Dissertation Abstract

Integrated Production-Distribution Models and Solution Approaches for Coordinating Supply Chains

Our study on this topic is motivated by the after-merge production-distribution coordination problem encountered in the supply chain practice of a major chemical company. After acquiring the manufacturing facility from one of the competitors, the company has experienced serious inefficiency in the operations of the combined manufacturing facilities and distribution networks. Since different manufacturing facilities have different production cost, material cost, inventory cost, and capacities, and since the combined distribution network is intertwined with more complicated relationships and constraints, it is very difficult for the management to sort out an effective and efficient supply chain logistics strategy. Consequently, the inventories are high and the transportation costs are high, while customer demand is still not satisfied on time at some customer locations. Since expensive ocean transporters (barges and ships) are used for transportation of cargo over the distribution networks, this inefficiency problem has cost the company millions of dollars more than necessary.

In the literature, the production planning and distribution/routing, as well as related inventory control, have been typically treated as independent problems and optimized separately. This independency, however, can no longer be assumed for coordinating supply chain processes. In a supply chain, all the business partners, directly or indirectly involved in the process of making the final product to the ultimate customers, must set a common goal toward maximizing the supply chain profitability. This can only be achieved by integrated optimization.

In general, optimally solving the integration problem is not an easy task due to its combinatorial nature. In many cases, often a closed form formulation can't be developed because of the complexity of the constraints. Even with a given formulation, the required computation time for verifying the optimal solution can be unbearable because of enormous amount of integer variables involved. Consequently, available results in the existing literature for handling this integration and coordination problem are very limited, despite its vast amount of applications and implications to the supply chain management practice. There is a natural need to develop new models and methodologies for solving integrated production-distribution problem for supply chain processes.

Most of the works on production-distribution integration ignore transportation capacity regarding fleet size, transporter travel speed, and amount of time available to make delivery. The transportation function is simplified as a fixed cost associated with quantity shipped. This simplification in most of the case will lead to infeasibility in the implementation of transporter schedules. For example, the assigned quantity may exceed the fleet capacity, or there is no enough time to make designated delivery. There are only four papers in current literature, to our knowledge, that try to accommodate explicitly transportation capacity requirement in the production-distribution model.

In this research we further extend the existing results. Our work differs from those existing ones in terms of

- number of production facilities (multiple vs. single)

- fleet characteristics (heterogeneous vs. homogeneous)

- transportation flexibility (multi-trip vs. single trip per transporter per period)

This research provide the first attempt so far to consider a multi-plant production planning and distribution problem, in which material transportation is carried out by heterogeneous fleets, each plant has an associated fleet, each transporter can make multiple trips in a time period, and customer demand may be fulfilled via deliveries by several transporters from different plants. All these extensions are based on the real world problem that motivated this study.

What we plan to study

The problem of coordinating the production and distribution can be briefly stated as follows. We are given a planning horizon H consisting of multiple time periods, a set of manufacturing sites, M, a set of customer locations, N, a fleet of heterogeneous transporters, V, and a distribution network with known transportation cost/time between each pair of nodes on the network. In particular, we have the following:

- Each manufacturing facility in M has a unit production cost, a unit holding cost, the available production capacity for each time period in H, and a fleet of heterogeneous transporters.

- Each customer has a sequence of demand to be filled, and a limited storage capacity, and a time-period dependent safety .stock requirements.

- Each transporter in the fleet has its own capacity, traveling speed, cost estimation. Whenever transportation need exceeds the fleet capacity, chartered transporters from the third party logistics providers are available but at a higher cost.

The integrated production-distribution problem is concerned with a quality solution that coordinates the production, distribution and inventories along the supply chain so that the total cost involved in this process is minimized. This cost minimization will in turn minimize the landed cost of a supply chain when the goods finally reach ultimate customers. This study will

- Provide a thorough literature review for the integrated production-distribution models.

- Propose a model for the general integrated problem.

- Study two special cases of the general problem: integration problem with direct shipment, and integration problem with single transporter.

- Provide new methodologies for both of these two cases.

- Finally, investigate solution approach to the general integrated problem.

What we have already done

We have

- Conducted a literature review for the integrated problem (in chapter 2).

- Developed a general model for the integrated procedure (in chapter 3), together with an analysis of its computational complexity.

- Proposed a new methodology for the integrated production and distribution problem assuming direct shipment (in chapter 4), and applied it to a real supply chain integration problem (see Appendix).

- Presented a heuristic algorithm for a sub-problem of the integrated problem involving single-transporter routing issues (in chapter 5), and analyzed its performance.