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Transforming the Supply Chain
10 steps to successful supply chain redesign
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For the better part of 35 years, truly leading-edge firms have made supply chain design/redesign an integral part of their overall corporate strategy. The focus has gradually evolved from a myopic consideration of the number and location of warehouses to a comprehensive examination of the entire supply chain, from sources of raw materials to the customer. To accomplish this analysis they employ tools known as strategic supply chain design computer-based mathematical models. The purpose of this article is to give the reader some notion of what it takes to use these tools.

Steps to Success

A typical supply chain redesign study proceeds as follows:

- Step 1: Establish Project Scope
- Step 2: Describe the Network
- Step 3: Obtain Customer Demand Data
- Step 4: Obtain Freight Costs
- Step 5: Obtain Facility Data
- Step 6: Validate the Model
- Step 7: Prepare Scenario Generation Data
- Step 8: Run Optimization Exercises
- Step 9: Analyze Solver Results
- Step 10: Develop the Plan of Action

A brief word about each step in the supply chain redesign process:

Step 1: Establish Project Scope. "But of course," you say, "don't all well-conceived projects begin here?" Well, yes. However, in this instance the process is a bit more complex. Consider, for example, a representative list of issues that may be addressed by a supply chain design tool (see Figure 1).

Figure 1: Issues Addressed by Supply Chain Design Tool

I. System Structure Issues
- A. Number and location of raw material suppliers
- B. Number and location of plants
- C. Number and location of production lines
- D. Number and location of DCS, cross-docks, ports, etc.
- E. Transportation link selection

II. Facility Ownership Issues
- A. Owned
- B. Leased
- C. Public (third party)

III. Facility Mission Issues
- A. Raw material suppliers 1. Procurement levels 2. Costs and capacities
- B. Plant locations 1. Manufacturing levels (a. intermediate products, b. finished products) 2. Costs and capacities
- C. DC locations 1. Throughput and storage levels 2. Costs and capacities

IV. "What if" Issues
- A. Business Decisions/Policy Issues 1. Supply chain vulnerability 2. Multi-division mergers 3. Facility capacity planning 4. Transportation policy 5. Seasonal demand/supply 6. International markets and outsourcing 7. Customer profitability 8. Product intros/deletions 9. Alternative networks 10. Implementation analysis
- B. Environmental Issues 1. Economic climate 2. Competitive pressures
- C. Sensitivity Issues 1. Cost vs. customer service 2. Cost vs. number of facilities 3. Parametric analysis of inputs

It is clear that the breadth of these issues is a far cry from the old "warehouse locations models." But the definition of scope does not end with issue selection. Rather, it is tightly coupled with the consideration of the supply chain scope to be included in the analysis as well:

- Geographic: United States, North America, Western Hemisphere, Europe, Pacific Basin, entire world
- Commodity: finished product categories, inclusion/exclusion of raw materials and intermediate products
- Manufacturing Detail: simple variable costs, fixed + variable costs, breakdown by process (production line), inclusion/exclusion of capacities

- Procurement Detail (if raw materials included): simple variable costs, fixed + variable costs, inclusion/exclusion of capacities
- Facility: ownership options, mission alternatives (eligibility of a given commodity at a given location), candidate sites
- Transportation: mode choices, policy alternatives

Step 2: Describe the Network. Network description is a straightforward process but it is not without pitfalls. Essentially it consists of developing lists for each of the fundamental model components, as applicable (see Figure 2).

Figure 2: Network Description

Commodities

- Raw Materials
- Intermediate Products
- Finished Products

Locations

- Raw Material Suppliers
- Manufacturing Locations
- Distribution Centers, Cross-Docks, Ports
- Customer Regions

Other

- Channels of Distribution
- Time Periods

For modeling, it is understood that ship-to-customer locations are customarily aggregated into larger customer regions and individual products stock-keeping units (SKUs) are grouped into major product lines or categories. While customer aggregation is usually straightforward, product aggregation requires experience and skill to do properly. With respect to time periods, many models are built at an annual level of detail. However, it is sometimes desirable to construct models with multiple time periods, or "buckets," so that questions of seasonality, inventory pre-build or long-term strategic planning may be explicitly addressed.

Step 3: Obtain Customer Demand Data. Customer demands, measured in units of weight, cube or units (cases, pallets, gallons, liters, etc.) must be obtained for each customer region/channel/finished product/time period. While theoretically this can be done by ad hoc methods, it is generally much more efficient and accurate to obtain the data from an actual business system such as an invoice or shipment history file. These historical demands can then be scaled by means of suitable forecast factors to drive out-year analyses.

Step 4: Obtain Freight Costs. Many options are available here, including use of the firm's own rates, distance-based equations and sophisticated simulations of proposed traffic management policies. Commercially available databases are available for less-than-truckload (LTL), truckload (TL) and parcel rates for most North American locations. When properly used, these databases are a rich source of unbiased data and can greatly facilitate the model-building process. Unfortunately, for the rest of the world machine-readable tariffs are generally not available; the study team must rely on internal resources and/or ad hoc rate solicitations.

Step 5: Obtain Facility Data. Facility data consist of procurement, manufacturing, distribution center, cross-dock, port, etc., costs and capacities, as well as conversion recipes (bills of material) at manufacturing locations. Facility data are technically optional. However, from a managerial perspective they are essential to a well-developed supply chain model and are often the principal drivers for the recommended supply chain design. Sources include historical cost accounts, engineering standards, extant contracts and commercial databases, the latter useful for establishing and understanding inherent regional differences. As with any effort that involves accounting data, challenges here include fixed vs. variable classifications, allocations by product and understanding the reasons for reporting differences across facilities (region, mission, managerial and/or workforce competence and so on). Facility data are typically a small percentage of the database but are often the most difficult to prepare and can generate the most controversy.

Step 6: Validate the Model. At this point, the model structure and database are essentially complete. But before succumbing to the temptation to turn the optimization engine loose, it is essential that the database be validated by means of an historical cost/flow baseline. The traditional methodology consists of "locking down" all facility and transportation link volumes per historical values, multiplying these flows by the cost coefficients developed for the model (thereby generating an estimate of total historical costs) and comparing the results with accounting data. The objective, of course, is to reconcile (or at least explain) differences to the satisfaction of both study team and management, thereby building credibility for the analyses to follow. At first blush, model validation would appear to be a daunting task; however, it can be greatly simplified if the database has been properly constructed and the software package includes well-designed baseline preparation features that leverage historical business system-derived data.

Step 7: Prepare Scenario Generation Data. Key to the success of a strategic supply chain design study is the rapid generation and solution of a wide range of scenarios. Real learning takes place as the team works its way through a well-structured series of "what if" questions, many of which will suggest themselves only after the modeling results start coming in. This is greatly facilitated by a rich selection of options, including (1) facility mission specification, (2) data scaling, (3) facility and process "lock in/lock out" features, (4) customer service limits, and so on. Both study team and management will rapidly lose patience if there is a substantial delay between posing a "what if" and obtaining an answer.

Step 8: Run Optimization Exercises. Each scenario defined in step 7 is done in conjunction with running a solver engine, a computer-based algorithm that takes a given set of data and finds the best (optimal) network configuration. It is generally acknowledged that the engine of choice for strategic supply chain design studies is mixed integer linear programming (details are beyond the scope of this article). The goal may be (1) cost minimization, (2) profit maximization (requires the introduction of selling prices so as to maximize margin) or (3) a weighted combination of cost and service.

Optimization exercises run the gamut from the very conservative (rationalization of network flows without any facility open/close decisions) to wide-open "green field" studies. The issues list above suggest the possible breadth of the analysis.

Step 9: Analyze Solver Results. Contemporary supply chain design packages come with an extensive repertoire of results interpretation/presentation aids, including maps, business graphics, canned reports, and links to MS Office. The latter is perhaps the most important because it enables the user to easily customize analysis and presentations consistent with management preferences.

Step 10: Develop the Plan of Action. The desired result of a supply chain design study should be a plan of action, not simply a recommendation for more study. Relevant issues here may include (1) requests for capital; (2) site selection assistance; (3) facility design (outside & inside); (4) negotiation of leases; (5) negotiation of contracts for outsourcing of raw material procurement and/or manufacturing; (6) selection of third-party providers of distribution center, transportation, freight payment, etc., services; (7) negotiating new carrier contracts in light of a redesigned network; (8) acquisition of software such as transportation management systems (TMS) and warehouse management systems (WMS).

Conclusions

Contemporary strategic supply chain design tools provide the means by which management can analyze the entire supply chain with a degree of rigor and accuracy that was heretofore essentially impossible. They can serve as the organizational catalyst for implementing supply chain concepts and can suggest strategies that establish genuine competitive advantage.

One last point: There is an unfortunate belief among some that supply chain strategy in general, and network design in particular, should be revisited only periodically, say once every five years or so (perhaps in conjunction with capital approval cycles or lease expirations). Nothing could be farther from the truth…or potentially more damaging to the firm. Contemporary supply chains exist in an environment so dynamic that leading-edge firms use supply chain design tools on a continuous basis and revisit major strategic questions at least annually. The benefits derived typically far exceed the modest marginal investment.

About the Author: *Dr. Jeffrey Karrenbauer is president and a founding director of INSIGHT, a provider of decision support systems for supply chain professionals. His latest work includes a focus on hardening supply chains and reducing their vulnerability to acts of nature, or those of an intelligent adversary, as well as merging supply chain design with inventory optimization and transportation procurement. More information at www.insight-mss.com.*