Placement of Safety Stocks in Multi-Echelon Inventory Systems

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Thesis Summary

Multi-echelon systems represent a network of activities that are often encountered in practice in the context of production and distribution systems. Instead of treating each activity in isolation, which might result in sub-optimality, multi-echelon systems take a holistic view of all the activities starting from the procurement of raw materials to the consumption of finished goods. The objective of multi-echelon systems is often defined in terms of minimising the system inventory level subject to achieving a desired customer service level.

Placement of safety stocks has been a key concern in the context of multi-echelon inventory systems. While placement of safety stocks in single stage systems has been satisfactorily dealt with in the literature, the same becomes extremely complicated when multiple stages are involved. Various solution procedures based on simplifying assumptions and approximations for specific multi-echelon systems exist in the literature, but there is no single answer to the problem. Deriving an exact formulation and solving it for general multi-echelon systems remains an extremely difficult task.

The objective of this study is to examine various multi-echelon inventory systems with a view to efficient and effective management of safety stocks under different operating conditions. For the purpose of the study, the multi-echelon inventory problems are classified based on the nature of demand. The complexity of the problems dealt with gradually increases in moving from stationary to non-stationary demand situations and from unlimited to limited availability of resources. For each class of problems, an exhaustive survey of the literature is carried out to identify the research gaps, and mathematical models are developed based on the research gaps for deciding on the placement of safety stocks that minimises the overall cost of the system. The solution methodologies developed are not only easily computable but also easily implementable. Implementation of the models is demonstrated by simulation. A case study is also presented to show how the models can be implemented in a real-life situation. The specific contributions of this study can be summarized as follows.

- An improvement of an existing model for a two-stage serial system under continuous review policy is suggested. The model has been widely referred to in the literature. The improved model results in lower expected total cost of the system under certain conditions.
- An operating policy is designed in the context of a distribution system under periodic review that helps in reaping the benefits of end-item demand information. It is shown that that the benefits of information can be obtained only when the lead time at the higher stage is smaller than the review period. It is also shown that the benefits of information can be availed of by dynamically setting the order-up-to levels at the higher stage, even though the end-item demand distribution is stationary over time.
- In the context of MRP systems, a methodology is developed for introducing a control over uncertainty, which is otherwise absent in the current MRP framework. This is achieved by developing a heuristic, which computes order-up-to levels, instead of order quantities, for different periods.
- In most of the cases, the functioning of the models is demonstrated with the help of numerical examples. A case study of the distribution system of a company is also presented, where the relevant models developed in this study are applied, and the implications of the models for real-life situations are examined. The models developed in this context are applicable to any distribution system prevailing in practice.

It is expected that the contributions of this study will be helpful to both academia and industries. The study will provide a ready platform for carrying out further research in this field. Also, the various models developed in this study may be applied by companies to achieve operational excellence and sustain competitive advantage in the long run, especially in the context of Supply Chain Management and Enterprise Resource Planning.