Proceedings of the International MultiConference of Engineers and Computer Scientists 2009 Vol II
IMECS 2009, March 18 - 20, 2009, Hong Kong

Value Chain Coordination Using Multiple Period Newsboy Model

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***Abstract*—A number of commodities, such as electronic components, computer, communication and consumer electronics (3C) products, and fashion goods, are characterized by limited lifecycles with multiple replenishing cycles. A retailer can purchase these commodities many times within a short selling season. But these commodities can be replenished once during each cycle. Then, a multi-period newsboy model extended from a single period newsboy model can be applied. This paper will extend the traditional single period newsboy model to a multi-period model between a manufacturer and a retailer to determine replenishment decisions for a product characterized by multiple ordering during a selling season that is replenishing only once during each period. For achieving the value chain coordination and enhancing the profits of all supply chain members, some coordination mechanisms will be adopted. A numerical analysis will be provided to demonstrate the proposed model.**

***Index Terms*—Supply chain coordination, Multiple period newsboy model, Fashion commodities**

I. Introduction

Individual companies no longer complete as independent entities with unique brand names, but rather as integral part of supply chain links in today's global market. In that sense, Supply Chain Management (SCM) deals with total business process and represents a new way of managing the business and relationships with other members of the supply chain. The shift from an adversarial to a longer team and close relationship is associated with new process management leading to greater synergy, transparency, openness, sharing and trust. This is why more business is seeing SCM as a key to remaining their competitive.

Many commodities, like retailers selling seasonal or fashionable goods, newsstands, and food retailers selling dairy products before expiration dates, have short lifecycle and only can be sold within a single selling period. The classical newsboy model is a single-period single-product model of a retailer and can be applied on the replenishment decisions for a product with a short shelf or demand life [1].

Manuscript received October 1, 2008. This work was supported in part by the the National Science Council (Taiwan) under Grant NSC 97-2410-H-251-010.

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Some commodities also have short selling season or lifecycle; however, they can be replenished many times during the selling season. The retailer can order the commodities once during a fixed duration. For example, many shops order goods, like electronic components, computers, communication and consumer electronics (3C) products and fashion goods, once a week during a selling season. It is important to decide the ordering quantity for each period to maximize overall profit in a selling season.

Supply chain members always make a decision to obtain their own maximal profits from the market. The manufacturer can adopt some coordination policies to achieve the cooperation between the retailer and herself and enhance the profits of overall channel and individual supply chain member. This paper aims to present a multiple period newsboy model with some channel coordination mechanisms. Additionally, a numerical analysis will be provided to illustrate the proposed model.

II. Literature Review

The basic architecture of an ERP (Enterprise Resource Planning) system builds upon one database across the entire enterprise providing integrated business solutions for the core processes and the main administrative functions of an enterprise [2]. ERP became attractive to business because of its ability to integrate the flow for material, finance, and information into a single package and manage resources of a company. The value chain model in enterprise logistics is shown as Figure 1. However, some supply chain cooperation problems cannot be easily solved in an ERP system. For example, the quantity of the retailer ordered from the manufacturer which can maximize the profit of the retailer. That is, the focus of supply chain is now not only limited to increasing the internal efficiency of organizations, but has been extended to include methods of adding value and reducing cost across the entire supply chain.

The classical newsboy model is a single period and single product model. The product has a short selling time or lifecycle. It is assumed that any retailer will only place one order with the manufacturer. If there is some remaining commodity after the demand life exhausted, the retailer needs to undertake the cost. If the commodity is depleted, the goodwill cost associated with customers whose demand is unsatisfied is occurred [3]. The key question is how to determine the optimal ordering quantity for maximizing the retailer's profit.

Many commodities characterize the newsboy products; but

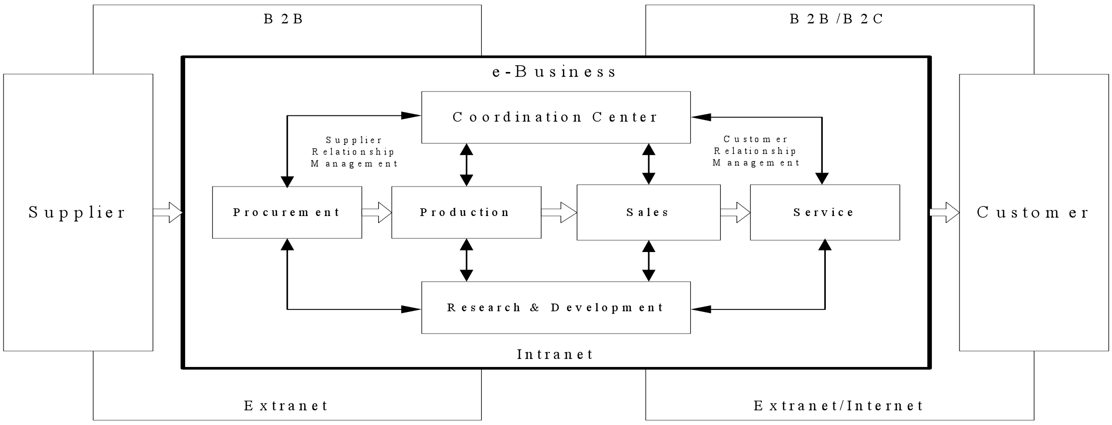

Figure 1. Value chain model in enterprise logistics [2]

they can be replenished many times during a selling season. Matsuyama [4] extended the classical newsboy model into a multi-period problem. In a multi-period newsboy model, the retailer must consider the sales results of last period and the expected demand of this period to decide the ordering quantity at the beginning of this period. If some unsold goods remained last period, the inventory holding cost must be incurred. Additionally, the ordering quantity of this period must be determined by calculating unsold inventory. If there is unsatisfied demand in last period, the ordering quantity of this period must be considered how to complement unsatisfied demand.

For enhancing the coordination of supply chain, manufactures and retailers can adopt and negotiate many mechanisms, like wholesale price, cost sharing or subsidy provisions for holding inventory, backordering to meet unsatisfied demand, and return policies [3, 5-7]. These coordination policies share the cost and risk, increase profits and broaden real demand of market. Then, the profits of the whole supply chain and individual members can be enhanced.

This paper will extend the model of [4] to solve the multi-period newsboy problems. Some coordination mechanisms will be considered to achieve the channel coordination and increase the profit of the channel and members in a supply chain. A numerical analysis will be provided to illustrate the proposed model.

III. The Models

This paper considers a multi-period newsboy model for integrating both a retailer and the manufacturer. A manufacturer produces a product to a retailer. The product has short selling season or lifecycle, but it can be ordered once at beginning of each period during the selling season. The market demand is uncertain. Assume the sale price is fixed. If some unsold products remain, no any returns of remaining inventory are allowed except the end of selling season. But some inventory holding cost will occur at a specified period. Additionally, the portion of remaining inventory can be sold at next period. Conversely, if there is some unsatisfied demand, goodwill cost will be charged at a specified period. Assume some customers are willing to wait and get the product at next period. Then, a ratio of the amount of unsatisfied demand can be complemented at next period. No any salvage exists for both the retailer and manufacturer.

In order to formulate the problem, the following symbols will be introduced first.

x_i : total amount of demand during the *ith* period
$f(x_i)$: probability density function of demand at the *ith* period
p_i : selling price per unit of the product by the retailer at the *ith* period
q_i : ordering quantity of the retailer at the beginning of the *ith* period
w_i : whole sales price per unit of the product from the manufacturer at the *ith* period
c_i : manufacturing cost per unit by the manufacturer at the *ith* period
l_i : initial inventory level at the beginning of the *ith* period
g_i : goodwill cost per unit due to stockout incurred by the retailer at the *ith* period
h_i : holding cost per unit at the *ith* period
SR_i : setup cost by the retailer at the *ith* period
SM_i : setup cost by the manufacturer at the *ith* period
ST_i : setup cost by the channel at the *ith* period e
$ST_i = SR_i + SM_i$
α : ratio of the amount stocked to the amount unsold, $0 \le \alpha \le 1$
β : ratio of the amount sold at the beginning of next period to the amount of unsatisfied demand during present period, $0 \le \beta \le 1$

In this paper, some coordination policies are adopted, including inventory holding cost sharing, and unsatisfied demand backordering mechanisms for each period and a return policy at the end of the selling season. As space is limited, we only present the framework of our models as Figure 2.

Condition 1. If the real demand was smaller than the initial inventory in the previous period, $x_{i-1} \le l_{i-1}$, some inventories was burdened by the retailer. Then, the inventory holding cost is incurred by the retailer. The retailer must consider the inventory level to decide the ordering quantity in the beginning of the current period.

After coordinating with the manufacturer, the manufacturer is willing to share the inventory holding cost to reduce the risk of the retailer.

Condition 2. If the real demand was larger than the initial

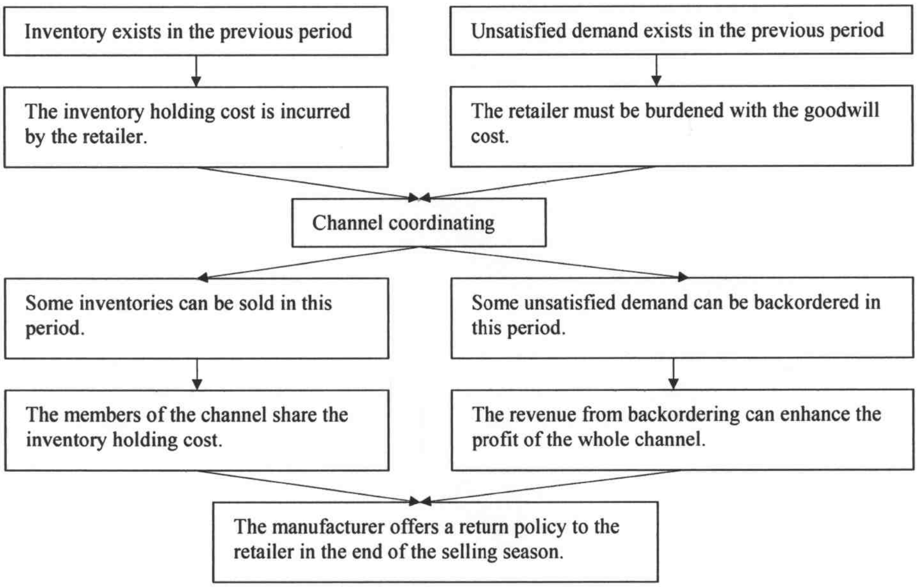

Figure 2 the framework of supply chain coordination model

inventory in the previous period, $x_{i-1} \geq I_{i-1}$, some unsatisfied demand occurred. The retailer needed to burden the goodwill cost. After coordinating with the manufacturer, the manufacturer can offer more commodities to backorder parts of unsatisfied demand. Then, the manufacturer hopes to enhance the profit of the whole channel.

Simultaneously, the manufacturer provides a return policy to the retailer at the end of the selling season. If the retailer has some inventories at the end of the selling season, she can return parts of unsold stock to the manufacturer.

Summary all profits of the retailer at each period, then calculate her maximum profits. Then, we can obtain the total profit of the retailer, the profit of the retailer at each period, and the ordering quantity at each period, q_i. By substituting all q_i into the equations of the manufacturer and the channel at each period, we can obtain their total profits and their profits at each period.

The manufacturer hopes that the total profits of the channel and herself can be increased through the channel coordination policies. The coordination policies can reduce the risk of the retailer to encourage the retailer to order much. Additionally, if customers are willing to wait, the profit from the backordering quantity offered by the manufacturer can enhance the profits of all members of the supply chain.

IV. Numerical Analysis

A numerical example may illustrate the models. A retailer sells a product within 3 months. That is, the selling season consists of 12 periods. The retailer orders once per week during the selling season. The unit wholesale price is \$32. The probability density function of dynamic demand x_i is a normal distribution with μ=500 and σ=90. The selling price is \$60 and a unit manufacturing cost is \$10. A goodwill cost is \$6 per unit and a holding cost due to inventory is \$2 per unit. For calculating easily, the setup costs of the retailer and the manufacturer each period are 0. There is no any salvage value at the end of each period and the last period. Table 1 lists the results of all periods. The column of q_i shows the results of ordering quantity at each cycle. The column of $\pi_{R,i}$ represents the profits of the retailer. $\pi_{M,i}$ shows the profit of the manufacturer. Additionally, $\pi_{T,i}$ lists the profit of overall channel.

Table I Numerical analysis

i	x_i	q_i	$\pi_{R,i}$	$\pi_{M,i}$	$\pi_{T,i}$
1	563	644	9248	14173	23421
2	617	411	13535	8973	22508
3	536	729	16409	16037	32446
4	482	558	11932	12182	24113
5	527	514	13271	11188	24459
6	635	382	14428	8311	22738
7	716	571	14196	12569	26765
8	518	788	13284	17343	30627
9	446	543	12378	11850	24228
10	338	486	14164	10526	24689
11	581	399	16842	8538	25380
12	455	542	12832	11178	24010
Total		6568	162517	142867	305384

V. Conclusion

This paper has proposed an ordering quantity decision-making model extended the classical single period newsboy problem to a multiple period model. We are given a time interval that consists of n period. Each period is the same duration. The retailer can order a product once each period. The multi-period model can ensure to maximize the profit of the retailer by considering the unsold quantity or the unsatisfied demand. For achieving the channel coordination, the manufacturing offers some coordination policies, like return policy, inventory holding cost sharing and backordering. The numerical results have shown the feasibility of the proposed model.

ACKNOWLEDGMENT

This research was partially supported by the National Science Council (Taiwan) under Grant NSC 97-2410-H-251-010.

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