

# An Integrated Approach to Supply Chain Design: The Case of a Multi-Product, Multi-Region Production-Distribution System

## Abstract

Offering broad range of products and maintaining high customer service levels are presently two important strategic tools employed by firms. In this context, improving the supply chain efficiency has been receiving immense attention. Improving supply chain performance implies reduction of inventory and operating costs while ensuring a high customer service. The thesis looks at two alternatives to improve supply chain efficiency, *phasing strategy* and *postponement strategy*, for firms offering a broad range of products and having a widespread geographical presence. Phasing is the balanced spreading out of replenishments from central inventory to regional inventories, in a multi-echelon system. Postponement is delaying the point of product differentiation in an operational process to a later point in the supply chain.

In this thesis, a stochastic multi-product, multi-region production-distribution system with multi-echelon inventories is constructed to comparatively evaluate different production-distribution strategies. The production-distribution models are developed on the basis of existing literature and a survey of relevant industry practices. Production capacity, inventory (central and regional echelons), transportation costs and cost of switching to alternative strategy are the performance measures considered. Each strategy model is expressed as a non-linear programming problem. The strategies are comparatively evaluated by studying structural as well as infrastructural level differences. The strategies are compared analytically and using statistical and sensitivity analyses, to establish the conditions that favour each strategy.

The major findings of this thesis are:

1. The comparison of strategies in this thesis confirms the findings of previous phasing and postponement strategies studies with regards to significance of postponement investment cost and shipping lead-time factors.
2. Literature has highlighted the need for broader and integrated framework for evaluating production-distribution system performance. Assembly capacity and shipping costs have trade-offs with inventory carrying costs in production-distribution systems. The decision, of which strategy to adopt, rests on understanding these cost trade-offs clearly. This thesis work has attempted to understand these trade-offs by modelling different costs in detail.

3. Postponement investment cost, shipping lead-time, Modularity Index, fixed cost of shipping, fixed cost of assembly resources capacity and number of regional distribution centres are the significant parameters affecting the production-distribution strategy choice. Postponement strategy scores over the no-postponement strategies (phased or no-phasing) when postponement investment cost, fixed cost of assembly resources capacity and number of regional distribution centres are low, and when shipping lead-time, Modularity Index and fixed cost of shipping are high.
4. The use of an integrated and broader framework in this thesis helps understanding of impacts of Modularity Index, fixed cost of assembly resources capacity, fixed cost of shipping and number of regional distribution centres on production-distribution strategies. They have not received sufficient attention in previous works.
5. The use of Modularity Index and few other inventory related indices, developed in this thesis, enables explicit and easy determination of inventory cost savings. The highlight of Modularity Index developed in this thesis is that it captures the effects of product structure and demand variance.

It is felt that this thesis provides firms a framework to evaluate and improve supply chain performance. The thesis has derived the factor conditions that make each of the strategies attractive. The thesis modelling and findings in this thesis help firms in determining the ideal strategy for various industry scenarios. From research viewpoint, it is felt that this thesis work addresses some of the issues that have been cited as lacunae in integrated production-distribution systems research. It is hoped that this thesis will provide directions for future research on inventory-operating costs trade-offs in integrated production-distribution systems. The introduction of Modularity Index and certain other indices should be looked at from this perspective.