Optimal Order Quantity and Inventory Classification Using Clustering

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ABSTRACT

Clustering is the process of analyzing data to find clusters of data objects that are similar in some sense to one another. Some research studies have also extended the usage of clustering concept in inventory management. Yet, not many research studies have considered the application of clustering approach on determining both optimal order quantity and loss profit of frequent items. In this paper, ordering policy of frequent items in each cluster is determined and inventory is classified based on loss rule in each cluster. This helps inventory manager to determine optimum order quantity of frequent items together with the most profitable item in each cluster for optimal inventory control. An example is illustrated to validate the results.

KEYWORDS

ABC Classification, Association Rule Mining, Clustering, Cross-Selling, Data Mining, EOQ, Inventory Management, Loss-Profit

INTRODUCTION

Inventory is usually one of the biggest numbers on their balance sheet, therefore, effective inventory control and management is a vital function to help insure the continued success of distribution and manufacturing and companies. The effectiveness of inventory control is typically measured by how successful a company is at reducing inventory investment, meeting its customer service goals, and achieving maximum throughput and cost containment. Several monitoring systems and processes can be employed to check inventory imbalances to minimize the supply and demand dynamics. To simply these monitoring systems and process items/materials/products are classified into different groups. Traditionally, ABC analysis has been based on the criterion of dollar volume (Silver et al., 1988).

However, traditional ABC analysis is based on only single measurement such as annual dollar usage. It has been pointed out that other criteria can be important; among these are lead time, item criticality, durability, scarcity, reparability, stock ability, commonality, substitutability, the number of suppliers, mode and cost of transportation, the likelihood of obsolescence or spoilage, and batch quantities imposed by suppliers. Several methods have been developed to perform multi-criteria ABC analysis that can be quite easily implemented today. Multiple criteria can be used for classification of inventories including lead time, criticality, commonality, obsolescence and substitutability criteria etc. (Cohen & Ernst, 1988; Chase et al., 1998). However, the criteria such as cross-selling effect...
defined by Anand et al. (1997) should also be considered when classifying inventory items. Further, one of the most popular data mining techniques is association rule mining. The patterns discovered with this data mining technique can be represented in the form of association rules (Agrawal et al., 1993). Recently, clustering has become a core technical data processing technique to deal with similar data. Data mining adds to clustering the complications of very large datasets with very many attributes of different types. This imposes unique computational requirements on relevant clustering algorithms. A variety of algorithms have recently emerged that meet these requirements and were successfully applied to real-life data mining problems. Broder et al. (1997) defines clusters as maximal connected components of some pair-wise similarity of transactions, thus suffers from the breakdown of the transitivity of pair-wise similarity. Guha et al. (2000) proposed the common neighbors of two transactions as a measure of pair-wise similarity. Wang et al. (1999) method does not use any notion of pair-wise similarity. They cluster transactions that contain similar items. The difference is that clustering emphasizes the dissimilarity of clusters.

Further, Economic order quantity is defined as the order quantity that minimizes the total inventory holding costs and ordering costs. Most existing economic order quantity models assumed that items produced are of prefect quality. However, it may not be pertinent to real market environments, not only because of production processes, but also because of delivery processes or other unknown factors, all of which might more or less damage the product quality. Considering these facts, many researchers have devoted a great amount of time to develop EOQ models for defective items. Porteus (1986) incorporated the effect of defective items into the basic economic order quantity model. Rosenblatt and Lee (1986) assumed that the time between the beginnings of the production run; i.e., the in-control state; until the process goes out of control is exponential and the defective items can be re worked instantaneously at a cost. Later, Lee and Rosenblatt (1987) considered using process inspection during the production run so that the shift to out-of-control state can be detected and restoration made earlier. Further, Salameh and Jaber (2000) developed an EOQ model where each order contains a random fraction of imperfect quality items with a known probability distribution. They also considered that the imperfect - quality items are sold at a discounted price as a single batch by the end of the screening process. Goyal and Cardenas-Barron (2000) presented a simple approach for determining economic production quantity for imperfect quality items and compare the results based on the simple approach with optimal method suggested by Salameh and Jaber (2000), which results in almost zero penalty. Papachristos and Konstantaras (2006) examined the Salameh and Jaber (2000) paper closely and rectify the proposed conditions to ensure that shortages will not occur. Maddah and Jaber (2008) mentioned that the expected annual profit in Salameh and Jaber (2000) is not accurate and the exact annual profit could be calculated using the renewal-reward theorem. Maddah et al. (2010) made a modification to the model of Salameh and Jaber (2000) to avoid shortages. They assumed that an order is placed when the inventory level is just enough to meet the demand during the screening time.

Furthermore, for forecasting demand and evaluating ordering policy, cross-selling effect should also be considered. Brijs et al. (1999) proposed a PROFSET model that combines accounting calculations with a knowledge discovery technique to take into account cross-selling effects among items. The model is able to select a user-defined number of products that contributes the most to the overall profitability, maximizing cross-sales potential. However, there is little research on how to maximize profit when the environment changes. An algorithm of ranking items with association rules is proposed by Kaku and Xiao (2008). To represent the strength of relationship between items, a profit ranking approach of items based on a “Hub-Authority” analogy was exploited in Wang and Su (2002). An inventory classification based on loss rule is proposed in Wong et al. (2003, 2005). Xiao et al. (2011) proposed lost profit of item/item-set with cross-selling effect as a criterion for evaluating the importance of items. The loss profit of item/item-set is defined as the criterion for evaluating the importance of item, based on which inventory items are classified. Further, Mittal et al. (2015a, 2015b) determines ordering policy using association rule mining. However, because
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