INVENTORY MANAGEMENT IN SUPPLY CHAINS

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Abstract

Managing of supply chains is now seen as a very strong competitive advantage. One of the most costly aspects of supply chains is the management of inventory. In the inventory management are many inefficiencies. In the paper are presented some examples and approaches how a coordination of actions brings benefit for the whole supply chain.

1. Introduction

A supply chain is defined as a chain of organizations that are involved, through linkages, in the different processes and activities that produce value in the form of product and services in the hands of the ultimate customer. A structure of supply chains is composed from potential suppliers, producers, distributors, customers etc. The sets are interconnected by physical, financial, information and decisional flows. The analysis and design of the supply chains has been an active area of research (see [1] - [6]). Most supply chains are composed of independent units with individual preferences. Each unit will attempt to optimize his own preference. The competition degrades supply chain performance and the units can benefit from coordination. There are some possibilities to design some centralized or decentralized systems with different performance measures.

One of the most costly aspects of supply chains is the management of inventory. The importance of inventory management and the need for the coordination of inventory decisions has been evident for a long time. Order quantity is a very important factor in inventory management. In the paper we show some examples and approaches for optimal assessment of order quantity for the whole supply chain. The problems of double marginalization, applying the economic order quantity and risk pooling in supply chains are presented.

2. Double marginalization problem

Double marginalization is a well-known cause of supply chain inefficiency (see [6]). Double marginalization problem occurs whenever the supply chain’s profits are divided among two or more firms and at least one of the firms influences demand. Each firm only considers its own profit margin and does not consider the supply chain’s margin.
We consider a supply chain with a supplier and a retailer that sells a product. The supplier produces each unit for a cost \( c \) and sells each unit to the retailer for a wholesale price \( w \). The retailer chooses an order quantity \( q \) and sells \( q \) units at price \( p(q) \), assuming that \( p(q) \) is decreasing, concave and twice differentiable function.

Centralized solution assumes a single agent has complete information and controls the entire supply chain (this is referred as the first-best solution) to maximize supply chain profit

\[
z(q) = q \left( p(q) - c \right).
\]

Solution of the problem we denote \( q^0 \).

Decentralized solution assumes the firms have incomplete information and make choices with the objective of maximizing their own profits. The retailer’s profit and the supplier’s profit are

\[
z_r(q) = q \left( p(q) - w \right), \quad z_s(q) = q \left( w - c \right)
\]

Solution of the problem we denote \( q^* \).

If the centralized and decentralized solutions differ, investigate how to modify the firm’s payoffs so that new decentralized solution corresponds to the centralized solution.

It can be shown that the retailer orders less than the supply chain optimal quantity \( (q^0 > q^*) \) whenever the supplier earns a positive profit and it holds

\[
z(q^0) > z_r(q^*) + z_s(q^*)
\]

Marginal cost pricing \((w = c)\) is one solution to double marginalization problem, but the supplier earns a zero profit. A better solution is a profit sharing contract, where the supplier earns \( v \) \( z(q) \) and the retailer earns \((1-v) \) \( z(q) \), for \( 0 \leq v \leq 1 \). The wholesale price \( w \) is now irrelevant to each firm’s profits and the supply chain earns the optimal profit.

3. Economic order quantity

It is assumed that the producer produces a product for which demand is relatively predictable and stable. The classic Economic Order Quantity (EOQ) model is a simple model that illustrates the trade-offs between ordering and holding costs. The question is how is applicable the model for supply chains.

We suppose that a producer produces a product for which demand is stable and the producer operates in an Economic Order Quantity type of environment. The problem arises because the order quantity that is optimal for the producer may not be optimal for the supply chain as a whole. One possibility of problem solving is focused on coordination of supply quantity between members of the supply chain. To illustrate a benefit of coordination we show a simple example.
4. Example

Suppose that a supply chain is composed of two members, a supplier and a producer. The producer produces $D = 1000$ units of a product per year at a constant rate. The producer purchases a component for the product from an upstream supplier. The ordering cost is $S_p = 500$ for a order and the holding cost of one component is $H_p = 10$ per year. Total cost for the producer is

$$TC_p = \frac{Q_p}{2} H_p + \frac{D}{Q_p} S_p .$$

The optimal order quantity for the producer is given by EOQ formula

$$Q_p = \sqrt{\frac{2DS_p}{H_p}} = 316 \text{ units}. $$

The supplier produces a bath of components with a production setup cost of $S_s = 1000$. The annual setup cost is a function of the producer order quantity

$$TC_s = \frac{D}{Q_p} S_s .$$

Total cost for the whole supply chain is

$$TC_c = \frac{Q_c}{2} H_p + \frac{D}{Q_c} (S_p + S_s) .$$

The optimal order quantity for the whole supply chain is given by EOQ formula

$$Q_c = \sqrt{\frac{2D(S_p + S_s)}{H_p}} = 548 \text{ units}. $$

We can compare the costs for optimal order quantity for the producer and the costs for optimal order quantity for the whole supply chain (see Tab. 1).

<table>
<thead>
<tr>
<th></th>
<th>$Q_p = 316$</th>
<th>$Q_c = 548$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$TC_p$</td>
<td>3162</td>
<td>3652</td>
</tr>
<tr>
<td>$TC_s$</td>
<td>3165</td>
<td>1825</td>
</tr>
<tr>
<td>$TC_c$</td>
<td>6327</td>
<td>5477</td>
</tr>
</tbody>
</table>

Tab. 1

The coordination of order quantity decreases total costs for the whole supply chain, but it is necessary to reallocate the costs between units of the supply chain.

5. Risk pooling

Risk pooling is an important concept in supply chain management (see [3]). In a supply chain is a variable demand for a product. We analyze connections between a supplier
and retailers and can compare a decentralized distribution system with a specific warehouse for each retailer and centralized distribution system with a warehouse for all retailers. Risk pooling concept suggests that demand variability is reduced by aggregation of demand. It becomes more likely that high demand from one retailer will be offset by low demand from another. The reduction of variability allows to reduce safety stock and therefore reduce average inventory. The reallocation of inventory is not possible in a decentralized distribution system where different warehouses serve different retailers. Benefit from risk pooling increases by higher coefficient of demand variation and by more negative correlation of demand by different retailers.

The outputs are illustrated by reports. The screen of the Risk Pool Game see Fig. 1.

There is a computerized version of the risk pool game (see [3]) to demonstrate effects of risk pooling concepts. The game proposes to compare a centralized system with a decentralized system by setting options:

- Initial inventories.

![Fig. 1](image_url)
6. Conclusion

Supply chain inventory management goes out the situation that supply chains are usually operated by independent units with individual preferences. There are many inefficiencies in supply chains. To be a supply chain more efficient as a whole it is necessary to apply coordination techniques to manipulate the behavior of one unit to the advantage of another. The Internet has affected inventory management most dramatically in the ability to be proactive and cooperative in the management of inventory systems. The paper presents some examples and approaches for coordination and cooperation activities in inventory management of supply chains.

The research project was supported by Grant No. 402/01/0771 from the Grant Agency of Czech Republic „Modeling of Supply Chains“ and CEZ: J 18/98: 311401001 from the University of Economics „Models and Methods for Economic Decisions“.

References


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