Essays on the Modeling of Integrated Production/Procurement, Distribution and Routing of Perishable Products

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Abstract

The major costs in a supply chain are the procurement of raw materials, transportation of raw materials from the suppliers to the manufacturing units, production of final goods, inventory carrying, and distribution, which includes costs such as transportation of finished goods to the distributors and the retailers or end customers. Optimization of overall supply chain cost involves a trade-off between various cost components. While maintaining high levels of inventory ensures high service level compliance for customers and handling uncertainties in production and distribution, it also increases the inventory carrying cost. Similarly, producing materials in bigger lot sizes can result in savings of manufacturing setup costs, but it negatively affects the inventory carrying costs.

The nature of products manufactured has an impact on supply chain modeling. While some of the products can be kept in inventory for a very long duration without deteriorating, products such as edible items and medicines start deteriorating with time and have a finite shelf life and are known as perishable items. Perishable products deteriorate with time and have a fixed shelf life beyond

which they are not fit for consumption for the end customers. Deterioration could be in the form of change, damage, decay, spoilage, obsolescence, and loss of utility or marginal value of a commodity. Examples of perishable products are vegetables, fish, milk, medicine, blood, and radioactive chemicals. A constant rate of deterioration has been assumed in most of the research carried out so far on perishable products. They may or may not have a scrap value.

Cost reduction has been one of the main objectives of supply chain management. Initial work in this area was done on production lot sizing, optimal order quantity, routing, and distribution. Increasing competition led to further research towards more cost reduction and the integrated models were developed where production and distribution decisions were made simultaneously. While a considerable amount of work has been done on IPD for perishable products, integration of all the processes considering the various parameters and entities is still going on. Also, there is a significant gap in the work for multi-perishable products in an IPD network. IPD integrated with vehicle routing to deliver goods to the end customers further increases the complexity of the process, but this coordination also significantly brings down the cost. Following IPD problems have been modeled and studied in the thesis based on the need, gaps identified, and their practical applications in the real world:

- Three basic models to demonstrate the modeling of an integrated production and distribution(IPD) system, VRP and a basic IPD with VRP for perishable products.
- IPD of multiple perishable products with inventory holding facilities at multiple echelons with direct delivery to end customers.
- IPD of a perishable product along with vehicle routing to the end retailers considering multiple routes, tolls, fast unloading, overtime driving, and FASTag usage.

- IPD of multiple perishable products considering the production in the dairy industry. Products have been considered with different perishable times across multiple periods in the planning horizon.
- Traveling purchaser problem for the procurement of perishable and breakable products.