Network Flow Design & Safety Stock Placement for a Multi-Echelon Supply Chain

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Summary: This study developed a three stage procedure for the design of network flow and placement of safety stock in a Multi-Echelon supply chain shared by a large consumer goods manufacturer and a prominent retailer. The procedure provides a way to optimize the supply chain reducing the logistics cost while achieving desired customer service levels.

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KEY INSIGHTS
1. Trade-off between safety stock holding cost and transportation cost should be considered for the development of optimized flow design for distribution networks.
2. Product characteristics affect the network flow pattern and should be considered along with demand variability.
3. The placement of safety stock within a multi-echelon supply chain can be optimized by applying multi-echelon evaluation techniques.

Introduction
Supply Chain Management (SCM) is a set of approaches to integrate suppliers, manufacturers, warehouses, and stores efficiently, so that goods are produced and distributed at right quantities, to the right locations, and at the right time, in order to minimize system wide costs while satisfying service-level requirements (Simchi-Levi at. al., 2000). This field has received enormous attention in recent years as it can be utilized as a tool for gaining competitive edge in the increasingly competitive markets.

Historically, the echelons of the supply chain, warehouse, distributors, retailers, etc., have been managed independently, buffered by large inventories. Increasing competitive pressures and market globalization have forced firms adopt innovative techniques to design the supply chain that can deliver the requisite service with least cost. To remain competitive and decrease inventory, these firms must use multi-echelon inventory management interactively, while reducing operating costs and improving customer service.

So, the supply chain consists of various stages. A supply chain is a dynamic, stochastic, and complex system that might involve hundreds of participants. Inventory usually represents from 20 to 60 per cent of the total assets of manufacturing firms (Arnold J.R.T 1998). Therefore, systems for inventory management are critical in determining the bottom line profits of such firms. With the increasing complexities and intricate supply chains and
increasing global trade integrated supply chain network design is utilized by the firms to design and develop the supply chain network in order to reduce the overall cost and serve the customer with requisite levels of service. In this study we have presented a framework for the design of multi echelon supply chain network subjected to uncertain demand. We have provided the details of each step to describe the methodology and developed mathematical models for the design of multi echelon network.

**Business Situation**

The demand at the end customer level has to be fulfilled using a multi-echelon distribution network with multiple locations at each stage. The facilities at each stage in the supply chain have to be located geographically to deliver the goods for replenishment at a downstream stage to meet the end customer demand. There are service level requirements for the fulfillment of end customer demand generally set by the business policies and the stock out cost considerations. The facilities at each stage may be owned by separate business entities thus the distribution network can be a shared supply chain. The SKU demand is stochastic in nature and steady over a short planning horizon. The purpose of this study is to develop and suggest a method for the distribution network design in order to fulfill the customer demand at the minimum possible supply chain management cost for the channel.

**Three-Stage Procedure**

The general situation and the associated problem defined above can be witnessed across business categories particularly depicts the structures in the retailing scenarios. In order to solve the problem defined above and achieve the set objectives the multiple facilities at each stage have to be aligned in order to minimize the overall cost of supply chain management to meet the end customer demand originating at the extreme downstream end of the supply chain. The comprehensive view of the supply chain has to be considered for designing the network flow patterns for the various SKU groups thus in effect designing the distribution network based on SKU physical and stochastic demand characteristics.

In order to solve the problem defined in the section above we propose the approach described in detail in the chapters further. The three step approach developed can be summarized as given below:

**Network flow design**

In this section we provide the methodology to develop the network flow design based on the product characteristics and the stochastic demand considerations. We utilize the risk pooling effect in the generation of flow patterns for the SKU groups in order to effect the safety stock requirements and thus leading towards the consolidated network. On the other hand the higher level of consolidation gives rise to the higher transportation cost thus the model provides a tradeoff between the safety stock holding cost and the transportation cost for the network flow design.

**Multi echelon inventory management**

In this step we develop the multi echelon inventory management system for the selected network flow patterns for various SKU groups to reduce the overall cost of serving the customer. We use Guaranteed Service model developed by Graves and Willems in this step.

**Shelf Management**

Third and last step is to access the impact of the change in network flow and the inventory management systems o the interface with the end customer of the supply chain. In this step we develop methodologies to access the impact of the changes on the service parameters and develop the models to maximize the profit by considering the level of service required in each of the SKU segments.

**Conclusion**

The procedure developed above along with the mathematical modeling approach developed during the study for each step in the procedure leads to significant reduction in the total supply chain management cost for a Multi-Echelon supply network.