RETAIL SINGLE-TRIP IN-STORE REPLENISHMENT

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Abstract

Ideally, we want to have a single-trip in-store replenishment. Namely, only a single trip is needed for a retail store worker to have to travel to fill the shelf after a product is received at the store. This can be achieved by having the lot size received smaller than the shelf space less the number of units left on the shelf at the shelf replenishment time. In this paper, we introduce the consideration of the in-store handling cost by the second trip in retail replenishment decision models, given the retail shelf space. We consider the case where products are ordered in multiple packs and there is a part of the distribution-handling cost that is for each pack handled. From the concept developed in this paper, there are several future research opportunities to develop optimization models, which will help retail and vendor managers to better coordinate and make decisions with regard to the lot size produced, ordered, and delivered in the supply chain.

Keywords: Retail replenishment; EOQ; Inventory control; Shelf space allocation; Store handling; Distribution handling.

INTRODUCTION

In today's competitive retail industry, retailers are finding ways to stay competitive by reducing costs while improving service to customers; and they must look beyond the boundary of functions in the companies, and even further to their external supply chain partners, particularly their vendors. This is because a decision at some part in the supply chain will impact not only that particular part but across the supply chain. An example is that the decision on pack quantity (i.e. the number of product units in a pack) impacts the manufacturing process, the distribution handling cost, the in-store handling cost, and the inventory level across the supply chain.

The replenishment process is core to the retail supply chain operations, which starts from retailers ordering products from vendors, to putting the products on shelves. Hence, it is the

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process that retailers must manage correctly in order to control the supply chain costs while improving the services to customers. The replenishment process involves many decisions by various retail supply chain partners and the impact of these decisions span across not only functions within the retail company but also the vendors. Therefore, coordination among the retail supply chain partners must be made when making the retail replenishment decisions, and we must carefully consider various parameters involved in making these decisions.

In this paper, we will discuss the impacts by, and relationship among, decisions involved in the replenishment process. Specifically, we want to discuss the case where the decisions about the order quantity, the pack quantity, and the retail shelf space can have an impact on the in-store handling cost, and the distribution handling cost. Research in this area, which is still very limited, is usually either for optimizing the shelf space allocation or determining the order quantity, considering the vendor-buyer relationship. However, none of these studies incorporates the consideration of in-store handling cost and distribution handling cost into determining the order quantity, pack quantity, and shelf space allocation.

The in-store handling cost is a significant part of the total retail replenishment cost, as evidenced in an empirical study by Saghir and Jonson (2001). They show that 75% of the handling time in the replenishment process is found to occur in-store. Therefore, it is important that we account for in-store handling and its related costs as part of replenishment decision models. However, there has been little attention to account for the cost of the in-store handling (Zelst et al., 2009). The in-store handling includes the process from receiving products from a delivery truck, then moving the products to either the sales floor or the store's backroom, depending on the store's policy and timing of the delivery and shelf-fill operations.

(1) In the first case, the products are moved straight to the sales floor for filling shelves. Then, after the shelves are filled, if not all the units can fill the shelves, the leftover units will be moved to the store's backroom for storage.
(2) In the second case, the products are first moved to the backroom for storage and will later be moved to the sales floor for filling shelves. Then, like the first case, after the shelves are filled, if not all the units can fill the shelves, the leftover units will be moved to the store's backroom for storage.

In both cases, any leftover units stored in the backroom will have to later be moved back to the sales floor for filling the shelves; thus, a second trip is required.

Since retailers, especially those operating large discount stores having thousands of square meters of sales floor space and carrying thousands of stock-keeping units (SKUs), the in-store handling activities are significant. These activities can be reduced substantially if the second trip is not required. The decisions on the ordering and shelf space, which will result in whether all the product units can fill the shelf, are the major contributing factors for whether such a second trip will be needed.

There are studies in the literature that attempt to jointly consider the assortment and shelf space allocation problems and the replenishment decision problems. Corstjens and Doyle (1981) develop a shelf space allocation model using a nonlinear programming model to maximize the profit, subject to available supply and minimum and maximum space allowed for each item. Urban (1998) develops models that integrate assortment, allocation, and replenishment decisions. The models explicitly consider that the demand rate is a function of inventory level. Several other papers also discuss the inventory level-dependent demand to account for the displayed units on the shelf space; they include Mandel and Phaunjdar(1989), Datta and Pal (1990), Urban (1992), Pal et al. (1993), Wang (1994), Urban (1995), Giri et al. (1996), Khmelnitsky and Gerchak (2001), Gerchak and Wang (1994), and Gerchak (2001). Further, in this area, Hariga et al. (2007) propose an optimization model to solve the product assortment, inventory, display area, and shelf space allocation decisions that maximize profit within the constraints of shelf space and backroom storage. The model explicitly distinguishes between on-shelf or sales floor and backroom inventories. However, none of these models considers the in-store handling activities, especially the second-trip required when not all units can fill the shelf.

Another stream of studies, in attempting to model buyer-vendor coordination for replenishment decisions, involves extending the Economic Order Quantity (EOQ) model to consider the quantity-related cost function such as quantity-price discount and quantity-freight cost discount. These papers, includingGoyal(1976), Monahan (1984), Lee (1986), Lee and Rosenblatt (1986),Tersine and Barman (1994), Corbett (2000), Toptal et al. (2003), and Toptal (2009), consider the cases where there is a change in replenishment costs when the order quantity changes. However, again, they do not consider the impact from an order quantity decision on the in-store handling cost.

This paper introduces the consideration of such in-store handling cost by the second trip in addition to the distribution handling cost. We want to explore research opportunities for developing replenishment decision models, which incorporate the in-store handling cost, when not all the units of a product that a retail store orders and receives from a delivery can fill the shelf. The models will help improve the understanding of the impacts of the pack quantity and order quantity decisions when taking into account the retail shelf space, the in-store handling cost, and the distribution handling cost.

SINGLE-TRIP IN-STORE REPLENSIHMENT

In this section, we discuss the in-store handling activities. Ideally, in terms of in-store handling, we want to have single-trip in-store replenishment. Namely, only a single trip is needed for a store worker to travel to fill the shelf. This can be achieved by having the lot size of the received product smaller than the shelf space less the number of units left on the shelf at the shelf replenishment time. On the other hand, in case not all the units of a product that the store receives from a delivery can fill the shelf, a second trip is needed for the worker to travel between the store's backroom and the shelf. Figure. 1 illustrates the in-store handling activities considering the number of trips traveled by a worker.

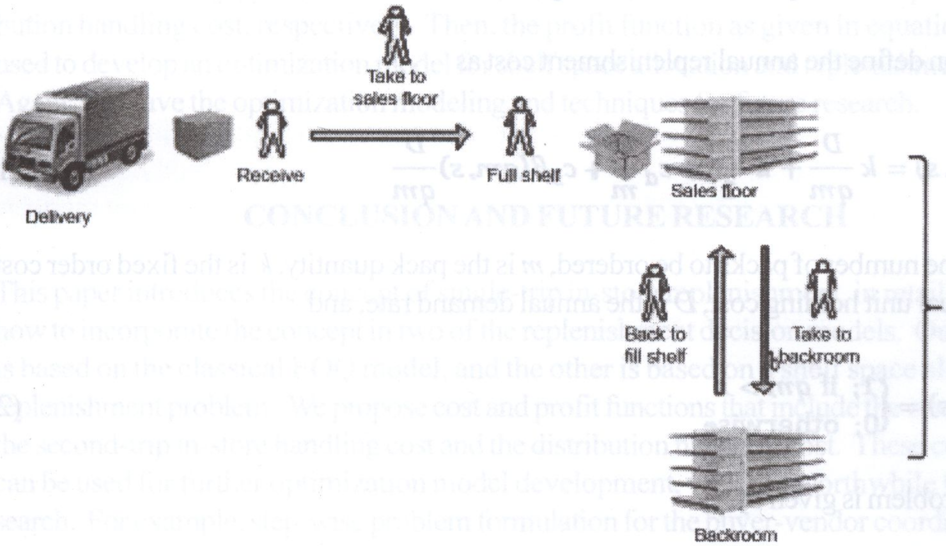

Fig. 1: The in-store handling when the second trip is needed.

REPLENISHEMENT DECISION MODELS

From the discussion in the above sections, decision models can be developed, which capture the concept of single-trip in-store replenishment to determine the order quantity, pack quantity, and shelf space, with consideration of the second-trip in-store handling cost and the distribution handling cost.

EOQ-type model to determine the optimal order quantity and pack quantity

In this section, we discuss how we can incorporate the concept of single-trip in-store replenishment into an EOQ-type model to determine the optimal order quantity and pack quantity. To develop the model, we assume:

(1) When there is a second-trip to replenish the shelf, there will be a constant second-trip in-store handling cost, c_s.

(2) When a product is ordered, it is ordered in multiple of packs, with a pack quantity of m units.

(3) For each pack that we order, there is a part of the distribution handling cost that is per each pack handled, c_d.

(4) The shelf space, s, which is in multiples of product units.

(5) Other usual EOQ assumptions apply, such as continuous and constant demand and instantaneous order replenishment (see e.g., Nahmias, 1997).

Then, we can define the annual replenishment cost as

$$G(q,m,s) = k\frac{D}{qm} + h\frac{qm}{2} + c_d\frac{D}{m} + c_s\beta(qm,s)\frac{D}{qm} \tag{1}$$

where q is the number of packs to be ordered, m is the pack quantity, k is the fixed order cost, h is the annual unit holding cost, D is the annual demand rate, and

$$\beta(qm,s) = \begin{cases} 1; & \text{if } qm > s \\ 0; & \text{otherwise} \end{cases} \tag{2}$$

Then, our problem is given by:

$\min G(q, m, s)$,

subject to q, m, and $s = 1, 2, 3, \ldots$

In order to solve the above problem, we may assume m and s as given and solve for an optimal q. Then, we can iteratively change the values of m and s in a search for optimal values of m and s. We leave to future research the techniques to solve this problem.

A shelf space allocation and replenishment optimization problem

We will use the formulation of the shelf space allocation and replenishment problem by Urban (1998) as our base formulation. Let us define the following notations.

r	Reorder point
T	Order cycle time
p	Product unit selling price
c	Product unit cost
C_{sh}	Shelf space unit cost
$\bar{I}$	Average inventory level including backroom inventory

Then, based on the cost function given by Urban (1998), we have the following profit function:

$$\pi(q,m,s,r)=\frac{(p-c)qm}{T}-\frac{k+c_s\beta(qm,s)}{T}-hI-c_{sh}s-c_d\frac{D}{m} \qquad (3)$$

The difference between Urban's formulation and ours is that in our formulation we have two additional terms $c_s\beta(qm,s)/T$ and $cd\ D/m$, which are the cost of a second-trip and the distribution handling cost, respectively. Then, the profit function as given in equation (3) can be used to develop an optimization model for shelf space allocation and replenishment decisions. Again, we leave the optimization modeling and techniques for future research.

CONCLUSION AND FUTURE RESEARCH

This paper introduces the concept of single-trip in-store replenishment, in retail. We discuss how to incorporate the concept in two of the replenishment decision models. Our first model is based on the classical EOQ model, and the other is based on a shelf space allocation and replenishment problem. We propose cost and profit functions that include the consideration of the second-trip in-store handling cost and the distribution handling cost. These cost functions can be used for further optimization model development, which is worthwhile for future research. For example, step-wise problem formulation for the buyer-vendor coordination problem based on an EOQ-type and the solution techniques, similar to those in Lee (1986) and Toptal(2009), can be further developed to include the concept of single-trip in-store replenishment. Furthermore, the shelf space allocation and replenishment optimization models by, for example, Urban (1998) and Hariga, M. A.(2007), can be extended to include the additional cost elements as in equation (3). The contribution of this paper is clear because it introduces a new concept, single-trip in-store replenishment, and illustrates how the concept can be applied to well-known problems, which also results in several future research opportunities.

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