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Inventory control system design by integrating inventory classification and policy selection

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ABSTRACT

Very large numbers of inventory items complicate the inventory control process. Companies categorize their inventory items into a few groups and take similar inventory control policies for the items in each group to overcome this problem. In this regard many grouping methods have been proposed. Some researchers have studied the appropriate inventory policy for each group. Since both the actions of categorization and policy selection are sub-optimal solutions for the original problem of efficient inventory control policy, this paper proposes an integrated model to categorize the items and find the best policy simultaneously. As it is difficult to find a global solution, simulated annealing is used to find appropriate solutions. The model results are compared with the findings of other methods both for dissimilarity and total inventory values.

1. Introduction

Classification is widely proposed in the literature to tackle the problem of very large numbers of inventory items. Thousands of inventory items in companies even with moderate size increase the risk of losing sight of the most important items and spending unnecessary resources in controlling less important ones. Therefore companies try to classify the items and select appropriate control policies for each group. In this regard many authors have studied the classification process and proposed various exact and heuristic methods to classify inventories satisfying some criteria. ABC classification is the most widely employed technique, which in its basic form considers the only criteria of annual use value (Cohen and Ernst, 1988).

Some other authors have focused on the appropriate control policies for each group of the items. Reorder point, two-bin systems and material requirement planning (MRP) are some of the developed strategies (Hautaniemi and Pirttila, 1999).

Thus, in the literature, the original problem of making an effective inventory control system has been decomposed into two problems of classification of inventory items and finding appropriate strategies for each group. This has misled some authors to focus on decomposed sub-problems independently and forget the original goal. Although this may produce some sub-optimal solution for the original problem we should not forget that the aim of the classification is not solely to classify items but to excel in the performance of inventory control policy.

In this paper we propose a model that concurrently classifies inventory items and selects appropriate policies for each product group with the objective of having an effective inventory performance.

The paper is organized as follows. In Section 2 the related literature is reviewed. The developed model is described in Section 3. The coding of the problem in simulated annealing is described in Section 4. An illustrative example is solved in Section 5. Section 6 discusses the algorithm's time complexity and finally Section 7 presents the conclusions.

2. Literature review

The most important reason for applying ABC classification is that in most practical situations the number of inventory items is too large to implement a specific inventory control system for each item (Ernst and Cohen, 1990). However in practice, the traditional ABC classification may not be able to provide a good classification of inventory items (Partovi and Anandarajan, 2002; Huiskonen, 2001; Guvenir and Erel, 1998). Although ABC classification is simple to implement it classifies parts based only on the dollar value of the sales, which tends to allocate a large portion of the capital investment to expensive parts and also by itself does not eliminate the need for optimization of stocking parameters in each group (Zhang et al., 2001). Teunter et al. (2010)

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states that the criteria used in the ABC classification give results far from the cost optimal. They propose a single criterion to be used instead of the criteria used on the traditional ABC and claim it leads to a more cost efficient solution. Some researchers proposed multi-criteria ABC classification. Flores and Whybark (1986) provide a matrix based methodology for multi-criteria ABC classification. In the case of two criteria, a joint criteria matrix is developed though their methodology is relatively difficult to use when there are more than two criteria.

Gajpal et al. (1994), Partovi and Burton (1993) and Partovi and Hopton (1994) applied the analytical hierarchy process (AHP) to ABC analysis. The subjectivity involved in the analysis is the most important issue associated with AHP. Also the method is not easy to implement in the case of large numbers of inventory items.

Ernst and Cohen (1990) used cluster analysis to group similar items. The main advantage of this approach is that it can accommodate large combinations of attributes. The excessive statistical data necessary in their method is the most important weakness, which makes it impractical.

Heuristic approaches such as genetic algorithms and artificial neural networks have also been applied to address the problem (Partovi and Anandarajan, 2002; Guvenir and Erel, 1998). Clearly, these heuristic approaches may not provide optimal solutions in all environments.

Ramanathan (2006) developed a scheme using weighted linear optimization for ABC inventory classification with multiple criteria. An extended scheme was presented by Zhou and Fan (2007).

All the mentioned methods in inventory classification disregarded the original problem and focused on the classification process. The decision maker can only try to select appropriate criteria to help these methods produce good sub-optimal solutions.

Tsai and Yeh (2008) used a particle swarm optimization approach for inventory classification problems where inventory items are classified based on a specific objective or multiple objectives, such as minimizing costs, maximizing inventory turnover ratios and maximizing inventory correlation. They compare their model with classification by suppliers, ABC classification scheme, no grouping and placing all items in a single group. They conclude that their algorithm performs comparatively well with respect to those schemes that are commonly used in practice.

3. Model

An effective inventory system has many characteristics, including the simplicity of implementation, the service quality and cost effectiveness. The most mentioned criterion is cost effectiveness. We try to design an inventory control system by categorizing the items based on their similarity and the inventory cost. In order to achieve this goal, one of the objective functions of the model is the minimization of the costs. It is assumed that items classified in the same group have the same replenishment cycle. Therefore the distinction between inventory policies would be in the order interval of each group. The objective is to identify the optimal order interval for each group.

In selecting an inventory control policy it is important to know what kind of demand we are encountering. Demand could be dependent or independent. Reorder point systems are used for independent demand and MRP based systems for dependent demand. In addition the demand could be deterministic or stochastic. When the inventory parameters (demand, lead time, etc.) are deterministic both continuous and periodic reorder point policies produce similar results (quantity, reorder level, etc.) and the only difference would be in the managerial complications of the system. In general when there are stochastic parameters in the inventory model, the continuous review system needs to keep less safety stock than the periodic review. This usually results in lower inventory costs, unless the cost of having a continuous review of the system is much larger than for the periodic reviews. In most of the cases, for the very important items the continuous review is proposed and for less important items a periodic review system. Nowadays with new technologies it is more common for companies to have continuous review of their inventory items. Based on the issues discussed earlier, in our deterministic independent demand inventory environment a continuous review reorder point system is proposed for the items categorized as A and a periodic review reorder point system for items categorized as C. Also, considering the development of new technologies in inventory control, the class B items could be controlled by continuous review, even though periodic review would not be illogical for them.

Ordering and inventory holding cost are the most visible factors, which we could encounter in the model. However there are some other factors that affect the overall cost of the inventory system. For example items that are bought from the same supplier may have less ordering costs if they are classified in one group and have a joint order. However it is neither easy nor efficient to directly include all these factors in the model. To tackle this problem some researchers have used non-quantity factors in their proposed models.

In practice an efficient inventory control system is not based solely on the total inventory cost. There are other factors that might not be explicitly seen in the cost. For example when the items in each group with the same replenishment time are ordered from the same supplier it may create some flexibility in planning and also reductions in cost. When the items with similar ordering requirements (certificates, bank statements, etc.) or similar keeping characteristics are put in the same groups it creates some advantages for the companies. Therefore it is very sensible that in an appropriate solution, similar items should be classified into the same groups. This has been the basis of the classification proposed in the literature. As mentioned earlier ABC classification tries to put items with high annual value into the same group and items with low annual value into another group. Other classification techniques also try to classify similar items into the same groups. This similarity is based on the scores that items achieve in the criteria. The only difference could be in the way similarities are calculated. Our model defines a dissimilarity index for each pair of items and tries to minimize it in another objective function. In this regard many criteria can be defined and used in the algorithm. Based on the weight that we consider for this objective we might have a classification totally based on dissimilarity or in the other extreme totally based on the total inventory cost objective.

3.1. Notation

n	number of inventory items
m	number of criteria
U	number of classification groups
w_k	weight of criteria k
y_{ik}	performance score of the ith item in terms of the kth criterion
s_i	setup cost of item i
T_g	order interval of classification group g
D_i	demand per unit time of item i
h_i	holding cost per unit per unit of time of item i
$x_{ig}\begin{cases}1\\0\end{cases}$	If item i is classified in group g else
d_{ij}	dissimilarity index of item i and item j