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대형할인매장의 VMI 시스템을 위한 효율적인 재고관리 시스템
Efficient Deterministic Inventory System in VMI System of the Discount Retailer

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Abstract

Excessive inventories result from poor scheduling, planning, and controls, and the converse is also same.With adequate inventories, supplies can transport products to customers in time without excessive delivering cost. So efficient inventory control is vital for successful logistics management operation.

In terms of mass discount retailers such as Wal-Mart, Carrefour, E-Mart, and so on, they require the high-quality services such as a small-amount and a high-frequency delivery because of having small warehouse and wanting possess much more various goods. In the opposite, manufactures ask mass discount retailer to delivery more lots of goods because of reducing the number of deliveries. It goes without saying that both wish to prevent stockout(lack of inventories). Usually, mass discount retailers have the power more than manufactures.

This paper proposed how to manage inventory and how many to order in view of the TPLC and supplier. We considered the economic order quantity models for multiple items so as to prevent urgent deliveries as possible as. And the tradeoff stockout costs and delivering costs.

1. INTRODUCTION

The logistics costs continue to increase from the business's point of view. Especially, the biggest costs are transportation and labor costs, and there are many researches for reducing these costs. Important cost savings can be achieved in terms of vehicle systems by determining simultaneously the timing and sizes of the retailer deliveries as well as efficient vehicle schedules so as to minimize total transportation and inventory carrying costs. But if inefficient inventory system is equipped in spite of having a good performance of transportation or routing system, total system's performance has limits of improvement. Bad inventory system results to occurring urgent ordering and high delivering cost. So it is necessary to enhance the performance through well managing inventories.

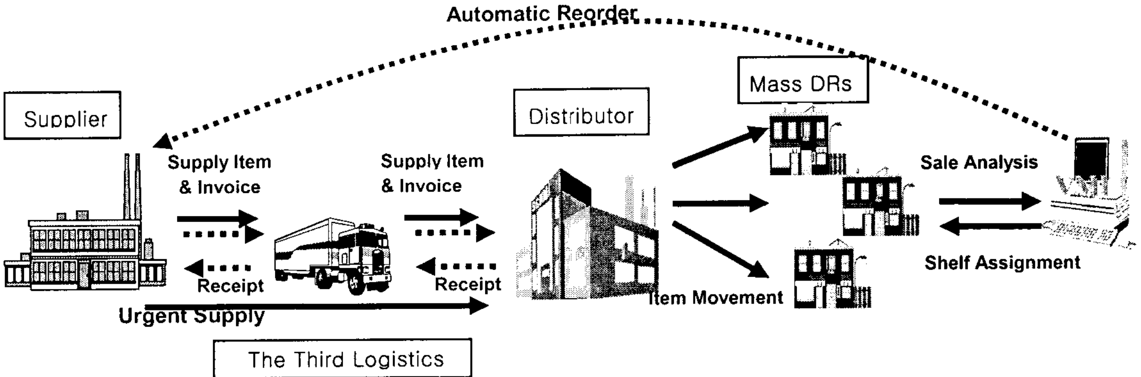
Logistics corporations are working closely together to bring better value to the customers (retail store, wholesale dealer and sale dealer). Consumers have demanded various products from manufactures. This creates need for more flexible manufacturing systems. But increasing the diversity of items lead to growing total inventories. Consequently, that generates limits for potential improvement of productivity and needs more and more efficient inventory management. But it is not easy to manage much kind of inventories. So many businesses have consigned their function to the third corporation.

As businesses have globalized their operations, logistics planning and decision factors have become even more complex. Especially, result from the increasing need for outsourcing the logistics function constitutes, suppliers become more conscious about their TPLC(Third Party Logistics Corporation) selection. Estimates anticipate that more than 50% of logistics functions would be outsourced by the 21st century[5].

This paper proposed how to manage inventory and how many to order in view of the DR(discount retailer), TPLC, and supplier. The environment of problem is the flowing product via DRs, such as Wal-mart, Carrefour, K-mart, E-mart, and so on. We considered the economic order quantity models for multiple items so as to prevent urgent deliveries as possible as. This work similar to a multi-product generalization of distribution system considered by Anily and Federgruen[1]. The model combined an economic order quantity problem, where a tradeoff is to be found between stockout costs and delivering costs. The objective of the problem is to determine the replenishment quantities for each item so as to minimize inventory costs, and smoother flow of product into DRs tightly coupling the flow of product out of DR. We computed the value for order up to levels at each fixed period with real data and adjusted the levels by the proposed function with on-line data. We applied this model to a business Λ, the TPLC, and the results will be presented. It is expected that this system is useful for suppliers, TPLC and DRs in sharp market competition.

2. BACKGROUND

The life cycles of products, which are consisted of several kinds of items, are shorter and many businesses strive to meet this trend. One of alternatives is outsourcing. The market of DRs in Korea was generated a few years ago. It is needless to say that this market is very important



<Fig 1> The Flow of Product in Discount Retailer

these days.

This paper's concern is the market consisted of DRs, suppliers, and TPLCs. A business A, the TPLC, has delivered products from suppliers to a distributor of DRs. The flow of products and the participants is as like figure 1. Generally, suppliers cannot delivery their products to DRs directly. They must do via a distributor of DRs because DR deals with extremely various products. This distribution channel via DR is different from another channels. This distribution channel is simpler and more special than others. The order policy in the channel uses VMI(Vender Management Inventory)system integrated with POS system. VMI system utilizes DR perpetual inventories coupled with an order point level to automatically rigger the replenishment orders for items within a DR. The main force of efficient replenishment depends on consumers' sales data as captured via POS system. Accordingly, we can significantly reduce product handling, non-value adding activities, inventory, and associated carrying costs using this system.

The Dilemma of Supplier and the TPLC

DRs require a small-amount and a high-frequency delivery because of having small scale of warehouses and wanting possess much more various goods. In the opposite, manufactures ask DRs to delivering more lots of goods because of reducing delivery times. Then suppliers make a contract of logistics service level (delivery per week, quantity per delivery, the shelf position, fee, etc) with the head office of DRs. Namely, the replenishment quantity is fixed and a period between orders is constant. But urgent supplies happen to supplier due to inconstant and unexpected demand. There is urgent order when one of DRs runs short of products. DRs require items to be coded according to EOQ levels, and items are replenished regularly when each order quantity reaches a safety level. But suppliers can recognize reorder through only VMI system of DR whether or not reordering any time. It is hard for manufactures and the TPLC to know reordering point and reordering quantities. So suppliers had so a burden of increasing delivery frequency that they would push on with outsourcing of logistics functions into the TPLC.

The Dilemma of Discount retailers

DRs want to keep a rich assortment of goods and to receive a little ordering quantity. It goes without saying not to happen stockout in DRs. Therefore small-amount high-frequency delivery have been required by DRs. If a shelf in DR was bare of present, sales volume would reduce and MDs(Manager of Division) would be attacked penalty by DR's manager due to neglecting of duty. So MDs must manage not to be short supply of items on shelves in DR. Namely, MD's competency of a work runs counter to supplier's efficiency. So supplier and the TPLC must determine the number of delivers and quantity per delivery considering expense as well as the performance of service.

3. The Proposed Algorithm

Costs

We consider holding costs, ordering costs(including delivering costs), and stockout costs. These costs in this paper are different in meaning and in occurring places, and can be computed easily. But, it is hard to estimate these costs due to inadequate and insufficiency demand history.

Holding costs happen at DRs in this paper. We can estimate the value as regarding this cost as rental fee for DRs and distributor. Ordering costs including delivering costs are subject to the TPLC. Whenever a vehicle is sent out to replenish inventory, it incurs a fixed cost plus a cost proportional to the total distance traveled from the supplier's warehouse to the distributor. We have classified orders into regular order that happens regularly and urgent order that happens unpredictably. The urgent costs depend on the order quantity, on how urgent the order is, on the period when order, etc. We computed ordering cost by operational expenses of TPLC. Lastly, we dealt with stockout cost too. The measurement of the stockout cost is very hard because many qualitative parameters must convert quantitative unit. Stockout is very important on inventory system because stockout often means a lost sale and can also mean a lost customer. Petsinis et. al[3]. proposed the expected stockout cost as like:

$$C_q = q_u C_u + g q_d C_d$$

C_q : the expected stockout cost
q_u : coefficient representing the criticality of the SP
C_u : the urgent order cost
g : the probability of belated delivery to the destination
q_d : coefficient representing the resentfulness of the destination
C_d : the cost due to the delivery delay

P.Attwood and N.Attwood[2] had shown that a lost sale occurred in 67% of stockouts, a lost customer in 23% of stockouts and a delayed sale in 10% of them. This paper has utilized their results except the value of delayed sale, because of no delayed sale in our case. Furthermore, we considered a term of MD's dissatisfaction in this system. If there is a stockout in DR, DR's manager imposed a penalty on MD due to neglecting of duty. That became the seeds of discord between MD and supplier. Recently, the effect of integrated inventory and routing strategies was emphasized by Stalk et al[4]. who review the evolution of the discount retailing industry.

Algorithm

We computed the value for order up to levels at each fixed period with real data, and adjusted the values with the proposed function using on-line data. Each cost function is below.

$$SO_{it} = (a_i y_i + b_i y_i \beta) \times \max[\,0, \frac{q_{it}}{|t'|}|t| - q_{it}\,] + \alpha(\frac{q_{it}}{|t'|}|t| - q_{it})$$

$$O_{it} = [pRO + (1-p)UO + \gamma]$$

$$H_{it} = [\sum_{i=1}^{m}\sum_{t=1}^{n_i}(x_{it} \times pr_i) \Big/ \sum_{i=1}^{m}\sum_{t=1}^{n_i} x_{it}] \times \lambda \times q_{it}$$

$$\min \sum_{t=1}^{ni} TC_{it} = SO_{it} + O_{it} + H_{it}$$

$$q_{it+1} = q^{*}_{it} + \theta$$

RO : Regular ordering
UO : Urgent ordering
SO_{it} : Stockout cost
O_{it} : Ordering cost
H_{it} : Holding cost
TC_{it} : The total cost of item i at period t.
y_i : The profit of item i
a_i : The rate of lost sale
b_i : The rate of lost customer
α : The coefficient of MD's dissatisfaction
β : Lost customer's recurring lost sales
γ : Cost including depreciation and insurance
λ : The fee of distribution center and DRs
$|t|$: Length of period t
$|t'|$: Length from the starting of period t to the stockout
q_{it} : Order quantities of item i during period t
p : The probability of occurring regular ordering
x_{it} : The number of sale item i in period t
m : The kind of items
pr_i : Price of item i
θ : If stock happens, this value is '1', and if retaining inventory is 7 times more than expected demand per day, this value is '-1'. Otherwise, the value is zero.

The assumptions of this model are: an order cannot be delivered separately, shortages are permitted, and fixed quantity is delivered any time. Actual data was used for the purpose of drawing general values about parameters. A lost customer means a recurring loss(β) of sales, and it will be assumed in this case that each customer lost would make two more purchases and we did not consider γ . The flowchart of algorithm is figure 2.

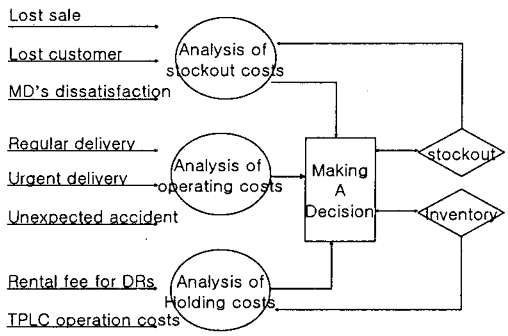


Figure 2. The flow of algorithm

4. CASE STUDY

A company Λ is TPLC for managing items at only DRs. Main operations of Λ are arrangement, replenishment, and delivery for many items. Of course, Λ has managed

Table 1. Sales and Replenishments Record

DR K's sales

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	SUM
A	2	3				1						2	2	1	1	3				1	1			3		1	1			1	1	24
B		2	1		1				2						1	1				1	1		2	1	1			1	1	1		17
C	2	1		1	2		1	1		2					2			2		2		2	1						2	1		22

DR K's replenishments

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	SUM
A	7						10																	5				5				27
B	12																							5		5						22
C	10													5			5		5							5						30

Regular Delivery
Stockout

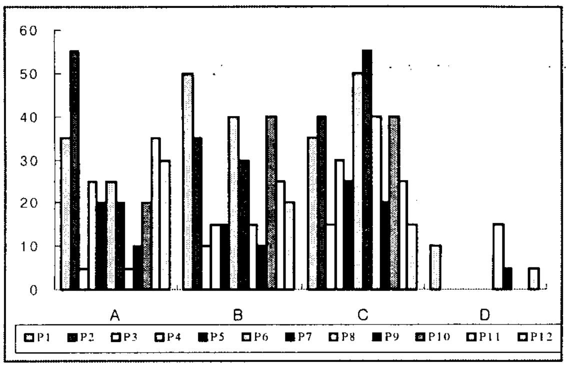


Figure 3. Fluctuating Demands of product at DRs

inventory. Λ treats 24 items of meta goods at every DRs. The flow of products and the participants is as like previous figure 1. The fixed service level of Λ, the number of delivery per week, was made a contract with DRs. Namely, the activities related to the replenishment of a large number of items are carried out periodically. But unexpected demands result in inconstant service level, which is irregular delivery. So high operating cost happened to Λ and stockout happened to DRs. According to contract, although delivery times are two per week, there are more than before due to urgent orders. For example, table 1 has shown the sales and replenishment records for a month at DR K out of all DRs. In practically, there are 8 regular orders, 1 urgent order, and 4 stockouts (for 7days) in a month at DR K. Ordering quantities of each item at all DRs are extremely various as like figure 3.

This paper considered only 3 homogeneous items of a product. We sought to maintain a proper balance between too much stock and too little, and these difficulties have been solved with the proposed algorithm.

5. RESULTS and CONCLUSION

This study has proposed the proper ordering quantities of each item. This system is coded with Visual Basic 6.0 and Access for database. The parameter's values and results are as like table 2 and 3. We estimated these values with analyzing operating costs. Item A and B has often failed at DR K. In case item C, several stockouts occurred at DR K in spite of holding enough goods in ordinary times. Generally, total inventory of item A, B, and C is growing up, but stockouts frequently happen to DR. So a DR has accumulated plenty some items on shelf, but the others are unoccupied. Also a DR made a pile with item B, some DRs did not contain item B at all. Although all DRs except a DR have item B, an order is sent to supplier automatically by VMI system and supplier must replenish item B.

Table 2. Parameters' values

	A	B	C	
H	7.55	7.15	9.91	RO = 847.5, UO=1076.19, γ =0, λ =0.15, a=0.67, b=0.23, β =2,
y_i	795	720	735	

The result of this simulation has shown that the proper order quantity of item A is about three, item B is two, and item C is three and we can reduce inventory costs to about 40%. Besides, order quantities can be flexible changed automatically according to the rate of demand and the quantities of holding items. This system can propose the adequate the number of delivery and determine the rate of shelves occupancy among homogeneous items. Although various quantities of replenishment in every period produce good performance of system, much complex inventory policy increases the difficulty of management and heavy burden of employees.

As businesses continue to face new distribution structure, it is imperative that costs are restricted and profits enhanced for high competitive power. So it is much more necessary to control inventory efficiently. And in the trend of outsourcing, there is no doubt that good system can be simultaneously considered profit for supplier, TPLC, and DRs. These companies would have the mutual goal of achieving performance improvements that are greater than what could be achieved through each company's separate performance improvement efforts. Further works will make effort to establish the system for win-win strategy.

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Table 3. Simulation Results

	A					B					C				
# Order	Real	4	3	2, 4	2, 3	Real	3	2	2 & 3	1 & 4	Real	4	3	2 & 3	2
₩ Cost	7953	4212	3276	3216	12679	4497	3777	2891	3305	2969	8672	4580	5502	4538	20813
Percent	100	55	42.8	42	165.7	100	84	64.3	73.5	66	100	52.8	63.4	53.3	240
#Stockout	2	0	0	0	3	1	0	0	0	0	1	0	1	1	4
Rate of Inventory	4.88	10.33	5.17	4.83	2.41	10.71	11.94	4.53	7.47	5.18	8.1	10.27	4.64	3	1.41