Proceedings of the 2000 Winter Simulation Conference
J. A. Joines, R. R. Barton, K. Kang, and P. A. Fishwick, eds.

A SUPPLY CHAIN CASE STUDY OF A FOOD MANUFACTURING MERGER

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ABSTRACT

A large food manufacturer recently decided to merge with another food manufacturer of similar size. The companies anticipated dealing with complex issues of combining their operations and supply chains. The companies decided to use simulation as an analysis tool for the merging of their supply chains. This paper presents a case study of the simulation study and the results.

1 INTRODUCTION

Companies experience many growing pains when involved in a merger situation. There are the usual issues found in the newspapers, such as who will be CEO, where will the headquarters be located, which employees will survive in redundant departments? In the case of manufacturers, the operational managers have to sort the huge issues of how the supply chain of the new entity will operate. Which plants will survive? Will existing distribution centers be used? Are there enough? Are new ones needed? If there are similar products, which plant will ship to which customer? These are extremely complex issues, which are affected by many dynamic factors. Simulation is an excellent tool for analyzing dynamic issues.

The two companies merging had many of these typical issues to deal with, and they realized this was an opportunity to analyze how their supply chain was currently operating. For the sake of this case study, we'll call one company "orange" and the other company "green." The green company has 4 manufacturing facilities which ship product to 3 different distribution centers. The orange company has 3 manufacturing facilities which all ship their products directly to their customers. The companies have some customers who are the same and each has customers that the other doesn't have. All of their customers have their own distribution centers.

The green company designed their supply chain system to use distribution centers, and therefore, planned little storage space at their plants for finished goods. They have very good response from their own distribution centers. The orange company planned to not use distribution centers and ship directly from their plants. They have a large amount of space at their manufacturing facilities for storing finished product. Currently, they even have available space for additional storage. Some suppliers are the same for both companies, some are independent. There is essentially no crossover in the products that each company produces and none is planned for the future.

Some potential options for the future supply chain are:

1. Continue all existing policies – more or less operate like 2 separate manufacturing entities with one central office.
2. Start the orange company shipping to the green company's distribution centers.
3. Start the green company shipping to the orange plants (make the orange plants be quasi distribution centers).

In general, the supply chain team believes the option to have the orange ship to the green distribution centers is going to be the most cost effective. The team believes that these distribution centers can be more responsive to their customers. They also believe that responsiveness can be gained with less inventory in the system and shorter cycles. Some general restrictions on the team are that there are funds available to expand existing distribution centers, but there are not funds to build or locate new distribution centers. Capacity relative to demand is very low in some plants. They know this at certain times of the year. The supply chain team has to answer question such as:

1. What is the reorder policy for each SKU?
2. What are the safety and target levels for inventory of each SKU?
3. What is the minimum order size for each SKU?

2 ANALYSIS TOOLS

The first step the supply chain team took was to discuss what analysis tools where available for such a problem. They discussed the merits of two analysis tools: linear programming (LP) and simulation. LP tools are very often used to determine where to locate distribution centers. The 2 main strengths of LP tools are that it provides a global optimal solution and that it can handle millions of alternative designs very quickly (Hicks 1999). The main weaknesses of LP are that it is often too cost focused and it is not able to consider stochastic (variable) issues through time. “And because of the nature of optimization, the optimal answer can change dramatically if there is a slight change in the inputs.” (Ingalls 1998) Such as demand or productive capacity or transportation costs.

The supply chain team started to realize that their problem was primarily about the setting of inventory policy. What is the risk of running out of product? Some examples of things companies find by analyzing their inventory policies are:

1. They are building safety stock on both sides of a pipeline. In many cases, a supplier and a customer build safety stocks on either side of a pipeline, so that both are insuring against stockouts. In other cases, a customer is unaware of the “hidden cost” associated with a supplier insuring against stock-outs.
2. There are huge lags due to the timing of decision making. In this situation, an order goes to Supplier 3 from the plant on Wednesday, but Supplier 3 plans its schedule on Tuesday, so that this information is not put into play for 6 days. This pattern repeats itself throughout the ordering chain, until the information that Supplier 1 has is nearly 3 weeks old.
3. Internal policies are inflating safety stock. In this situation, safety stock is not protecting against variability in demand so much as protecting against variability in supply from the plant, due to shipping policies, which require full truckloads.

The only way to assess risk is to consider the dynamics of a problem through time. If the problem is not dynamic, there are little or no risks. However, everything is dynamic – time moves on and things change that affect other things. The supply chain team knew that their problem was full of things that changed and decided that simulation was the only tool that could effectively analyze the problem considering these dynamics through time.

The supply chain team chose to use Simulation Dynamics because of their background in analyzing such problems in the consumer goods, foods, and pharmaceutical industries. Before diving into the actual simulation, the supply chain team had SDI help them identify these dynamics that affected their inventory policy:

1. Internal process of handling orders,
2. Plant capacity (sensitive to product mix changes through time),
3. Transportation time, and
4. Demand – dynamics of consumption.

The team realized that demand was probably the most important of all the issues they had to deal with. “The most critical factor in supply chain performance is demand variance or forecast error.” (Ingalls 1999) They realized that demand was very much related to the overall makeup of their product mix. They identified some characteristics of the product mix which affect demand:

1. Most products are high-volume, predictable demand,
2. A few products are low-volume, unpredictable demand,
3. Some products just fall in between (very tricky to predict demand),
4. Some products have strong seasonal demand (such as canned soft drinks in the summer), and
5. Some products are tied to extensive promotional efforts.

3 WHAT SHOULD BE MODELED AND HOW MUCH DETAIL?

3.1 Basic Processes and Elements

SDI spent time with the supply chain team in determining what the scope of the simulation would be. In addition to the above options and limitations, much more information was important to the construction of the simulation. The supply chain team along with SDI had to first identify the things that could be modeled with elements and processes. SDI Supply Chain Builder has a system of elements representing the following:

1. Locations,
2. Item types,
3. Items (materials, vehicles, resources),
4. Inventories,
5. Orders, and
6. Shipments.

An internal database structure stores these elements and the relationships among them. Supply Chain Builder also has a system of processes:

1. Consumption (Demand),
2. Ordering,

3. Assigning orders,
4. Filling orders,
5. Assembling from bills of materials,
6. Loading and unloading, and
7. Routing.

Figure 1 below shows the top level of the simulation which is an overview of the supply chain network as it exists for the 2 companies.

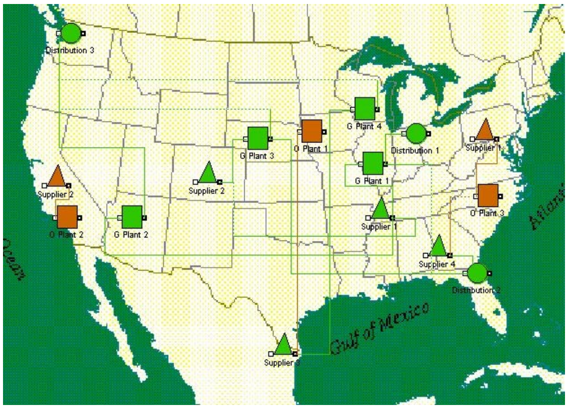

Figure 1: Overview of Supply Chain Network Model

3.2 Broad Simplifications, Options and Risks to Validity

Every simulation represents a compromise between exact reality and what the computer and the modeler are able to comprehend and construct in a reasonable time period. If a model errs on the side of too much detail, then the simulation process takes far too long, and a complete model is never delivered to be analyzed. If a model errs on the side of too little detail, then the model doesn't come close to representing reality, and the analysis results are not of any value. Simulation is also an iterative process. It is best to start with simple overview models and add detail as is determined necessary. One of the biggest issues discussed in the early stages of this simulation project was the issue of scaling.

How many locations and materials are needed to represent the dynamics of interest within the system? However, scaling can create some of its own problems. One of the problems is how do you scale uniformly? For example, if you choose to represent only one-third of the demand for a particular product, how big should a truck be – one-third normal size? How big should the distribution center be?

As mentioned above, every model represents a compromise. Some other simplifications considered in modeling the supply chain were:

1. Representation of trucks,
2. Representation of plant capacity, and
3. Long term planning.

Each of these was discussed before the actual model building began. The issues were then revisited as each iterative step of model building took place. There was more discussion to determine if more detail needed to be added for a particular area at each step.

3.2.1 Representation of Trucks

The transportation of goods brings up a lot of issues around the vehicles and policies employed. Many companies talk of policies such as "wait until full truckload, "don't wait until full truckload," and "wait a certain time, then send." All of these policies can be represented in the simulation. These issues can also have very serious effects on model run speed. Some conceptual simplifications made in this model were to 1) restrict orders to multiples and 2) have minimum order sizes that are the same as truckload sizes. It was decided at this time, that for the study of such a large system, this would yield sufficient detail.

3.2.2 Representation of Plant Capacity

In a supply chain model, orders are received at plants, and the simulation has to represent how the orders are produced. Some of the possible ways to represent the plant are:

1. Simple – constrained due to minimum order size,
2. Complex I – capability of delivering each SKU at X/day,
3. Complex II – treat plant as a finite capacity schedule, or
4. Complex III – full plant model.

The Simple representation of the plant assumes that the plant has an unlimited ability to provide product. However the production of product is delayed due to minimum order sizes. If the minimum order for some product is 100, and there is an order for 20, the customer won't receive it until a minimum order of 100 is produced. This representation is adequate for many models. The risk to validity of this approach can be assessed by q) some measure of plant utilization or b) analyzing the patterns of orders that are made against individual plants. Some patterns of orders will quickly be recognized as unfeasible for any plant to produce. While this approach is very simple, people focused on broad supply chains are very happy with this as a starting point. Detail can always be added later.

The Complex I representation looks at broad material-based constraints. It assumes the plant has the ability to produce a set amount of each product every day. This approach does not consider scheduling or sequencing issues of any type. However, it does include priority issues. If you run out of capacity, which customer do you short?

In the Complex II scenario, the plant's capacity is represented by a simulated finite capacity scheduler responding to the requirements placed on it. A detractor of this is that finite capacity schedulers typically make gross assumptions regarding the synchronous flow issues within a plant. Finite capacity schedulers are unable to recognize the lack of protective capacity (a buffer) or the need for reduced variability in an area.

Finally, the Complex III scenario uses a full plant model which represents multi-stage production processes with in-process buffers, in-process rate reliability. It includes a finite capacity scheduler as the driver of the plant.

3.2.3 Long Term Planning

Plants which have a low capacity relative to demand often build stock for anticipated future demand. This is commonly called "pulling ahead" of "stockpiling." When a forecast indicates that demand for production at a plant will exceed capacity, product should be stockpiled during periods of lower demand so that orders can be met during the demand peaks. In accounting terms, this is called a reserve. Representation of this issue can be tricky. There are several requirements to be able to represent this issue:

1. The planners know about some future period of demand that outstrips capacity – a promotion, a season (say Halloween, if you make candy).
2. The planners can do something about it – they have unused capacity leading up to that time period.

SDI Supply Chain Builder considers the issues of when to create reserves and how to calculate constraints.

4 REPRESENTING CONSUMPTION AND FORECASTING

The company has hundreds of SKUs that they want to represent. Each SKU has a daily base demand at each distribution center, and it also has a profile of changes to the actual demand over 150 days. Forecasting of the actual demand is represented by an optional look ahead or look behind capability looking at actuals dispersed by forecast error.

Each of the different SKUs can be represented in the database as falling into one of the categories that the supply chain team determined early in the process (repeated from earlier part of this paper):

1. Most products are high-volume, predictable demand.
2. A few products are low-volume, unpredictable demand.
3. Some products just fall in between (very tricky to predict demand).
4. Some products have strong seasonal demand (such as canned soft drinks in the summer).
5. Some products are tied to extensive promotional efforts.

Also, it is necessary to represent different forms of forecasting for the same SKU. Day-to-day forecasting or a standard look ahead – look behind process is used. In addition, a promotional look ahead method is used. For example, some products are strongly linked to promotions which are planned beyond the normal forecast period. Various strategies are employed for handling these promotions.

5 OUTPUT MEASURES

The simulation produced a number of output measures which were used to analyze different scenarios. Some of the output measures were:

1. Material in System – measured by each SKU at each location and each SKU in transit and by who owns it,
2. Percent Orders Filled – measured by SKU and by location be it plant, distribution center or customer distribution center, and
3. Costs – product, order processing, warehousing, shipping costs, tracking of product aging.

While costs can be derived on anything, what tends to be important in these models is the material in the system, percent orders filled, and truck trips.

6 RESULTS

The two companies completed their merger and very soon after modified their supply chain to be a more efficient operation. The supply chain team was able to use the simulation to determine how to size their existing distribution centers to accommodate the new products in their system. The idea to route the orange products through the green DC's was a great idea. After this change was made, it smoothed out the order pattern for the orange plants tremendously. They were able to go to their customer's DC's and devise ways to reduce the customer's stock and improve the customer's product availability.

Figure 2 shows the performance results for two alternative networks considered in the analyses. The model helped decrease inventory at the customer DC's by 25% while still having 99% orders filled at the customer. This decrease in inventory increased the number of truck trips, but the increased cost was dwarfed by the savings of the decreased inventory.

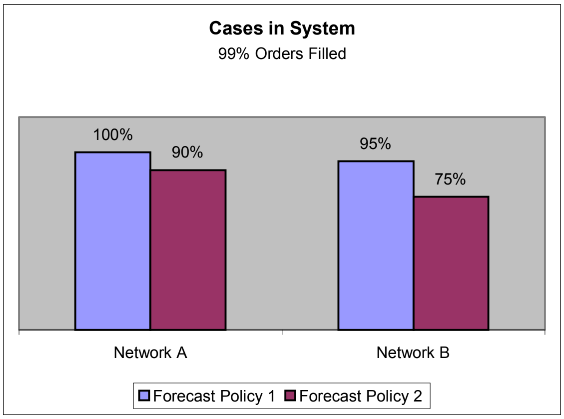

Figure 2: Performance Results for Two Alternative Networks

The team discovered interesting things about how to measure the results. In particular, they discovered that there were many ways to achieve high rates of percent orders filled at the customer. Figure 3 shows various ways to achieve a goal of Percent Orders Filled at customers' distribution centers.

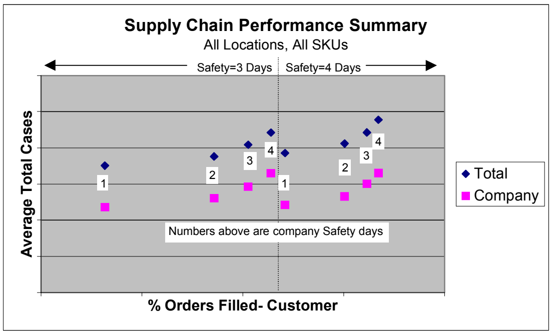

Figure 3: Percent Orders Filled Results – 2 Different Ways

Figure 4 compares the percent orders filled at the company with the percent orders filled at the customer.

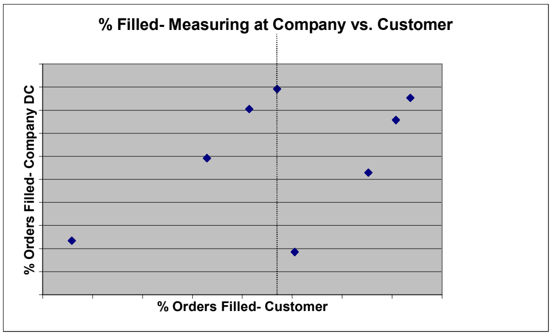

Figure 4: Percent Orders Filled at Company and Customer Comparison

These results gave the team an opportunity to drive their company to focus on what are the correct measures. They learned that things can be done so that both the customer and the manufacturer are making lots of money while not striving to reach unrealistic goals. Many times these unrealistic goals are just not the right goals.

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