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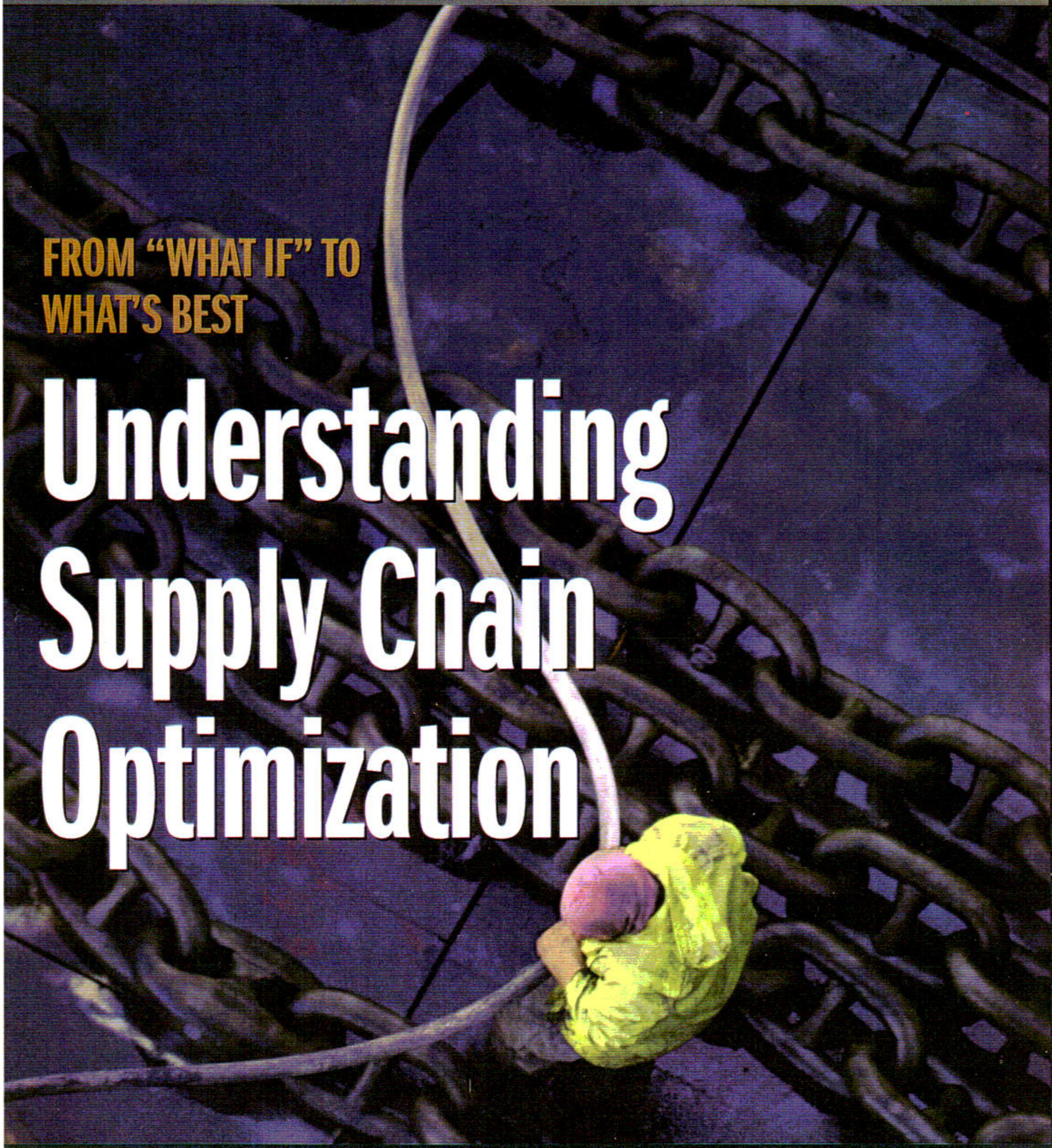

FROM "WHAT IF" TO WHAT'S BEST

Understanding Supply Chain Optimization

GETTING A HANDLE ON THE MATHEMATICS AND PROCESSES THAT DRIVE SUPPLY CHAIN OPTIMIZATION SOFTWARE WILL NOT ONLY HELP YOU MAKE THE RIGHT CHOICE FOR YOUR FIRM'S NEEDS, BUT WILL PROVIDE INSIGHT INTO THE VERY NATURE OF DECISION-MAKING THAT DRIVES YOUR PROCUREMENT, PRODUCTION AND LOGISTICS PROCESSES.

UNDERSTANDING SUPPLY CHAIN OPTIMIZATION: From "What If" to What's Best

By Jerry Bendiner, M.Sc.

DAY IN AND DAY OUT, ORGANIZATIONS ARE FACED with the need to evaluate both tactical and strategic supply chain management decisions, from the sourcing of raw materials to the ultimate distribution of finished goods to the customer. The effective management of the product supply chain has grown in importance with the realization that it represents a major opportunity for organizations to improve operational performance and overall margins.

From fertilizers to cookies, from cement to beer and chemicals, the basic goal remains the same: to identify the most cost-effective or profitable way of getting the right product to the right place at the right time, given a host of working and business constraints and parameters.

This is easier said than done. The size of the scenarios to be analyzed grows almost exponentially with the size of the operation. As the number of plants, production processes, terminals, modes, products and customers increases, the decision maker faces a very large number of feasible and "logical" action plans to chose from. Furthermore, he needs to balance supply, capacities and demand and trade off all relevant costs, such as transportation, production and storage. To make matters worse, the answers are usually needed yesterday.

The introduction of spreadsheet technology in the 1980s and its evolution has offered the logistics planning community a user-friendly environment where models can be built and modified quickly by the user himself. It is by far the most prevalent planning/modeling choice in most industries. These tools allow the user to arrive at a feasible plan or solution for problems of reasonable size, but usually not the optimal one.

FOR THE MODEL TO GENERATE the expected benefits, its scope must incorporate all those aspects of the product supply chain where trade-offs and decisions are being made. For organizations with multiple plants, terminals, products and modes, the model typically will encompass the entire network.

The challenge now is to provide decision makers an alternative tool. Such a tool will enable them to analyze situations and scenarios quickly and effectively, and will identify for them the best strategy or action plan. The growth in computing power over the past decade has made it possible to design supply chain optimization systems that accomplish this, for even the largest of companies.

The payoff can be dramatic. It is common to find a 5 to 15 percent bottom-line gap between a feasible, sound supply/distribution plan and the best, optimal one.

In its most generic format, the objective of these systems is to find the least annual cost or maximum annual margin production, inventory and distribution configuration. At the same time, they must satisfy customer demand at the targeted service levels, while ensuring that all prespecified operational and business constraints are being met.

Production capacities, inventory storage, production dependencies, rail car fleet size and loading/unloading capabilities by terminal are examples of typical operational constraints. Examples of business constraints are: minimum inventory levels, sourcing preferences (customer driven) and minimum (contracted) supply from an external source.

Although some operational and business constraints will vary, the basic concepts and modeling approach apply to most industries and business situations.

For the model to generate the expected benefits, its scope must incorporate all those aspects of the product supply chain where trade-offs and decisions are being made. For organizations with multiple plants, terminals, products and modes, the model typically will encompass the entire network, from the source of raw materials to the final distribution of finished goods to customers. In other situations, the model might focus on the transportation, production or raw material supply.

An important element that defines the size (and therefore the complexity) of the model is its planning horizon and the time unit. In seasonal industries such as fertilizers and cement, the need to capture these fluctuations requires typically a rolling 12-month model. In other cases, depending on the objective of the model, a one-year, single-period model might be sufficient.

In The Beginning There Was ...

THE APPLICATION of quantitative techniques in the supply chain/logistics field has to be considered one of the most successful marriages of academia and industry.

The basic mathematical technique, linear programming, and the theoretical framework for formulating and solving resource allocation, distribution and transportation planning problems were invented and developed in the late 1940s.

The theory became a reality in the late 1960s and 1970s, when the more widespread use of powerful mainframe computers made it applicable to industry. Since then, the incredible growth in desktop computing power and the introduction of improved algorithms is allowing organizations to model and solve very large supply chain problems in a matter of minutes instead of days (or weeks).

A typical supply chain network can be described very accurately by means of linear objective/cost functions and a variable number of linear constraints and relationships. The linear cost function incorporates "straight line" financial components such as variable manufacturing cost, overtime cost, handling and storage cost, direct and transfer freight, and revenue.

The bulk of operational and business constraints can also be represented in a linear, straight line format:

- resource utilization (labor, materials)
- production capacity
- demand fulfillment
- inventory storage capacity
- minimum inventory requirements
- fleet utilization
- product formulations and yields
- throughput capacity

The System and Its Major Components

A TRUE supply chain optimization system typically incorporates three components:

- an optimizer (the mathematical programming algorithm)
- a mathematical model/representation of the supply chain
- a front-end, menu driven database management and reporting system.

Other methodologies (such as heuristics) can be used to "solve" supply chain problems. Systems based on such methodologies do not include an optimizer and their solutions are not necessarily optimal.

The front-end database management and reporting component serves as interface between the user, the optimization model and other corporate sources of data. It should allow the user to first define the specifics of the scenario to be analyzed and then review the proposed supply/distribution plan via graphs, charts and/or management reports.

Via user-friendly menus, the user should be able to:

- refresh the system's database files with the most current data downloaded from other corporate databases and systems (forecasts, freight rates, prices, current inventories, etc.)
- view, list, query, sort and edit data
- check for input data inconsistencies (such as minimum demand exceeding maximum supply or a new customer demand record with no corresponding pricing data)
- establish the specific conditions and assumptions for a given scenario:
  - type of objective function (minimum total cost, maximum margin, etc.)
  - include/exclude a given plant, line, product, cost variable, etc.

AT THE STRATEGIC LEVEL, the system can help first determine the optimal network configuration (number and location of plants and terminals) and, subsequently, evaluate the financial impact of changes to this configuration, such as adding or removing terminals.

- establish a "base case scenario" for comparison purposes
- currency exchange rate, if applicable
- view/print solution information from the latest scenario run

An optimal solution to a specific scenario is generated by first interpreting, converting and feeding the corresponding data to the mathematical model and then solving it with the help of the optimizer. Both steps are fully automated and the process itself is totally transparent to the user. Once completed, the solution is available for analysis.

There are a number of features that will enhance the functionality and user-friendliness of the system:

- maximizing the update of data via automated downloads from other corporate databases
- the ability to store corporate data in its original codes and structure, and convert it to model-ready when a scenario is to be analyzed, thereby minimizing the risk of inconsistencies, especially in the areas of unit freight costs and unit prices
- the ability to upload planning information to other corporate systems (such as the annual production and shipping plan and the resulting financial figures)
- comprehensive data integrity capabilities to audit scenario data before the optimization procedure is invoked
- global demand, freight and price escalators to facilitate the generation of "what if" scenarios
- the ability to generate missing freight rates via standard third-party software packages
- the ability to compare scenarios (such as the annual budget vs. the latest estimate)
- comprehensive costing and profitability analysis
- multiple currencies and volumetric units of measure
- multi-echelon capabilities, (e.g., the ability to recognize and allow for multi-level transfers of materials and/or finished goods, such as plant-terminal-terminal-customer)

Tactical and Strategic Uses

SUPPLY CHAIN optimization systems are helping organizations improve the quality of tactical operational decisions and also quantify and analyze strategic business issues.

At the tactical level, the system can be used to generate optimal sourcing, production and distribution decisions for the length of the planning horizon, which typically covers a year. Scenarios are run either as part of the organization's planning process or on an ad-hoc basis to address "surprises."

The system is used first to establish annual operating plans/budgets and then to re-evaluate them (typically monthly or quarterly) as new demand, capacity, cost and pricing information becomes available.

The output includes detailed information on the timing and size of:

- production by plant, process and product
- flow of raw materials into and from facilities
- movement of finished goods through the distribution network
- seasonal inventory build, by location and product

It also includes detailed financial information (costs and margins) at the product, facility and customer levels.

At the strategic level, the system can help first determine the optimal network configuration (number and location of plants and terminals) and, subsequently, evaluate the financial impact of changes to this configuration, such as adding or removing terminals. It is also used to evaluate the impact of variability in the product line, demand, capacity, costs and pricing. The financial information derived from the solution provides, at all times, consistent cost and profitability estimates.

From Logistics to Corporate Planning

IT IS INTERESTING to observe the evolution of these systems from the time of inception to the point were they become "mature" planning systems.

Most of them start as "pure" supply chain management tools intended for the uses above. As their credibility is established and their ability to quantify and evaluate scenarios becomes evident to other corporate functions (marketing, sales, finance), they slowly evolve to become the focal point for both planning data and all planning and strategic analyses in the company, such as a new pricing strategies, potential acquisitions and line extensions.

Critical Success Factors: No Pain, No Gain

LETS START BY defining "success." A successful system is one that has been fully implemented, is being used consistently, and is generating the benefits it was intended to.

These are truly incredibly powerful planning tools. Their profiles can rise to the highest corporate levels and provide these organizations a clear competitive advantage.

Unfortunately, perfectly sound systems may be ready but unable to take off. This represents a monumental missed opportunity. It can be avoided through good data, the right amount of data, the flexibility to make changes and the recognition by management that the system needs a custodian. Such a custodian is a resource with sufficient time to ride the learning curve and then keep both himself and the system current.

Feed It Good Data. The amount of data required for even a medium-size model can be intimidating: 1,000 customers, 100 products, 12 months and we already could have 1,000 x 100 x 12 demand constraints.

It should therefore be no surprise that 70 to 80 percent of the total system development and implementation effort

Conceptually, the supply chain optimization model will establish longer-term production allocation, inventory and supply patterns that will then serve as input and drive the shorter-term scheduling/operational model.

focuses entirely on the data management aspects of the system, mainly:

- the automated procedures to refresh the databases with the latest corporate downloads
- the data integrity routines to identify data inconsistencies before the optimization procedure is invoked
- the automated procedures to convert downloaded and input data into a format compatible with the model. These models typically require data on a per unit basis (costs, yields, prices, production rates, etc.) and in the same units of measure (volumetric and monetary). In an international operation, as an example, foreign currency costs and prices would need to be converted to U.S. funds before the model is invoked.

Very often, the process of developing the proper input data procedures and then validating it serves as a valuable (and unexpected) business learning tool to the players involved in the exercise.

Make it Flexible. Invariably, the required features and functionality of the system will tend to evolve as it is developed and then implemented.

This is due to the nature of decision support systems in general and relatively complex supply chain optimization models in particular. When fully implemented, the system will resemble the intended outcome, but never be exactly as originally scoped.

Regardless of the initial system scoping and design efforts, the first attempts to run and validate scenarios with a full set of input data will usually not yield a realistic solution. It will typically identify the need to adjust the automated data consistency checks, the management reports and, in many cases, some of the constraints and assumptions in the model.

This iterative process needs to continue until the suggested production, distribution and inventory patterns either match what is currently being done, or the differences can be logically explained and understood.

The concept of managing data and mathematical logic separately (through the front-end database management system and the mathematical model, respectively) and integrating them as part of each scenario run makes sense from a systems perspective. Furthermore, it enhances the ability of the user to work with the system, facilitates the generation of "what if" scenarios, and reduces the need for model modifications and enhancements.

Keep It Simple. It is important to reiterate the fact that the size and complexity of these models can become problematic from a data management point of view. The relationship between size and complexity is simple. More detail results in more data. More data means more input, more maintenance, more time and, invariably, more chances for error.

A good recipe for avoiding these problems is to keep in mind that these are typically planning, not scheduling tools and that, if necessary, data can and should be aggregated.

A more detailed, shorter-term scheduling model can interface effectively with a supply chain planning model such as the one described in this article. The major consideration has to be the need to link them hierarchically. This hierarchical modeling approach allows us to partition a complex problem into more meaningful and manageable subproblems.

Conceptually, the supply chain optimization model will establish longer-term production allocation, inventory and supply patterns that will then serve as input and drive the shorter-term scheduling/operational model. Within this framework, the short-term model will identify optimal action plans based on short-term parameters or considerations.

The size of a supply chain model is determined primarily by the number of customer destinations, products, facilities, modes and the number of periods (12 months, four quarters, one year, etc.). Where possible, data should be aggregated or simplified, such as by grouping low volume customers by state/region.

Use It or Lose It. One of the main reasons systems fail to take off once implemented is the user's lack of time to stay and keep the system current.

These systems do not require a full-time resource, but they do need a computer-literate resource, an assigned user/custodian. Management must give the custodian the sufficient time to ride the initial learning curve (four to five weeks of intense work to get familiarized with and calibrate the model) and then to maintain the system.

Both elements are required for this to succeed. If the learning and calibration is completed, but there is no physical time to properly maintain or run the system, the initial effort will inevitably be lost.

And Finally ...

FOR AN ORGANIZATION with multiple locations, production processes, products, modes and customers, where one can no longer plan by the seat of their pants, and where instinct and experience are not able to cope with the size and complexity of the operation, this is the type of planning aid to be examined.

With management support and an allocated resource, the payback period can be measured in days or weeks.

The question is not whether you can afford it, but whether you can afford not to. ♦

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