An Approach for Estimating the Opportunity Cost Using Temporal Association Rule Mining and Clustering

4

Reshu Agarwal
Department of Computer Science, G. L. Bajaj Institute of Technology and Management, Greater Noida, India

INTRODUCTION

Inventory control is a process employed to maximize a company's use of inventory. The main objective of inventory control is to keep the total cost associated with the system to a minimum. This requires familiarity with supply sources, price negotiations including bulk quantity discounts, modes of transportation, budgeting, physical handling, record keeping, and monitoring the incoming quality of items. In real life situations, there are very large numbers of items in an inventory. It may not be possible to review (which includes computing inventory-on-hand, placing orders, receiving stock etc.) such a large number of items with equal intensity. Review activities take time and cost money. Hence items are usually classified into important and less important groups. The important ones get more attention than the others. The goal is to keep stocks at low level while giving good service.

Traditionally, ABC analysis has been based on the criterion of dollar volume and on the principle that there are a relatively small number of items. However, over the last 30 years, there has been an accumulation of research questioning this focus on a single criterion–the dollar volume. Several researchers suggested that multiple criteria should be used in the classification of inventories (Flores & Whybark 1987; Lenard & Roy 1995). However, the problem is that the profit of one item not only comes from its own sales, but also from its influence on the sales of other items or reverse, i.e., the cross-selling effect (Anand et al., 1997). In such a situation, it should be explained clearly whether the cross-selling effects would influence the ranking of items or not, and how to group the items if such effects existed, not concerning what and how many criteria could be used. For effective inventory management, lost sales should also be considered. Lost sales means the customer is impatient and may buy the products from other suppliers because of the shortage, the unmet demand is lost and opportunity cost (OC) of lost sales therefore occurs. Most researchers agree on selecting a constant value as the unit opportunity cost (UOC) of lost sales. Sharma & Sadiwala (1997) considered UOC as a constant value. However, such constant value should not be arbitrarily assigned. Sung & Seok Ock (1992) and Hsu & Lowe (2001) proposed that the penalty cost of lost sales can be estimated by customer goodwill loss. However, they do not provide a quantitative method to estimate the value of the goodwill loss. Many researchers (Wang (2002); Pentico & Drake (2009)) have considered opportunity cost by considering goodwill loss. Though, there are many models for calculating opportunity cost by considering goodwill loss, but there are very few models that have proposed a specific method to estimate the opportunity cost and the goodwill loss.

Further, Brijs *et al.* (2000) proposed a PROFSET model to select only the most valuable items for customized marketing. It determines the most profitable categories based on their profit lift into frequent item-sets of interest, by solving an all-binary optimization problem. The resulting categories imply a high

DOI: 10.4018/978-1-7998-3473-1.ch046

monetary value and the ability to initiate cross-selling in the respective customer segment. However, the PROFSET model does not consider the strength of relationship between items. Also, it does not provide relative ranking of selected items, which is important in classification of inventories. Therefore, the PROFSET model cannot be used to classify inventory items. Kaku & Xiao (2008), further extended inventory classification considering cross-selling effect and ABC classification. The main drawback of this model is that they have not considered that whether and how the quality of association with related items impacts such ranking methodology. Xiao et al. (2011) classified inventory items which are correlated each other using the concept of cross-selling effect together with ABC classification and loss profit. The main advantage of this model was that they ranked inventory items in such a way that it helps inventory manager in really perceiving most profitable items. They classified items based on loss rule (Wong et al. 2005). The loss profit of item/item set is characterized as the basis for assessing the significance of item, in view of which inventory items are classified. They disclosed that to pass judgment on the significance of a item (set), it is not only by looking at the profit it brings in when it is on the shelf, yet additionally the loss profit it might remove when it is missing or stock out. Further, Many reaearchers (Mittal et al. (2015a, 2015b); Agarwal et al. (2016); Agarwal(2017a, 2017b)) have determined ordering policy using data mining algorithms. The opportunity cost of lost sales should be equal to the sum of lost sales of the unmet demand and the ADU brought by the associated products (Kaku *et al*., 2011). However, they have not calculated opportunity cost for various clusters and particular time-periods.

Proposed Approach

In this chapter, how to estimate the opportunity cost, which are correlated each other is discussed by using the concept of 'cross-selling effect'. We have discussed two cases for calculating the opportunity cost with cross-selling effect.

Case 1: A mathematical model to estimate the opportunity cost based on association rules considering cross-selling effect in different clusters.

An association rule is an implication expression of the form X®Y, where X and Y are disjoint itemsets, i.e $X \cap Y = \varnothing$. The strength of an association rule can be measured in terms of its support and confidence. Support determines how often a rule is applicable to a given data set, while confidence determines how frequently items in Y appear in transactions that contain X.

Let $I = \{i_1, i_2, i_3, i_4, \ldots..i_m\}$ be a set of items. Now, support of item i_1 is defined as the frequency of its occurrences in total transactions and confidence is defined as conditional probability of purchasing i_2 when i_1 is purchased and is given by formula:

$$Support\left(i_1\right) = \frac{Frequencyofi_1}{TotalnumberofTransactions} \tag{1}$$

$$Confidence\left(i_1 \rightarrow i_2\right) = \frac{Supportof\ i_1 \cup i_2}{Supportofi_1} \tag{2}$$

The clustering algorithm aims to minimize the cost due to large items and small items (Wang *et al*., 1999). The overview of the clustering algorithm is described in Figure 1.