2332	0.4840	0.6184	0.1463
C₄	0.4382	0.7246	0.4221	0.4476
C₅	0.5164	0.6048	0.6981	0.2273
C₆	0.4562	0.6093	0.7692	0.5610
C₇	0.5216	0.6236	0.5808	0.3433
C₈	0.5955	0.6404	0.5330	0.7547

World Academy of Science, Engineering and Technology
International Journal of Mechanical and Mechatronics Engineering
Vol:8, No:2, 2014

The average aggregated ratings of each policy for each criterion is multiplied by the average weight of that criterion to get the absolute values of the criterion. The whole set of alternatives i.e. potential inventory policies with the absolute values of their criteria are shown as Matrix ([r]) as:

$$[r] = \begin{bmatrix} 0.08923 & 0.09474 & 0.01865 & 0.05461 & 0.07535 & 0.05004 & 0.06509 & 0.05345 \\ 0.12428 & 0.06087 & 0.03871 & 0.09031 & 0.08824 & 0.06683 & 0.07783 & 0.05748 \\ 0.13865 & 0.03892 & 0.04945 & 0.05260 & 0.10186 & 0.08437 & 0.07249 & 0.04785 \\ 0.06394 & 0.09116 & 0.01170 & 0.05578 & 0.03317 & 0.06154 & 0.04285 & 0.06775 \\ 0.13865 & 0.09474 & 0.04945 & 0.09031 & 0.10186 & 0.08437 & 0.07783 & 0.06775 \end{bmatrix}$$

The last row of this matrix represents the optimal value for any criterion. Since the largest value i.e. highest rating of a policy for a criterion is desirable, therefore the maximum value of a criterion for any inventory policy will be the optimal value of that criterion. The adjusted matrix obtained is shown as Matrix ([r']).

$$[r'] = \begin{bmatrix} 0.02529 & 0.05582 & 0.00695 & 0 & 0.04218 & 0 & 0.02224 & 0.00560 \\ 0.06034 & 0.02195 & 0.02701 & 0.03570 & 0.05507 & 0.01679 & 0.03498 & 0.00963 \\ 0.07471 & 0 & 0.03775 & 0.47139 & 0.06869 & 0.03433 & 0.02964 & 0 \\ 0 & 0.05224 & 0 & 0.00117 & 0 & 0.01150 & 0 & 0.01990 \end{bmatrix}$$

From (3), the average values of the criteria are 0.04008, 0.03251, 0.01793, 0.01072, 0.04149, 0.01565, 0.02172 and 0.00879. The standard deviation of each criterion obtained by (4) is 0.03384, 0.02647, 0.01749, 0.01804, 0.02970, 0.01429, 0.01539 and 0.00840, respectively. The standardized matrix and the distance matrix obtained using (6) and (7) are given as:

$$[Z_{std}] = \begin{bmatrix} -0.43732 & 0.88100 & -0.62773 & -0.48303 & 0.02350 & -1.09563 & 0.03444 & -0.37867 \\ 0.59847 & -0.39860 & 0.51935 & 1.49602 & 0.45743 & 0.07945 & 0.86179 & 0.10136 \\ 1.02342 & -1.22827 & 1.13362 & -0.59457 & 0.91594 & 1.30714 & 0.51482 & -1.04623 \\ -1.18457 & 0.74587 & -1.02525 & -0.41843 & -1.39687 & -0.29096 & -1.41106 & 1.32354 \\ 1.02342 & 0.88100 & 1.13362 & 1.49602 & 0.91594 & 1.30714 & 0.86179 & 1.32354 \end{bmatrix}$$

$$[Z_{dis}] = \begin{bmatrix} 1.46074 & 0 & 1.76135 & 1.97905 & 0.89244 & 2.40277 & 0.82735 & 1.70221 \\ 0.42495 & 1.27960 & 0.61427 & 0 & 0.45850 & 1.22770 & 0 & 1.22218 \\ 0 & 2.10926 & 0 & 2.09059 & 0 & 0 & 0.34697 & 2.36976 \\ 2.20798 & 0.13513 & 2.15887 & 1.91445 & 2.31281 & 1.59811 & 2.27285 & 0 \end{bmatrix}$$

Finally, the Euclidean composite distance (CD) between each policy to the optimal state is derived from (8).

TABLE IV
CRITERIA BASED RANKING OF INVENTORY POLICIES USING DBA

Inventory Policy	Sum	Composite Distance	Rank
Economic Order Quantity	19.3046	4.3937	3
Just In Time	5.4047	2.3248	1
Vendor Managed Inventory	14.5573	3.8154	2
Monthly Policy	26.2872	5.1271	4

Table IV shows the composite distance values and the rankings of each policy based on selection criteria. The policy

with lowest value of the composite distance is ranked as #1, and with second lowest value as rank #2, and so on. The policy with maximum value of the composite distance is ranked last. A flow chart for the evaluation, selection and ranking of the inventory policies using distance based approximation method has been prepared and is presented in Fig. 4.

VI. CONCLUSION

The result of the DBA model ranks inventory policies employing selection criterion and potential alternatives information. This model concludes that multi-attribute analysis is possible for inventory selection problem and it also not consist of any complexity as in any mathematical modeling. It is a more effective, efficient, simple and modest approach for evaluation and ranking of inventory policies. The proposed model can result numerous preferences using different set of attributes to reach at final decision.
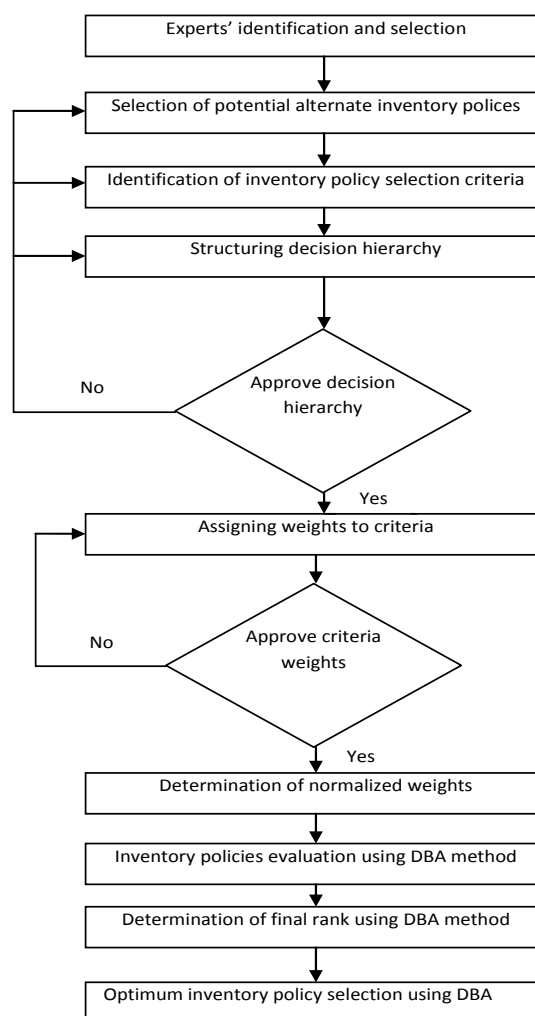

Fig. 4 Schematic diagram of proposed inventory policy selection mode 1

REFERENCES

[1] Gandhi, Ujval, "Vendor Managed Inventory: A New Approach to Supply Chain Management" Master of Science Thesis, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, 2003.

[2] Choi J., Bai S. X., Geunes J. and Romeijn H. E., "Manufacturing Delivery Performance for Supply Chain Management", Mathematical and Computer Modeling, 45, 2007, pp11–20.

[3] Demmy, W. S. and Constable, G. K., "Major elements of Just-In-Time production", IEEE, 1988, PP. 161-164.

[4] Petrovic R. and Petrovic D., "Multicriteria Ranking of Inventory Replenishment Policies in the Presence of Uncertainty in Customer Demand", International Journal of Production Economics, Vol. 71, 2001, pp 439-446.

[5] Weber C. A., Current J. R. and Benton W. C., "Vendor Selection Criteria and Methods", European Journal of Operational Research, Vol. 50(1), 1991, pp 2-18.

[6] Holt, G. D., "Which Contractor Selection Methodology", International Journal of Project Management, Vol. 16 (3), 1998, pp 153–164.

[7] Degraeve Z., Labro E. and Roodhooft F., "An Evaluation of Supplier Selection Methods from a Total Cost of Ownership Perspective", European Journal of Operational Research, Vol. 125 (1), 2000, pp. 34–59.

[8] Tahriri F., Osman M. R., Ali A. and Yusuff R. M., "A Review of Supplier Selection Methods in Manufacturing Industries" Suranaree Journal of Science and Technology, Vol. 15(3), 2008, pp 201-208.

[9] Ho W., Xu, X. & Dey P. K., "Multi-Criteria Decision Making Approaches for Supplier Evaluation and Selection: A Literature Review" European Journal of Operational Research, Vol. 202, 2010, pp 16-24.

[10] Cheraghi S. H., Dadashzadeh M. and Subramanian M., "Critical Success Factors for Supplier Selection: An Update" Journal of Applied Business Research, Vol. 20(2), 2011, pp 91-108.

[11] Agrawal V. P. and Rao J. S., "Structural Classification of Kinematic Chains and Mechanisms" Mechanism and Machine Theory, Vol. 22(5), 1987, pp 489–96.

[12] Agrawal V. P. and Rao J. S., "Identification and Isomorphism of Kinematic Chains and Mechanisms. Mechanism and Machine Theory, Vol. 24(4), 1989, pp 309–21.

[13] De Boer L., Labro E. and Morlacchi P., "A Review of Methods Supporting Supplier Selection", European Journal of Purchasing and Supply Management, Vol. 7, 2001, pp. 75–89.

[14] Garg R. K., Gupta V. K. and Agrawal V. P., "Quality Evaluation of Thermal Power Plants by Graph Theoretical Methodology" International Journal of Power and Energy Systems, Vol. 27(1), 2007, pp 42–48.

[15] Kumar, Rishi and Garg, R. K., "Optimal Selection of Robots by Using Distance Based Approach Method", Robotics and Computer-Integrated Manufacturing, Vol. 26, 2010, pp 500-506.

[16] Export-Import Bank of India, "Indian Automotive Industry: At the Crossroads" Occasional Paper No. 129, Published by Quest Publications 2008.

[17] Yahya S., and Kingsman S., "Vendor Rating for an Entrepreneur Development Programme: A Case Study Using the Analytic Hierarchy Process Method" Operational Research Society, Vol. 56(5), 1999, pp 916-930.

[18] Gupta, Amit, Garg, R K and Tewari P C, "Inventory Selection Criteria: A Proposed Classification" The IUP Journal of Operations Management, Vol. 9(4), 2012, pp.41-52.

Amit Gupta is a research scholar in the Department of Mechanical Engineering in National Institute of Technology, Kurukshetra, Haryana, India. He has obtained degrees of Bachelor of Engineering and Master of Engineering with Honours from Kurukshetra University, Kurukshetra and M. D. University, Rohtak, Haryana, India in 2003 and 2006 respectively. His research interests include inventory control, and management.

P. C. Tewari is working as Professor in the Department of Mechanical Engineering in National Institute of Technology, Kurukshetra, Haryana, India. He has obtained degrees of Bachelor of Engineering, Master of Engineering, and Doctor of Philosophy in Mechanical Engineering from University of Roorkee, Roorkee, University of Roorkee, Roorkee and Kurukshetra University, Kurukshetra, India. His research interests include inventory control, supply chain management, system design and reliability modeling & analysis. Dr. Garg has published more than 100 research papers and guided a number of research scholars.

Ramesh Kumar (R. K. Garg) is working as full Professor in the Department of Mechanical Engineering at Deenbandhu Chhotu Ram University of Science and Technology, Murthal, Haryana, India. He has obtained degrees of Bachelor of Engineering with Honours, Master of Engineering, and Doctor of Philosophy in Mechanical Engineering from M. D. University, Rohtak, Panjab University, Chandigarh, and M. D. University, Rohtak, Haryana, India in 1991, 1996, and 2006 respectively. His research interests include industrial engineering and system design, reliability modeling & analysis, and power & energy engineering. Dr. Garg has published a number of research papers and guided a number of research scholars.