Analyzing Postponement/Speculation Strategic in a Two-Echelon Supply Chain with Considerations of Uncertainty Profiles

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Abstract: - In the short life cycle era, many companies struggle to survive by increasing their product spectrum to gain more market share. For the pressure of such competitive environment coupled with the difficulty of forecast, the design of products tends to employ the concept of modularity and postponement strategy in supply chain management. In this study, a novel mathematical model with considerations of the environmental uncertainty profiles is developed to analyze postponement, speculation and hybrid strategies with diverse system properties to compare the cost effect incurred. Accordingly, the decision maker can utilize this model to determine which supply chain strategy should be adopted to reach better performance.

Key-Words: modular design, postponement, speculation, inventory management, uncertainty management, supply chain management

1 Introduction

In an emerging information society, product life cycles are reduced dramatically, customers are more sensitive to delivery times and service quality, demand for highly customized goods is increasing, information collection and comparison of products as far as both prices and quality are concerned required less effort and are less time consuming, making consumers less loyal. Delivering customized items on time as customers release their orders is critical to competition advantage [13]. Therefore, expanding the variety of the inventory in order to maintain the flexibility is beneficial. But, product line extension would increase the complexity of system because of proliferation of products ([3], [7], [9], [10], [15], [22], [26]). As a result, it becomes more and more difficult to make inventory decision by forecasting. In order to maintain competitive edge, the current product design tends to employ the modularity concept and postponement strategy, which is to make risk-pooling over demand uncertainty of different products sharing similar functional and physical attributes in a product family.

There are a lot of issues for implementing postponement strategies [11]. However, the postponement strategies can generally be classified into two kinds of approaches, which include manufacturing postponement and logistic postponement [19]. In this study, the authors would aim at manufacturing postponement rather than logistic postponement. If the system adopts the manufacturing postponement strategy, it would hold both the speculative and common products to supplement the service level. On the contrary, the speculation strategy is to hold only the distinct final products and deliver them immediately whenever the customers request. At last, the hybrid strategy utilizes both the postponement and speculation policy to jointly fulfill the customer demand.

In this study, the authors develop a decision support model to analyze postponement, speculation, and hybrid strategies with considerations of uncertainty profiles. Environmental uncertainty can be resulted by the variance of products, demand, leadtime, and service level. This study involves such uncertainty in the proposed model and analyzes the above three strategies to compare the cost effect incurred and to evaluate the effectiveness in supply chain decision.

2 Literature Review

Effective and efficient management in supply chain can bring tremendous leverage power for enterprises. Much research dedicates in managing supply chain's dynamic uncertainty and tries to overcome the defects incurred. Many theories and methodologies have been developed for theses purposes in recent years, especially the advent of the postponement concept in 1950 [1]. Organizational theorists emphasize that organizations must adapt to the environment so as to remain controllable and thus employing the postponement strategies has been considered seriously. The whole scope of postponement strategies has been expanded from marketing to logistics, manufacturing, purchasing, distribution, and promotion processes ([2], [7], [9], [12], [13], [15], [18], [21], [22], [23] and [24]). Logistics postponement strategy combines time and place postponement in order to stock the necessary inventory at the right supply chain nodes and at the right time ([4], [14], [17], [22], [24]). Yang et al. ([25], [26]) utilized two dimensions: Modularity and Uncertainty to describe the above postponement strategies, which are shown as Figure 1. Pagh and Cooper [19] proposed a profile analysis to discuss how to choose the right strategy among postponement strategies in supply chain management, they only described the key P/S decision determinants to identify the appropriate supply chain strategy for certain company, which still lacks an exact model to persuade decision makers to adopt the strategy provided. Brown et al. [6] studied the efficiency of two postponement strategies, namely product and process postponement in Xilinix, a semiconductor company. Ernst and Kamrad [8] introduced a conceptual framework to evaluate different supply chain structures in the context of modularization and postponement. Lin et al. [16] studied the impact of reduction in hardware complexity on the supply-chain inventory against alternatives for various customer on-time delivery and manufacturing environments. Bowersox et al. [5] developed the lean launch strategy, which is formulated on the principles of postponement and is based on response-based logistics (pull) and supply chain management. Garg and Tang [10] constructed a model to compare the effect of the early and late postponement with multiple points of differentiation.

Postponement strategies are employed to produce risk- pooling ability in order to manage and control uncertainty exists in current supply chain ([2], [17], [20], [23]). Although the concept and potential benefits are claimed in much literature, this study is dedicated to construct a mathematic model with the consideration of environment profiles to analyze such claimed benefits. While analyzing the postponement, speculation, and hybrid strategies, a so-called "common product" is introduced to be able to substitute various speculative products with minor modification due to modular design. Depending on the strategies adopted, the buffer stock will be determined by the trade-off between the common product and speculative products.

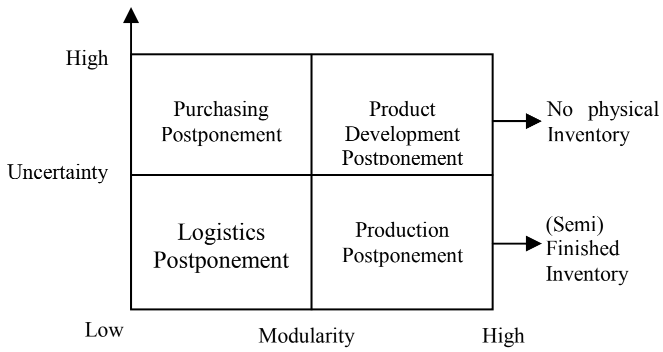

Figure 1. Postponement Strategies

3 System Description and Modeling

In traditional supply chain, distribution channel normally consists of various suppliers, which sell and distribute products to retailers. According to available literature, the postponement strategy can improve the service level and reduce the total cost [19]. This study, therefore, utilizes the following two echelon distribution system (Figure 2) to discuss and compare the postponement against speculation strategy. The detail system description and assumptions are presented as follows:

a. The supply channel of products consists of only one supplier, one transient Distribution Center (DC) and n retailers.
b. There are m speculative products from a family considered. However the supplier can also offer the common product to retailers for modifications, such as adjustment, labeling, etc., to achieve the exact configuration in retailers' own places with extra cost.
c. The transient DC will decide how to use postponement, speculation, or hybrid strategy, and then release the system orders of the respective inventory level for all the retailers.
d. Moreover, each retailer review inventory for products every H period, and order the items needed to transient DC in order to meet the customers' demand.

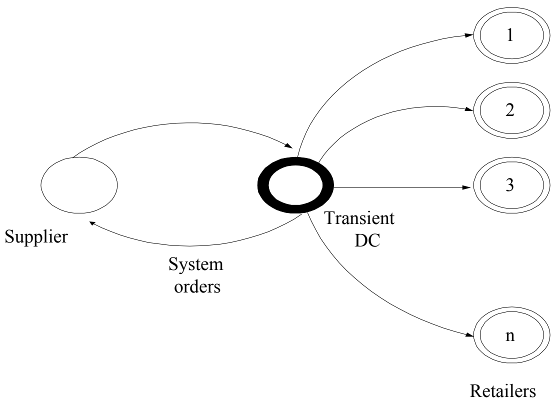

Figure 2. System schema

Nomenclature:

S_j: the system order of all the j^{th} product for the n retailers

BS_{ij}: the Base-Stock of the j^{th} product at retailer i

S_{si}: the inventory of common product at the retailer i

L_{wi}: the distribution of processing and transportation leadtime from DC.

L'_s: the supply leadtime distribution

$D_{ij}(t)$: the demand distribution for the j^{th} product at retailer i at time t

μ_{ij}: the mean demand of the j^{th} product at retailer i

σ_{ij}: the variance of the j^{th} product's demand at retailer i

P_0: the procurement cost including the cost of common product and the extra cost incurred by the modification in the retailers thereafter.

P: the purchasing price of the speculative products j, j=1,…,m.

c_0: the backorder cost of the common product

c: the backorder cost of the speculative products j, j=1,…,m.

The transient DC has to select one from the following three strategies to manage the supply chain:

a. Full speculation strategy: The system order will require the supplier to provide the full speculative items, i.e. the m variations, rather than the common product to directly meet the immediate demand from customers.
b. Full postponement strategy: The system order will require the supplier to provide the speculative products for the average demand of the system and the common product for the buffer stock. Then, the common product will be modified at the retailer's location with extra cost to become speculative products to fulfill the excess demand of respective speculative products.
c. Hybrid strategy: The transient DC simultaneously uses both of the above strategies. Therefore, the system can keep two kinds of inventory, which are common product and m speculative products.

Based on the strategies above, the supplier will supply not only speculative products but also the common product, with which the retailers can provide m different products to the customers. The customer's demand for product j, j=1,2,…,m, at retailer i, i=1,2,…,n, during period t is assumed to be a normal distribution $D_{ij}(t)$ with mean, μ_{ij}, and variance, σ_{ij}. Demand is independent across all retailers over time, and the unfilled demand is backordered. Furthermore, the transshipment among retailers is not allowed.

The retailers deploy periodic review to monitor inventory for various products, release orders , and then transient DC prepares base stock for each product j of the retailer i, namely BS_{ij}. Every H period when the orders have been released, there exist two kinds of lead time which are supply lead time and processing lead time. The supply lead time, L'_s is to prepare the required products and ship to the transient DC, which is a random variable with mean and variance of (L_s , σ_s^2). The supply lead time elapses from the moment when system order has been released to the moment when the transient DC receives the products. The processing lead time, L'_{wi} is for retailers to receive the products from the transient DC, which is also a random variable with mean and variance of (L_{wi} , σ_{wi}^2). The processing lead time includes the processing time at the transient DC and the transportation lead time to ship products to the retailer i, i=1, 2, … , n. Accordingly, the Base Stock is the sum of the average demand and buffer stock for the demand during (H+ L'_{wi}) period:

$$BS_{ij}=(H+L_{wi})\mu_{ij}+\alpha_{ij}[S_j-H\sum_{i=1}^{n}\mu_{ij}-\sum_{i=1}^{n}L_{wi}\mu_{ij}-\sum_{i=1}^{n}\sum_{t=-(L's+L'_{wi})}^{t=-(L'_{wi})-1}D_{ij}(t)]$$

$$\text{,where } \sum_{i=1}^{n}\alpha_{ij}=1 \quad (1)$$

From (1), it demonstrates that the system order supplies S_j for all the product j, in which S_j not only fulfills the average demand but also offers the buffer stock to avoid backorder. The value of α_{ij} is decided to minimize the total system's backorder of the product j at the retailer i. The expected backorder of product j at the retailer i is given by $EB_{ij}(\alpha_{ij})=\sigma_{oij}\,G((BS_{ij}-(H+L_{wi})\mu_{ij})/\sigma_{oij})$, where G( ) is the standard normal loss function. The BS_{ij} of (1) can be further developed to (2).

$$BS_{ij}=(H+L_{wi})\mu_{ij}+\frac{\sigma_{oij}}{\sum_{i=1}^{n}\sigma_{oij}}[S_j-H\sum_{i=1}^{n}\mu_{ij}+\sum_{i=1}^{n}L_{wi}\mu_{ij}-\sum_{i=1}^{n}\sum_{t=-(L's+L_{wi})}^{t=-(L'_{wi})-1}D_{ij}(t)]$$

$$\text{, where } \sigma_{oij}=[H+L_{wi}+\sigma_{wi}^{2}(\mu_{ij}/\sigma_{ij})^2]^{1/2}\sigma_{ij} \quad (2)$$

The base stock, BS_{ij}, in both (1) and (2) represents the inventory of speculative product j. In the other words, the above equations given are deployed under full speculation strategy. After developing the Base Stock for the product j at retailer i, the end-of-period net inventory of the product j at retailer i, I_{ij} , is the difference between the Base Stock and the demand during lead time of ($H+L_{wi}$). Therefore, the expected value and variance of the retailer's end-of-period net inventory are presented in (3) and (4), respectively.

$$E(I_{ij})=(\frac{\sigma_{oij}}{\sum_{i=1}^{n}\sigma_{oij}})[S_j-(H+L_s)\sum_{i=1}^{n}\mu_{ij}+\sum_{i=1}^{n}L_{wi}\mu_{ij}] \quad (3)$$

$$Var(I_{ij})=[(L_s\sum_{i=1}^{n}\sigma^2_{ij}+\sigma_s^2\sum_{i=1}^{n}\mu^2_{ij})/(\sum_{i=1}^{n}\sigma_{oij})^2+1]\sigma_{oij} \quad (4)$$

Moreover, the end-of-period net inventory can be met by the buffer stock. After the desired service level is given, the expected value of end-of-period net inventory is the multiplication of k and $Var(I_{ij})$, i.e. $E(I_{ij})$ = k $Var(I_{ij})$, where k can be obtained from the desired service level, $\rho=F_u(k)$ and $F_u(k)$ is a standard normal cdf. According to (3) and (4), the system inventory of product j is given by (5).

$$S_j=[(H+L_s)\sum_{i=1}^{n}\mu_{ij}]+\sum_{i=1}^{n}L_{wi}\mu_{ij}+k\left[\left(L_s\sum_{i=1}^{n}\sigma_{ij}^2+\sigma_s^2\sum_{i=1}^{n}\mu_{ij}^2\right)+\left(\sum_{i=1}^{n}\sigma_{oij}\right)^2\right]^{1/2} \quad (5)$$

By using the full speculation strategy, the system order for product j at every H period can be obtained from (5). Based on the customer demand, the transient DC can, therefore, decide the order quantity of the speculative product j, j=1,2,…,m, to be stored in the retailers.

While employing the hybrid strategy, the transient DC would consider the trade-off between the speculative and common products. The common product is included in the inventory as well to jointly achieve the desired service level with the speculative products. While the product j, j=1,2,…,m has a stockout, the common product will be employed to fulfill the unsatisfied customer's demand during the ($H+L_{wi}$) period. Assumed the excess demand of product j at the retailer i is x_{ij}, the mean and variance of x_{ij} can, therefore, be presented as

$E(x_{ij})=[R(k) - k]\sqrt{Var(I_{ij})}$ and $Var(x_{ij})=\{1+kR(k) - [R(k)]^2\}Var(I_{ij})$, where $R(k)=f_u(k)/(1-F_u(k))$, in which $f_u(k)$and $F_u(k)$ denote standard normal pdf and cdf, respectively. If the stockout of product j occurred, the common product will serve as the substitute to achieve the desired service level ρ with minor modification during the (H +L_w) period. Therefore, the service level ρ is equal to the service level offered by both product j and common product, which is presented in (6).

$$\rho = F_u(k)+ F_u(Z(k))[1- F_u(k)] \tag{6}$$

The inventory of common product at the retailer i , $S_{si}(Z(k))$, is then utilized to meet the excess demand's mean and the buffer stock, which is given in (7).

$$S_{si}(Z(k))=E(x_i)+Z(k)\sqrt{Var(x_i)}$$

$$,\text{where } E(x_i)=\sum_{j=1}^{m}E(x_{ij}) = \sum_{j=1}^{m}[R(k) - k]\sqrt{Var(y_{ij})} =[R(k) - k]\sum_{j=1}^{m}\sqrt{Var(y_{ij})} \text{ and } Var(x_i)=\sum_{j=1}^{m}Var(x_{ij}) =\{1+kR(k) - [R(k)]^2\}\sum_{j=1}^{m}Var(y_{ij}) \tag{7}$$

y_{ij} is defined as the negative value of the retailer i's end-of-period net inventory of product j, and has the following property:

$$E(y_{ij})= - E(I_{ij})= - k\sqrt{\mathrm{var}(y_{ij})}$$

$$,\text{where } \mathrm{var}(y_{ij})=Var(I_{ij})$$

$$=\left[\left(L_s\sum_{i=1}^{n}\sigma_{ij}^2+\sigma_s^2\sum_{i=1}^{n}\mu_{ij}^2\right)\Big/\left(\sum_{i=1}^{n}\sigma_{oij}\right)^2+1\right]\sigma_{oij}^2$$

By employing both the product j and the common product, the expected backorder can be obtained from $EB_i(Z(k))=\sqrt{Var(x_i)}\,G(Z(k))$. The total operating cost of the common product's buffer stock at retailer i, including procurement and holding costs and the expected backorder cost , is then presented in (8).

$$EC_i(Z(k))=(1+r)P_0S_{si}(Z(k))+c_0EB(Z(k)) \tag{8}$$

Since the buffer stock for product j, j=1,2,…,m at retailer i is given by k $\sqrt{Var(I_{ij})}$, the sum of the procurement cost and the expected holding cost of buffer stock for product j, j=1,2,…,m, at retailer i, i=1,2,…,n, is given in (9).

$$EC_{ij}(k)=(1+r)pk\sqrt{Var(I_{ij})}\,,\ j=1,2,\ldots,m \tag{9}$$

From (8) and (9), the expected cost function of the system that uses common product inventory to supplement the excess demand is given in (10).

$$EC(k)=\sum_{i=1}^{n}\left[ECi(Z(k))+\sum_{j=1}^{m}ECij(k)\right] \tag{10}$$

By applying (3), (4), (6), (7), (8) and (9) to (10), equation (10) can be rewritten to become (11).

$$EC(k)= \sqrt{\{1+kR(k)-[R(k)]^2\}}\ [(1+r)P_0Z(k)+c_0 G(Z(k))]\sum_{i=1}^{n}\left[\sum_{j=1}^{m}Var(I_{ij})\right]^{1/2} +(1+r)[pk+(R(k)$$

$$- k)P_0] \sum_{j=1}^{m}\sum_{i=1}^{n}\sqrt{Var(I_{ij})} \quad (11)$$

From (11), the expected operating cost of the system, which employs the common product to supplement the service level ρ, including the expected backorder, procurement, and holding costs for the common product, and procurement and expected holding costs of buffer stock for product j, j=1,2,…,m, has been derived. Since this study focuses on the trade-off among the three P/S strategies, it is intended to compare the cost improvement. In the following, the expected operating cost of full speculation strategy, EC(k'), which doesn't use any common product, needs to be derived as well. Clearly, the desired k' must be equal to the service level ρ if the required service level can be achieved without the common product. Therefore, the expected backorder of the product j in the retailer i is given as $EB_{ij}(k') = \sqrt{Var(x_{ij})}\ G(k')$. And the procurement and holding costs is given as $EC_{ij}(k')=(1+r)p\,k'\sqrt{Var(I_{ij})}$. Accordingly, the operating cost can be obtained from the summation of total products' procurement, holding, and expected backorder cost, which is presented in (12).

$$EC(k')=[(1+r)p\,k'+cG(k')]\sum_{j=1}^{m}\sum_{i=1}^{n}\sqrt{\mathrm{var}(I_{ij})} \quad (12)$$

4 Cost Evaluation for selecting appropriate Postponement/ Speculative Strategy

The following cost evaluations will elaborate the benefits among three strategies, namely full postponement, full speculation and hybrid strategies. Using such perspectives of cost management, the system manager can decide the inventory strategy accordingly.

a. Full postponement strategy:

The common product is hold as the buffer stock, which means the system holds the average demand for j=1,2,…,m products and only one kind of common product served to supplement the excess demand. Under such circumstance, the operating cost is shown in (13).

$$EC_1=EC(k_1=-\infty, Z(k_1)=F_u^{-1}(\rho)) \quad (13)$$

Following the procedure for forming (11), the operating cost of this strategy can be obtained as follows.

$$EC_1= \sum_{i=1}^{n}\left[(1+r)p_0Z(k_1)+c_0G(Z(k_1))\right]\sqrt{Var(I_i)} \quad (14)$$

, where $Var(I_i)=\sum_{j=1}^{m}Var(I_{ij})$ and $Z(k_1)=F_u^{-1}(\rho)$.

b. Full speculation strategy:

Based on this strategy, the system possesses the whole inventories by each speculative product. When the customers release specific orders, each order will be fulfilled with the exact products immediately. Therefore, the operating cost is given as (15), which the customers' service level, ρ, is achieved only by the speculative products.

$$EC_2=EC(k_2=F_u^{-1}(\rho), Z(k_2)=-\infty) \quad (15)$$

Similarly, (15) can be rewritten as (16), which is given in (12).

$$EC_2=[(1+r)pk_2+cG(k_2)]\sum_{j=1}^{m}\sum_{i=1}^{n}\sqrt{\mathrm{var}(I_{ij})} \quad (16)$$

, where $k_2=F_u^{-1}(\rho)$.

c. Hybrid strategy:

The system decides to hold the inventories of both the speculative and common products to jointly serve the service level, ρ, with the common product used as the buffer stock only. Then, the operating cost will be (17) based on the decision of both k and Z(k).

$$EC_3=EC(k_3, Z(k_3)) \quad (17)$$

According to (11), (17) can, therefore, be rewritten as (18).

$$EC_3=\sqrt{\{1+k_3R(k_3)-[R(k_3)]^2\}}\,[(1+r)P_0Z(k_3)+c_0 G(Z(k_3))]\sum_{i=1}^{n}\left[\sum_{j=1}^{m}Var(I_{ij})\right]^{1/2}+(1+r)[pk_3+(R(k_3)-k_3)p_0]\sum_{j=1}^{m}\sum_{i=1}^{n}\sqrt{Var(I_{ij})} \quad (18)$$

The service level, ρ, can be jointly achieved by the speculative products and the common product, which means ρ = Fu(k3)+ Fu(Z(k3))[1- Fu(k3)].

After deriving the above corresponding cost evaluations for three kinds of inventory strategies, which are full postponement, full speculation, and hybrid, the managers will then utilize such information to decide which is the best strategy with respective to the environment encountered.

5 Making decisions with respective to the profiles of environmental parameters

The different cost structure incurred by these three strategies had been developed in the preceding section. Accordingly, the comparisons are discussed to evaluate the effectiveness of the different strategies. The comparison from three different perspectives, which are demand uncertainty, service level, and price difference between the common product and the speculation products are given in the followings:

a. Comparisons between the full postponement and full speculation strategies, i.e. EC_1 and EC_2:

Applying (14) and (16), the cost ratio of these two strategies can be obtained as (19).

$$\frac{EC_1}{EC_2}=\frac{[(1+r)P_0k_1+c_0G(k_1)]\sum_{i=1}^{n}\sqrt{\sum_{j=1}^{m}Var(I_{ij})}}{[(1+r)pk_2+cG(k_2)]\sum_{i=1}^{n}\sum_{j=1}^{m}\sqrt{Var(I_{ij})}} \quad (19)$$

Now, consider the following scenarios to have further insights of cost ratio:

(1) If the procurement cost and the backorder cost from both the common product and the speculative products j, j=1, …, m are identical with the same service level, ρ (that is, $\frac{P_0}{P}=\frac{c_0}{c}$ and $k_1 = k_2$), then :

$$\frac{EC_1}{EC_2}=\frac{\sum_{i=1}^{n}\sqrt{\sum_{j=1}^{m}Var(I_{ij})}}{\sum_{i=1}^{n}\sum_{j=1}^{m}\sqrt{Var(I_{ij})}}\le 1 \quad (20)$$

, for the reason of $\sum_{j=1}^{m}\sum_{i=1}^{n}\sqrt{X_{ij}} \ge \sum_{i=1}^{n}\sqrt{\sum_{j=1}^{m}X_{ij}}$.

From the above, the postponement strategy will be always superior to speculation.

(2) If the procurement cost and the backorder cost of the common product are larger than the speculative products j, j=1,…, m, it is assumed that both ratios are equal to t, where t is a positive real number (that is, $\frac{P_0}{P}=\frac{c_0}{c}$ = t and $k_1 = k_2$), then $[(1+r)p_0k_1+c_0G(k_1)]$ = t $[(1+r)pk_2+cG(k_2)]$. Since the minimum of $\sum_{i=1}^{n}\sqrt{\sum_{j=1}^{m}X_{ij}}\Big/\sum_{i=1}^{n}\sum_{j=1}^{m}\sqrt{X_{ij}}$ will only occur at X_{ij} 's are identical, it implies that:

$$\frac{EC_2}{EC_1} = \frac{\sum_{i=1}^{n}\sum_{j=1}^{m}\sqrt{Var(I_{ij})}}{t * \sum_{i=1}^{n}\sqrt{\sum_{j=1}^{m} Var(I_{ij})}} \leq \frac{\sqrt{m}}{t}$$

(21)

, where $Var(I_{ij})$ is identical for i = 1,…,n; j = 1,…,m.

That is, the ratio of $\frac{EC_2}{EC_1}$ has the maximum value $\frac{\sqrt{m}}{t}$, which happens when the variations of the end-of-period net inventory of the speculative products are limited. Furthermore, if the extra modification cost to convert common product to become speculative products in the retailers is too high, i.e., t is much larger than $\sqrt{m}$, then, the ratio in (21) would imply $EC_2 \leq EC_1$. In the other words, if the procurement and backorder prices for the common product are too high and the customer demand for the speculative products is under control, then the full speculation strategy is preferred.

(3) If the above two respective costs are forced to be equal, for the same reason of $\sum_{j=1}^{m}\sum_{i=1}^{n}\sqrt{X_{ij}} \geq \sum_{i=1}^{n}\sqrt{\sum_{j=1}^{m} X_{ij}}$, the service level given by k_1 will be greater than k_2 under the assumption of $\frac{P_0}{P} = \frac{c_0}{c}$. That is, if the decision maker fixes the system cost, the full postponement strategy will result in a higher service level than full speculation.

b. Comparison of the Hybrid and the speculation strategies, i.e. EC3 and EC2:

Apply (16) and (18), the ratio of the EC3 and EC2 can be obtained as (22).

$$\frac{EC_3}{EC_2} = \frac{s(k_3)[(1+r)P_0 Z(k_3 + c_0 G(Z(k_3))]V' + (1+r)[Pk_3 + (R(k_3) - k_3)P_0]V''}{[(1+r)Pk_2 + cG(k_2)]V''}$$

(22)

,where $s(k_3)=\sqrt{1 + k_3 R(k_3) - R^2(k_3)}$,

$V' = \sum_{i=1}^{n}\sqrt{\sum_{j=1}^{m} Var(I_{ij})}$, and

$V'' = \sum_{j=1}^{m}\sum_{i=1}^{n}\sqrt{Var(I_{ij})}$.

When the procurement cost of the common product approaches speculative products, the ratio of (22) will remain less than 1, which means that the hybrid strategy is preferred. Furthermore, the worst scenario happens when the ratio is equal to 1, which implies that the costs incurred by the two strategies are identical.

The above comparisons take into account the environment factors to elicit the corresponding appropriate strategy. Such insights can be useful while utilizing the cost evaluation functions derived in the preceding sections. The management founding is summarized in table 1.

Table 1. Cost comparisons with respective to environment profiles

		Full Postponement Strategy	Hybrid Strategy
Full Speculation Strategy	Identical Service level & Extra cost incurred is ignored	Postponement is Superior	Hybrid strategy is superior
	Identical Service level & Extra cost incurred is significant	Speculation is Superior	
	Costs remain equal	Postponement results in better service level	

6 Conclusion

This study is dedicated to construct a mathematical model for two echelon supply chain in order to analyze the contributions of postponement strategy, under considering the environment profiles. Even though the model is utilized to compare the strategies only, the cost evaluation functions are tractable and solvable. In other words, while applying any inventory strategy in the corresponding supply chain, the decision makers can also employ the function derived in this study to figure out how to achieve the required service level and pool the risk. However, according to the preceding comparisons, the conclusions are presented as follows:

1. If the extra modification cost of the common product in the retailers is too high, the full speculation strategy is preferred. That is to say, the risk pooling incurred by the postponement strategy cannot leverage the benefit margin.
2. If the operating cost for each strategy is fixed at a certain level, the postponement strategy will result at a higher service level. For the ability of risk pooling, the postponement strategy can employ the common product to supplement the various ones, which can prevent the stock-out cost.
3. If the demand in each retailer varies too much, decision maker must face the trade-off between the end-of-period inventory variance and the ratio of the procurement and backorder cost between the common and speculative products. According to the ratio of such two factors, the proposed decision model can determine which strategy is preferred.
4. If the hybrid strategy is adopted, the cost incurred by the hybrid strategy will not exceed the cost of the full speculation strategy. Therefore, no matter what ratio of the procurement and backorder cost between the common and speculative products varies, the hybrid strategy is always preferred.

The comparisons among three different strategies provide the profound insight in both cost and performance perspectives. The model developed in this study can be used as a decision support tool to help determine which supply chain strategy is appropriate to the enterprise based on different system characteristics.

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