Ordering Policy and Inventory Classification Using Temporal Association Rule Mining

Reshu Agarwal, Banasthali University, Vanasthali, India

ABSTRACT

A modified framework that applies temporal association rule mining to inventory management is proposed in this article. The ordering policy of frequent items is determined and inventory is classified based on loss rule. This helps inventory managers to determine optimum order quantity of frequent items together with the most profitable item in each time-span. An example is illustrated to validate the results.

KEYWORDS

Association Rule Mining, Cross-Selling, EOQ, Inventory Classification, Inventory Management, Loss Profit, Temporal Association Rule Mining

INTRODUCTION

In any industry today, inventory optimization is considered a vital function. Excess and shortage of inventory in all levels of the supply chain can affect the availability of products and/or services to consumers. Several monitoring systems and processes can be employed to check inventory imbalances to minimize the supply and demand dynamics. To simply this 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, Pyke, & Peterson, 1988).

However, traditional ABC analysis is based on only a single measurement such as annual dollar usage. Multiple criteria can be used for classification of inventories including lead time, criticality, commonality, obsolescence and substitutability criteria, and so forth (Cohen & Ernst, 1988; Chase, Aquilano, & Jacobs, 1998). Furthermore, criteria such as the cross-selling effect as defined by Anand, Hughes, Bell, and Patrick (1997) should also be considered when classifying inventory items. A considerable number of researchers have studied the dependency of items using data mining. Various methods of data mining such as item-set mining, mining sequential pattern, association rule, classification, prediction, clustering, and regression are applied for the above areas (Han & Kamber, 2006).

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, Imieliński, & Swami, 1993). The popular approaches are Apriori and subsequent apriori-like algorithms and
pattern growth methods (Agarwal, Aggarwal, & Prasad, 2001). These approaches assume all items as binary variables considering whether they are consumed or bought or not. Few researchers proposed extension of item-set mining called item-set mining with quantities considering the consumption of item along with quantity.

Recently, temporal data mining has become a core technical data processing technique to deal with changing data. Temporal association rules are an interesting extension to association rules by including a temporal dimension (Li, Ning, Wang, & Jajodia, 2001; Lee, Chen, & Lin, 2003). Kleinberg, Papadimitriou, and Raghavan (1998) developed a microeconomic framework in which the influence of associations between items could be considered for maximising the expected profit. This influence reflects the cross-selling effect between different items. Brijs, Swinnen, Vanhoof, and Wets (1999) used association rules for selecting items considering relationships among retail items by discovering frequent items-sets and discovered the profitability per set of items by identifying the cross-sales effect of product items and using this information for better product selection.

This model was later extended by Brijs, Goethals, Swinnen, Vanhoof, and Wets (2000) to enable retailers to add category restrictions. However, there is little research on how to maximize profit when the environment changes. Wong, Fu, and Wang (2005) followed their work and proposed a methodology for suggesting recommendations from analysis of item-sets and the application of the concepts of association rules and selection of maximal profit item are investigated considering cross-selling effect. Bala (2008, 2012) suggested a model for making use of consumer insight information for inventory management in retail stores. Later a study on purchase dependence association rules for retail products was suggested by Bala, Sural, and Banerjee (2010) to make inventory replenishment decisions.

As per their observation, in a multi-item retail inventory of very large number of items, purchase dependence among the items is observed frequently and when there is stock out of one item, it may result in the decline in purchase of another item. Utilizing the concept of ‘purchase dependence’, Park and Seo (2013) developed a multi-item inventory control considering dependency based on availability of items demanded over the same customer order. The authors derived expressions for additional average cost of lost sales by other items when one particular item is out of stock.

Yin, Kaku, Tang, and Zhu (2011) described the association rule mining in inventory database. They have given brief explanations for frequent item/item sets, apriori algorithm, discovering association rules from frequent item sets, multi-dimensional association rules and association rules with time-window. Furthermore, economic order quantity is defined as the order quantity that minimizes the total inventory holding costs and ordering costs. Most existing economic order quantity (EOQ) models assumed that items produced are of perfect 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 unexpected factors, all of which might more or less damage the product’s 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 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 reworked 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.

Furthermore, Salameh and Jaber (2000) developed an EOQ model in which 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 compared 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)
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