A Simulation Model to Analyze the Impact of Outsourcing on Furniture Supply Chain Performance

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Abstract

As increasingly more companies outsource to Asia, US furniture companies' supply chains are becoming longer. To make their logistics networks more efficient, companies need to choose the right supply chain model, promote cooperation with their partners in the supply chain, and adopt new technologies to make better decisions and to manage better. Discrete-event simulation models are powerful tools that can be used by furniture manufacturers to perform what-if types of analyses to estimate the impact of their decisions on the overall performance prior to making any real changes to their system. We developed such a simulation model for a typical furniture manufacturer in northeastern Mississippi. By simulating the supply chain of the manufacturer under various scenarios, we show that outsourcing all of the business is not necessarily the best option because it may lead to a local reduction of capacity. This capacity reduction impacts the flexibility and profitability of the manufacturer. Outsourcing decisions may also be affected by product type. In general, outsourcing labor-intensive, slow-moving, and easy-to-transport items makes sense.

As increasingly more companies outsource to Asia, US furniture companies' supply chains are becoming longer. At the same time, US customers are demanding higher varieties of furniture products and shorter delivery times. Thus, furniture companies trying to succeed in an industry witnessing dramatic changes must have efficient logistics management to have a competitive advantage. To make their logistics networks more efficient, companies need to choose the right supply chain model, promote cooperation with their partners in the supply chain, and adopt new technologies to make better decisions and to manage better. Operations research (Winston 2004) tools, such as simulation, can be very effective in aiding the decision-making process. Our objective is to make the furniture manufacturers aware of such tools by presenting a simulation model that we have developed for a typical furniture manufacturer in Mississippi. Before we describe the simulation model, we give brief historical views of the state of the upholstered furniture industry in the United States and the key logistics issues that furniture manufacturers face.

The Upholstered Furniture Industry in the United States

Beginning in the late 1990s, the US furniture industry quickly shifted much of its production to Asia. Major furniture manufacturers either shut down their plants or reduced their production in the United States, like La-Z-Boy Inc., the second-largest furniture manufacturer in the country with $2.1 billion in annual sales, which shut down much of its US production and moved to China (Chavez 2007). Now, major US furniture companies focus on brand management and logistics management: Furniture retailers seek direct outsourcing. Furniture factories in Asia also seek direct US business relations. In other words, the whole furniture supply chain, in a global scope, is experiencing a dramatic change. To survive in this dynamic environment, all stakeholders need to define, develop, and maintain their competitiveness via tuning their supply chains.

In 2006, US consumers spent about $84 billion on residential furniture and bedding, which represents a 6.2 percent increase from 2005 (Epperson 2007). Table 1

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Table 1.—Shipments of wood and upholstered furniture in the United States (Epperson 2007).

	2005 ($, millions)	2006 ($, millions)	Change (%)
Wood			
Domestic	13,141	13,484	2.6
Imports	10,491	10,872	3.6
Upholstered			
Domestic	11,700	12,260	4.8
Imports	2,304	2,606	13.1
Imports from China	1,100	1,600	45.5

summarizes the shipments of wood and upholstered furniture in the United States.

In the United States, upholstered furniture imports from China have grown at an average of 56 percent a year over the past decade, and experts expect that the growth of upholstery imports from China will continue, especially for fabric upholstered furniture (Epperson 2007). The biggest upholstered furniture manufacturing cluster in the United States, which has about 200 companies and 25,000 employees, is located in northeastern Mississippi, and most of those companies receive supplies from Asia, usually from China and/or Vietnam (Mississippi State University 2006). A typical shipment from Asia to a furniture company located in northeastern Mississippi is illustrated in Figure 1. Three transportation modes make up the shipment: ocean, railway, and highway. After they arrive at Long Beach, California, by ocean, containers with furniture material, parts, or assemblies are shipped to Memphis, Tennessee, by rail and arrive at the northeastern Mississippi companies by truck.

As evidenced by the information provided in the preceding paragraphs, an increasing number of US furniture businesses are moving abroad to places such as China. Companies trying to prevent a complete outsourcing of their business as well as companies trying to take advantage of outsourcing can leverage logistics as a competitive tool. Some of the key logistics issues are provided next.

Logistics: A Key Issue in the Competition

As Table 1 shows, imports have a large share in the furniture market in the United States, and this share is growing. There are three major reasons why US furniture companies have been losing their market to imports in the past 15 years.

1. Globalization forces have exposed US furniture companies to global competition (Schuler and Buehlmann 2003).
2. Containerized shipping technology has significantly reduced global shipping costs (Schuler and Buehlmann 2003).
3. Production of furniture is labor intensive, and the labor cost in the United States is much higher compared with many developing countries (Scott 2006).

Table 1 also shows that the percentage of upholstered furniture imports is smaller than the percentage of case goods (wood furniture) imports. The underlying reasons include primarily the different requirements on delivery time due to the degree of customization and the different logistics costs. Typically, customers are not given many options with wooden furniture, so US furniture companies can order a large batch of standard wooden furniture without facing a big waste in inventory. Customers' orders are satisfied mainly from on-hand inventory, and delivery times are short. In contrast, with a diverse variety of offerings, customers often choose different colors or fabrics on their upholstered furniture. Holding a large inventory for all varieties is not only cost prohibitive but also risky because forecasting customers' demand is very difficult. At the same time, customers are not willing to wait months to receive their orders. They are typically willing to wait several days or weeks, and direct shipment from Asia cannot be shipped so fast in most cases. Therefore, US furniture companies must finalize the upholstered furniture production locally. Furthermore, upholstered furniture, such as bulky sofas and stuffed chairs, cannot be shipped as cheaply as case goods, and this is why case goods manufacturing in the United States has been hit hardest by Chinese competition in the past decade. However, imports of upholstered furniture have also started to increase in recent years because of significant

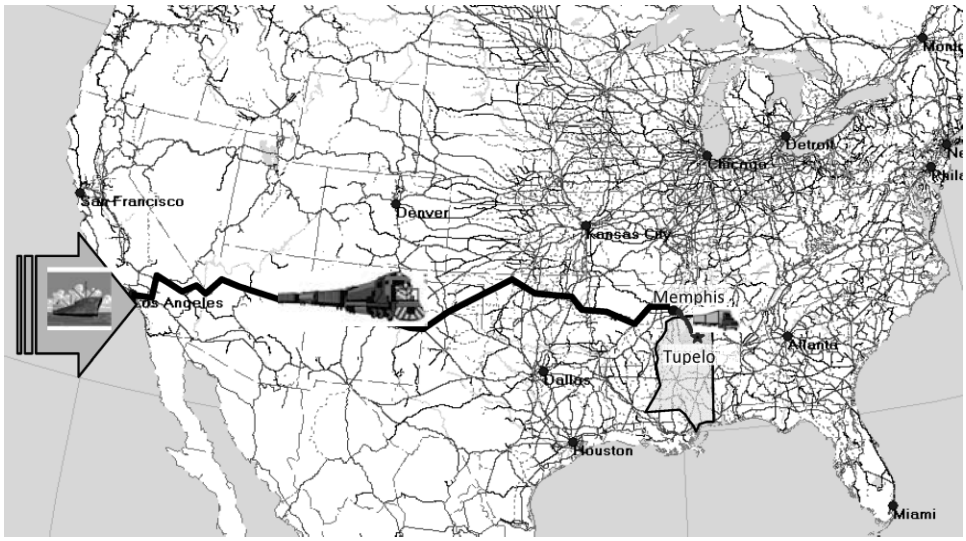

Figure 1.—A sample shipment from overseas to a furniture company located in northeastern Mississippi.

reductions in transportation lead times because of newly adopted business models and technologies in global furniture logistics.

Although the overall US furniture industry is in trouble, there are some furniture companies, such as Ashley Furniture Inc., that have done relatively well. For example, Ashley tripled its employment from 1998 to 2008 (Romell 2007). Their success was driven by two factors: *globalization* and excellent *supply chain management*. In fact, Ashley is listed along with IBM, Cisco, Canada Tire, and a few others as one of the ''supply chain icons'' by Gilmore (2006) because Ashley manages a long global supply chain using the just-in-time practice. From the success story of Ashley, companies can learn that logistics management is a key issue in upholstered furniture competition. This fact has been well proven by Wal-Mart's success in the retailing industry and Dell's success in the computer industry.

Logistics Management Challenges in the Upholstered Furniture Industry

In the preceding paragraphs, general logistics issues are discussed, but this section focuses more on the logistics challenges as they relate to the upholstered furniture industry. In an effort to identify the major logistics challenges faced by the upholstered furniture industry, we visited with 10 manufacturers in the northeastern Mississippi area. Based on our interviews with these manufacturers, we realized that the whole US economy—not just the furniture industry—is moving in the direction of customized products. For example, Dell succeeded in the computer industry because it allowed its customers to customize their computers. Similarly, IKEA is growing because it provides designed furniture to its customers. Upholstered furniture companies in the United States only recently realized that competitiveness can be improved by providing customized products for different markets. Midpriced upholstery maker Southern Furniture has recently launched a ''customer-order program'' to incorporate a major shift from ''factory-designed'' to ''have-it-your-way'' fabrics (Evans 2007). Another example is a Mississippi company that has been successful in the furniture business; this company assembles furniture for big resorts and hotel chains, such as Disney and Marriott, providing customized designs and assembling the furniture that goes to four- and five-star hotels. The material used in this company's furniture typically comes from China. The business has been profitable and has been able to grow because (1) it offers customized designs to a profitable market; (2) it provides timely service to repair damaged products, as this is very important for these luxurious hotels because of the loss of revenues when a hotel room is not fully furnished; (3) lead time is not a big concern because customers place orders well in advance; and (4) it uses outsourcing to its advantage by purchasing all its materials from China.

To better illustrate the logistics challenges, one has to analyze the structure of various supply chains that are utilized by furniture manufacturers. In general, there are four supply chain models for furniture imports from China to the United States, as illustrated in Figure 2 (Bryson et al. 2003).

In the Manufacturer Outsourcing Model, US manufacturers outsource parts or final products from China through agents but still keep some domestic production capacity. Most upholstery manufacturers in Mississippi follow this model because customers want to enjoy a large variety without having to wait too long. Many big furniture companies, such as Ashley or La-Z-Boy, have built their own production capacity in China and follow the Direct Investment Model. Big retail chains such as Wal-Mart and Pier 1 follow the Direct Sales Model and have established direct channels to obtain furniture products from Chinese manufacturers. However, many small and local furniture stores go through agents to receive furniture from China and follow the Agent Outsourcing Model.

The existence of agents in the first and fourth models happens because a small volume cannot justify the overhead costs of direct contact with Chinese manufacturers, and a small demand can cause large logistics costs. In our interviews with furniture manufacturers in Mississippi, company representatives said that they have to place an order 4 months in advance if they want a container load of raw materials directly from China. Although the price is low, the companies interviewed mentioned three problems: (1) the order delivery could be even later than promised, which results in additional in-transit inventory and loss of sales; (2) these small companies do not have the special equipment or expertise to unload containers, so container loading and unloading is costly (additional costs may also be due to product damages); and (3) predicting demand 4 months in advance is difficult and expensive. Therefore, small companies we have interviewed usually go through an experienced agent in Georgia that offers higher prices. For example, a company would call the agent 2 weeks in advance for about three truckloads of shipments. The agent operates a warehouse to hold inventory and provides a short lead time to its customers. An international furniture trade agent, which could be a third-party logistics provider, consolidates customers' demands so that they can fill containers easily, reduce the variability of demand over time, and improve inventory turn rates. Shipping furniture from overseas to the United States in full containers can reduce logistic costs by up to 20 percent (Terry 2007). However, only the largest furniture retailers and manufacturers can handle orders at the full container volume.

Although new technologies have been widely used in other industries to improve productivity, furniture manufacturing and logistics management have been slow to adopt these technologies. Furniture companies should invest more in new technologies in order to succeed or even to survive in

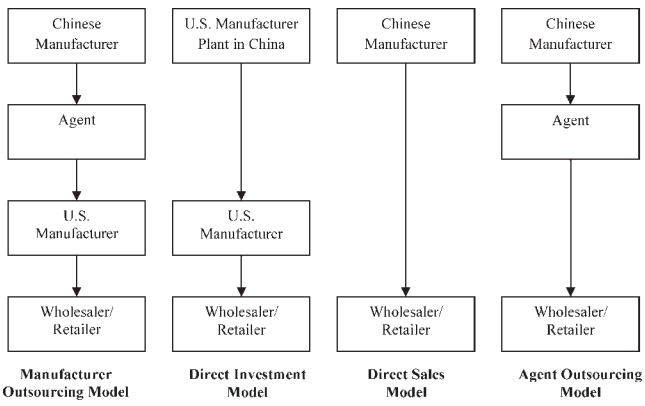

Figure 2.—Supply chain models for furniture imports from China to the United States (modified with permission from Bryson et al. 2003).

an industry that faces such a dramatic change. For example, bar codes can be used for inventory tracking in order to get accurate information on the amounts and locations of parts and products. Along the supply chain, different parties, including manufacturers, logistics companies, agents, wholesalers, and retailers, can use electronic data exchange technologies to share information in a more accurate and timely way. Better information sharing can help reduce the lead time and help each party to make better decisions.

Literature Review

We have provided some background on the current state of the furniture industry along with key logistics-related issues. This section provides an overview of the general outsourcing literature with examples from the furniture industry. Growth of furniture and home furnishing retailer sales value in the United States exceeded $100 billion in 2003 and increased to $123 billion in 2007 (US Census Bureau 2008). However, domestically produced furniture among these retailer sales has declined by more than $5 billion between 2000 and 2003 (Gazo and Quesada 2005). An increasing share of furniture imports, especially from Asia, fills the gap between domestic consumption and production. The increased competition from foreign furniture manufacturers has resulted in a loss of about 34,700 workers in the US wood furniture industry since 2000 (Buehlmann et al. 2003). The loss of business and job opportunities happens because of the influx of foreign-made products that are priced well below domestically made products (Nwagbara et al. 2002).

In furniture manufacturing, typically 40 percent of the total manufacturing cost is the labor cost (Whelan and Maklari 2002); this was the main reason why furniture manufacturers moved from New England to Michigan and then to Indiana, North Carolina, and Mississippi (Raymond 2004). To reduce manufacturing costs, companies now move to places like China to take advantage of lower labor costs. Chinese wages are about 16 times lower than US wages (International Labour Organization 2006). In addition, the Chinese-to-US currency exchange rate is fixed at an artificially low level and favors Chinese goods in the US market. To stay competitive, American wood furniture manufacturers use some of the following strategies: semi-customized products, fast order fulfillment, overseas manufacturing, and outsourcing to foreign manufacturers (Raymond 2002). The value of outsourcing depends on transportation costs, delivery time, and future market uncertainty (Nembhard et al. 2003). In the automobile, computer, and apparel industries, international outsourcing expanded considerably through the last decades of the 20th century (Taylor 1997, Dornier et al. 1998). This growth in globalization has motivated academic interest in global supply chain design and outsourcing management.

Product outsourcing is recognized as a way to gain the flexibility necessary for competitive advantage. Nembhard et al. (2003) developed a financial model to assess the option value of product outsourcing. Decision makers can use this valuation methodology to choose the appropriate outsourcing strategy, which is demonstrated by an example from the apparel manufacturing industry. A Monte Carlo simulation model was conducted to show the long-term value of outsourcing under dynamic market conditions. Nembhard et al. (2003) concluded that outsourcing is not always better than in-house production but can possibly be favorable. Jin (2005) conducted a survey with 113 US apparel manufacturers responding to show that companies with large sales volumes of fashion-oriented apparels tend to source globally. On the other hand, companies with small sales volumes that focus on basic items source mostly domestically. This empirical study concludes that global firms are not significantly different in terms of market performances versus domestic sourcing apparel firms. Finding a firm's optimal share of outsourcing is an emerging topic of interest. In some articles, outsourcing topics are analyzed by using a contract theoretical approach complemented with strategic organizational production mode research (Grossman and Hart 1986). Grossman and Helpman (2002) developed a model to exhibit the trade-off between in-house production and outsourcing: in-house production represents a more standard form of production with higher input costs for components, but outsourced production must overcome search frictions and contractual imperfections.

In an effort to do what was done for the apparel industry by Nembhard et al. (2003) as discussed previously, we have developed a simulation model to evaluate the advantages and the disadvantages of outsourcing in the furniture industry. The purpose of our model is to show the furniture manufacturing managers the value of operations research tools such as simulation.

Simulation Model

This section provides a description of the simulation model we developed to illustrate the supply chain structure of a typical Mississippi furniture manufacturer. The model was developed following our visits to the furniture manufacturers in the northeastern Mississippi area; it utilizes the information gathered from those manufacturers. The simulation follows the Manufacturer Outsourcing Model that was introduced in Figure 2 and is developed using ProModel, a ''provider of simulation-based, decision making tools and techniques for improving performance throughout the enterprise software package'' (ProModel 2010).

The simulation model is intended for midlevel managers of furniture companies to allow them to estimate the impact of various decisions related to outsourcing on the overall supply chain performance. The model can be used to perform what-if analyses. For example, the decision makers can adjust parameters such as defect rate, lead time distribution, demand distribution, and costs (inventory holding, production, and transportation) to estimate their impacts on supply chain performance measures. The performance measures that are captured by the model include order fill rate, lost sales, response time, inventory turn rate, and total cost. The results of what-if analysis (given in the ''Experimental Results'' section) can help furniture manufacturers, component suppliers, and retailers to compete more effectively in the national and international marketplaces.

The current model simulates a relatively simple supply chain of a typical furniture manufacturer. As shown in Figure 3, the furniture manufacturer located near Tupelo, Mississippi, has two suppliers and five customers. The customers are retail stores located in Portland, Chicago, Houston, New York City, and Jacksonville. One of the suppliers is an Asian supplier located in China, and the other one is local supplier located in Georgia. The manufacturer receives the raw material from the two suppliers and ships

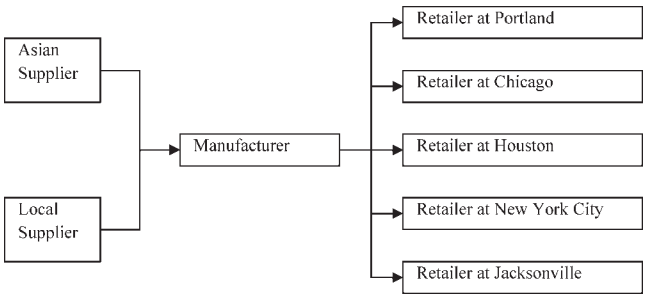

Figure 3.—Simulation model structure.

the finished goods to the five retailers. The model, however, can easily be customized to fit the needs of a specific manufacturer, such as adding more suppliers or retailers to the supply chain, adding more products, etc. Major changes to the simulation model would require the expertise of an employee with ProModel knowledge. Figure 4 shows a snapshot of the actual simulation model. Each component of the model is explained in more detail next.

Suppliers in the simulation model

There are two types of suppliers: an Asian supplier and a local supplier. The Asian supplier offers a lower price but longer lead times and higher damage rates. On the other hand, the local supplier offers a higher price but guarantees a short lead time with no damage. Input information for the two types of suppliers is estimated on the basis of the feedback collected from the furniture companies that we visited. Table 2 shows the current model settings on unit price, lead time, and damage rates of the Asian and local suppliers.

Lead time for the Asian supplier can be anywhere from 11 to 25 weeks and is divided into five components in the current simulation model.

- Transportation time on the sea (from the Asian supplier to Long Beach) is assumed to follow a triangular distribution with a minimum value of 9 weeks, the most likely value of 10 weeks, and a maximum value of 11 weeks. This is represented as $T(9, 10, 11)$ weeks.
- Waiting time at the import point of Long Beach: $T(0, 3, 8)$ weeks.
- Transportation time from Long Beach to Memphis via rail: $T(12, 13, 14)$ days.
- Waiting time at the Memphis load–unload station: $T(0, 1, 4)$ weeks.
- Highway transportation time from Memphis to the manufacturer in Tupelo: 1 day.

Lead time of a shipment from the local supplier is assumed to be constant at 1 week as long as inventory is available. We assume that the local supplier uses a (Q, R) inventory policy. The inventory at the local supplier is replenished at the beginning of the simulation to a level Q, and the local supplier continuously keeps track of its inventory. When the inventory level drops to R (the reorder point), the local supplier requests a new shipment of size Q, which is received after a fixed lead time. If the local supplier goes out of stock, retailers' outstanding orders waiting more than 1 week are considered as lost sales. In the current version of the simulation model, the capacity of the local supplier is set to a large number to make sure that no lost sales occur. However, we also analyzed other scenarios in which the local supplier has a limited capacity. All these settings are flexible so that a specific furniture manufacturer can use its input numbers and run the model to analyze its supply chain performance. The results of these different scenarios are presented in the ''Experimental Results'' section.

The manufacturer in the simulation model

We assume that the manufacturer produces only one type of finished product, which requires only one type of raw

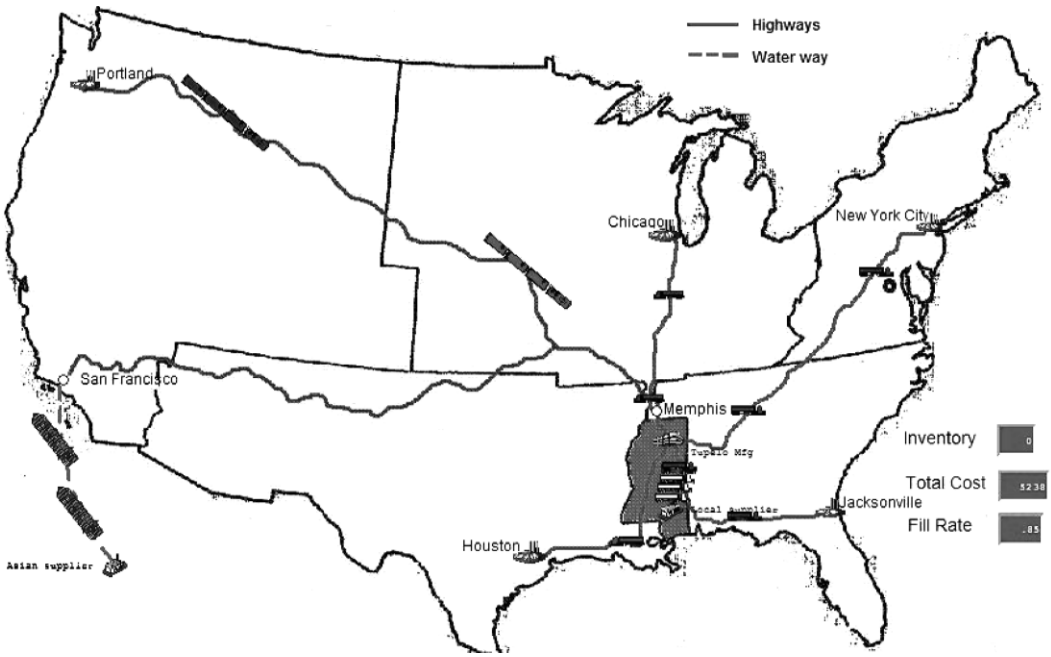

Figure 4.—A snapshot of the simulation model.

Table 2.—Model settings on parameters of suppliers (T denotes a triangular distribution).

	Unit price ($)	Lead time (wk)	Damage rate for upholstery goods (%)
Asian supplier	2	$T(11, 16, 25)$	10
Local supplier	7	1	0

material, but this assumption can be relaxed. To reduce the total cost of buying raw materials, the manufacturer would prefer to order everything from the Asian supplier since it offers a much cheaper unit price, but we analyze different scenarios to show that buying everything from the Asian supplier is not necessarily the best option. Also, in our interviews with Mississippi furniture companies, we found out that that they usually keep 1 month's worth of inventories and order a fixed amount of raw materials from the Asian supplier each month. The model uses the same setting, and we set the ordering amount equal to the total demand received in the previous 4-week period.

To study the impact of outsourcing on the manufacturer's purchasing cost, we run different scenarios where the manufacturer orders part of the required raw material from the Asian supplier and buys the rest from the local supplier. In these scenarios, when the manufacturer is out of stock (because of late arrivals or damaged items from the Asian supplier), we assume that the manufacturer places weekly orders from the local supplier.

Because the total lead time for an order from the Asian supplier varies significantly between 11 and 25 weeks, the manufacturer possibly goes out of stock sometimes. When there are not enough inventories to fulfill demands of the retailers, the manufacturer orders the backlog amount from the local supplier and can ship the delayed order to the customer 1 week later.

Retailers in the simulation model

The current simulation model includes five retailers that are distributed all over the United States. Weekly demands from each retailer follow the same normal distribution with a mean of 10 units and a variance of 2, i.e., $N(10, 2)$. We assume that the manufacturer schedules each retailer's delivery on a fixed day each week, as Table 3 shows.

All retailer orders during 1 week are aggregated on the delivery day. The manufacturer promises a 2-week lead time if the on-hand inventories will fill the order. The moving time along the path network in the simulation is not the actual travel time, but it is the total lead time from receiving the order to its delivery. If there is not enough inventory, then the manufacturer places an order from the local supplier and receives it 1 week later.

The arrival process in the simulation model

Once the simulation starts, the manufacturer initially has 1 month's worth of inventory on hand. Four prescheduled order arrivals are created in the simulation because the average lead time is set to be 4 months (16 wk). Because no historical demand data exist for these pre-scheduled orders, all the amounts are set to an average 4-week demand of 200 units. Once the simulation starts, the manufacturer places an order from the Asian supplier every 4 weeks. The ordering amount is equal to the total demand of the previous 4 weeks except for the first order, which is set to 200 units (i.e., same as the prescheduled arrivals). With the 1-year warm-up period set in the simulation, these initial starting conditions do not affect the final statistics.

Table 3.—Delivery schedule.

Retailer location	Weekly delivery day
Portland, OR	Monday
New York City, NY	Tuesday
Chicago, IL	Wednesday
Jacksonville, FL	Thursday
Houston, TX	Friday

The performance measures in the simulation model

Based on our interviews with furniture manufacturers in Mississippi, we identified the following six performance measures as those that are most commonly used. These six performance measures are collected in our current simulation model:

- *Inventory*: inventory level of the manufacturer's raw materials
- *Backlog*: backlog level of retailers' orders at the manufacturer
- *Purchasing costs*: total cost that the manufacturer spends to buy all raw materials
- *Fill rate*: percentage of retailer orders that are filled on time
- *Inventory holding cost*: calculated as a product of the average inventory level, an interest rate of 20 percent, and the unit cost of raw material from the Asian supplier at the end of the simulation
- *Backlog penalty cost*: calculated as a product of the average backlog level, a penalty rate of 30 percent, and the unit cost of raw material from the Asian supplier at the end of the simulation

The first four measures are tracked dynamically during the simulation, while the last two are collected at the end of the simulation.

Experimental Results

As discussed in the previous sections, we used our model to simulate the supply chain of a furniture manufacturer under different scenarios. The parameters that we change in our simulation are the unit prices of the materials purchased from the Asian supplier, the capacity of the local supplier, the percentage of demand supplied from the Asian supplier, and the time the retailers are willing to wait for an order.

In our base scenario, as Table 2 shows, the unit price of the Asian supplier is $2. However, we change this value from $2 to $7 in increments of $1. Each line in Figures 5 through 7 corresponds to a price level. The capacity of the local supplier in the base scenario is 120, but this value changes between 40 and 200 in increments of 40 in our experiments. Figure 5 shows the results for the scenario when the capacity of the local supplier is 200 (i.e., maximum local capacity). Figure 6 corresponds to the case when the capacity of the local supplier is 120 (average local capacity), and Figure 7 shows the case when the capacity of the local supplier is 40 (minimum local capacity). The other two scenarios (i.e., when capacity is 80 and 160) are not

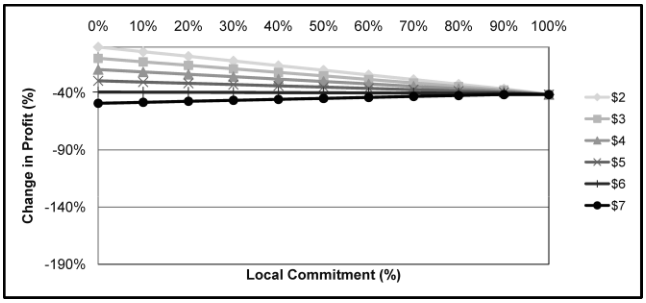

Figure 5.—Change in profit as outsourcing percentage changes when local capacity is high.

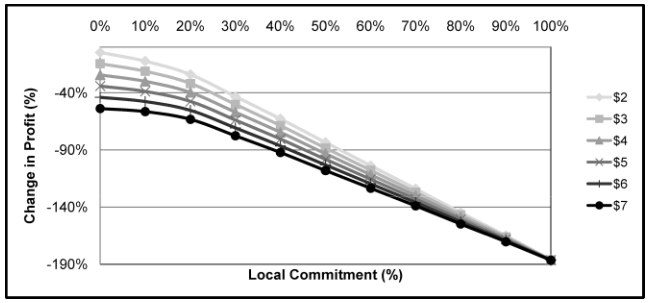

Figure 7.—Change in profit as outsourcing percentage changes when local capacity is low.

shown for the purposes of brevity. We also assume that the demand is fully outsourced in the base case. With the cost of the Asian supplier as $2 in the base case and the demand fully outsourced, the base case corresponds to the most profitable scenario. However, even when the manufacturer's demand is fully outsourced, because of uncertainties in lead time from the Asian supplier, the manufacturer will use the local supplier to satisfy retailers' demand on time. In Figures 5 through 7 the percentage of demand that the local supplier provides varies from 0 to 100 percent in increments of 10 percent, as shown on the *x* axis. We assume that the retailers are willing to wait a maximum of 1 week for items. If the order is not fulfilled within a week, then the retailers go to a different manufacturer. This assumption affects the value of lost sales. For example, we observed that as the capacity of the local supplier decreases, the value of lost sales increases. We also observed that as the percentage of demand requested from the Asian supplier decreases, the value of lost sales increases.

Figures 5 through 7 show how the profit of the manufacturer changes (the *y* axis of the figures) with respect to the base case. For example, Figure 5 shows the results when the local supplier has a high capacity (i.e., 200). Therefore, the demand can easily be met from the local supplier but at a higher cost. From Figure 5 we can conclude that $6 is the break-even price represented by the horizontal line. In other words, if the Asian supplier offers a unit price below $6, then seemingly all of the demand should be outsourced; however, this is not necessarily the case when the local supplier's capacity is lower as shown in Figures 6 and 7.

Figure 6 shows the results when the local supplier has an average capacity (i.e., 120). The results show that if the unit price of the Asian supplier is $7, then the manufacturer should purchase about 60 percent of its demand from the local supplier and outsource the remaining 40 percent of its demand. As can be seen from Figure 6, the line corresponding to $7 is almost flat until about the 60 percent level. This indicates that beyond the 60 percent point, the manufacturer's profit starts decreasing. If the Asian supplier's unit price is $2, then the manufacturer can potentially outsource all of the demand because the line corresponding to $2 is a strictly decreasing line. However, as Figure 6 shows, the increase in profits up to the 60 percent mark is not as significant as the gain in profits beyond the 60 percent mark by outsourcing. Therefore, purchasing 60 percent of the materials from the local supplier and outsourcing only 40 percent of the demand seems to be a good strategy for this scenario regardless of whether the unit price offered by the Asian supplier is as low as $2 or as high as $7 per unit.

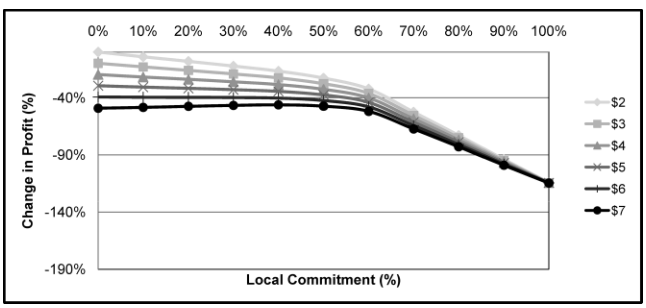

Figure 6.—Change in profit as outsourcing percentage changes when local capacity is medium.

Figure 7 shows a graph of the outsourcing impact on profit when the local supplier's capacity is low (i.e., 40). This case shows that the best decision for the furniture manufacturer would be to rely on the local supplier to satisfy 20 percent of its total demand and to outsource the remaining 80 percent of its demand.

Summary and Conclusions

Based on the analysis of our simulation results, we can derive a number of conclusions. Clearly, the results derived from the simulation analysis show that outsourcing all of the business is not necessarily the best option because it may lead to a local reduction of capacity. This reduction in capacity impacts the profitability and flexibility of the manufacturer. It is a fact that the prices that US manufacturers are facing for services outsourced to China and other low-wage countries are not as competitive as they used to be because the US furniture industry is getting weaker and outsourcing is still competitive at higher cost levels. The concern is that the supply chain of this industry is long. The furniture supply chain starts with planting and growing trees in forests, which takes years. In addition, the loss of the supporting infrastructure such as finishing suppliers, loggers, sawmills, pulp mills, etc., adds to the complexity of this supply chain. Therefore, recovering local capacity once it is lost will require time and large investments. Because of high investment costs, the incentives for recovering this capacity will be lower in the future. However, we recognize that outsourcing decisions are affected by product type. In general, outsourcing labor-intensive, slow-moving, and easy-to-transport items makes sense.

The models developed in this study allow furniture manufacturers to calculate a break-even point at which outsourcing becomes an attractive option for their businesses. It also allows performing what-if types of analyses.

Our study also demonstrates that simulation is a powerful tool if provided with the right input data. Simulation allows for incorporating interactions among decision variables and problem parameters as well as for incorporating uncertainties with input data. These are features that a spreadsheet-based model would not capture. These features allow building a more realistic model and therefore a more reliable model. A potential future work is to build a user-friendly interface for the simulation model so that the user would not be required to know ProModel to add/delete retailers to/from the supply chain, to add/delete products to/from the supply chain, and to add/delete transportation modes to/from the model.

Acknowledgment

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