Uncertainty in Textile Supply Chains

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Abstract

This study analyses the impact of uncertainty at different points in the textile supply chain, and tries to identify the weak points in the supply chain. The design adopted for the study is descriptive in nature, involving primary data collection from a sample of textile units in Bangalore city. The data was collected by interviewing the different textile units about their supply chain practices, the constraints they face in terms of uncertainty, and strategies adopted by them to resolve it. The paper suggests appropriate strategies and solutions to manage the uncertainty that occurs in textile supply chains at various nodes and due to varied reasons.

Keywords: Supply chain uncertainty, uncertainty in demand, uncertainty in supply, uncertainty in manufacturing.

1. Introduction

Textile and apparel retailing is a seasonal business. It is synonymous to rapid change, and as a result, commercial success or failure in the market is largely determined by the organization's flexibility and responsiveness. Responsiveness is characterized by short time-to-market, the ability to scale up (or down) quickly and the rapid incorporation of customer preferences into the design process. Therefore to meet the variable demand, manufacturers must build inventory and then draw them down as customer activity increases. The textile industry is a complex industry involving unpredictable variation in market trends.

The textile and apparel supply chain consists basically of the retailer, manufacturer, and fabric supplier. The retailer sells the apparel to the consumer. The manufacturer is the apparel producer, and in some cases the manufacturer gives the work to subcontractors, who do the actual apparel manufacturing work in accordance with the quality and construction specifications issued by the manufacturer. The fabric supplier provides the required fabrics to the manufacturer. The fabric supplier may have his own production facility or may be a distributor of fabrics to the apparel manufacturers.

The current functioning of the textile supply chain is a linear process. The retailer issues orders to the manufacturer after his inventory goes down. The manufacturer sends orders to the fabric supplier for necessary fabrics to process the retailer's orders. The fabric supplier manufactures the ordered fabrics and delivers them to the manufacturer. The manufacturer receives the fabrics and other accessories (e.g. zippers, buttons, labels, and so on) and manufactures the styles and delivers them to the retailer.

The garment manufacturer has an important role in coordinating production activities according to the trends in the market. Based on the forecasts and point-of-sale tracking at retail, the retailer places purchase orders with garment contractors. Then the garment manufacturer works out his production schedule, and finalizes the delivery and shipping dates to the retailer. Next the garment manufacturer places fabric orders with the textile manufacturer. A good understanding of the fashion industry is essential in order to gauge the impact of several factors on the supply chain.

The order-fulfillment process involves the coordination of diverse supply-chain activities, such as sales commitment, manufacturing, and relationships with suppliers for purchasing or shipping, that normally take place in several different business units. Uncertainty cannot be avoided for a finished product, because the processes involve the many different organizations that comprise the supply-chain network. The mechanism by which the order-fulfillment process is managed to mitigate the

negative effects of uncertainty is the key to the successful operation of a supply chain (Ho et al, 2005). In light of the complexity of the interactions among companies in the order-fulfillment process, Davis (1993) concluded that demand, manufacturing, and supply uncertainty were the main problems that plague the management of order fulfillment. Each of these uncertainties must be thoroughly measured and analyzed if its impact on the order-fulfillment process is to be fully understood and performance improved.

Uncertainty in Demand: Variations in customer demand are one source of supply-chain uncertainty. Demand uncertainty is associated with product characteristics or environmental factors, and this makes it difficult to predict and control the demand for a final product. From the previous studies, there are many facts on the demand side that must be considered in determining demand uncertainties, such as rate of new product introduction (Chopra and Meindel, 2001), product lifecycle (Fisher, 1997), product variety (Fisher, 1997), lead-time from design to production, variation of marketing product mix (Lee and Billington, 1993), number of sales channels, accuracy of demand forecasts, and predictability of product demand (Vickery et al. 1999).

Uncertainty in Supply: Failure to deliver as required by the customer is another source of supply chain uncertainty. It may be caused by a malfunctioning production process at the supplier, late delivery due to unexpected weather conditions, or unacceptable quality of the delivered products. Supply uncertainty may be caused due to reasons such as frequency of changing suppliers of critical materials, complexity of critical materials, complexity of procurement technology for critical materials, time specificity of materials procurement, delivery frequency of critical materials, delayed delivery of critical materials, and fluctuations in the selling price of critical materials.

Uncertainty in Manufacturing: Variations in manufacturing lead-time are the major source of manufacturing uncertainty. Manufacturing uncertainties include degree of process interaction, degree of process decomposition, degree of interaction among components, degree of product decomposition (Khurana, 1999) and process yield stability.

Supply chains are multi-location entities, and disruptions are almost never purely local; rather, they cascade through the system, with upstream disruptions causing downstream stock-outs. Supply uncertainty and demand uncertainty share several similarities. In both cases, the problem boils down to not having enough supply to meet the demand. Firms may use similar strategies to protect against supply uncertainty and demand uncertainty; for example, they may hold extra inventory, utilize multiple suppliers, or try to improve their forecasts of uncertain events.

Inventory Placement: In supply chain management, a common question is which stages should hold inventory. Under demand uncertainty, the tendency is to push inventory as far upstream as possible, since the cost of holding inventory tends to increase as one move downstream in a supply chain. Under supply uncertainty, however, the tendency is reversed. It is preferable to hold inventory downstream, since such inventory can be used to protect against disruptions anywhere in the supply chain.

Supplier Redundancy: Consider a single firm with a single supplier. The question here is what would be the value of adding additional, backup, suppliers? Let's suppose that each supplier has sufficient capacity to meet a reasonable level of demand. Then, under demand uncertainty, the value of the backup suppliers is small—they fill in only when the demand exceeds the capacity, which happens infrequently. On the other hand, the backup suppliers play a vital role under supply uncertainty, since they can provide capacity both to meet demand during a disruption to the primary supplier and to ramp back up after a disruption.

The Cost of Reliability: A firm that is used to planning primarily for demand uncertainty may recognize the importance of planning for supply uncertainty but may be reluctant to do so if it requires a large up-front investment in inventory or infrastructure. Fortunately, a small amount of extra inventory goes a long way in protecting against disruptions.

Shift the de-coupling point: A major problem in all supply chains, but significantly worse for global business, is that they have little visibility of 'real' demand. Because global supply chains tend to be extended with multiple echelons of inventory between the point of production and the final market place they tend to be forecast-driven rather than demand-driven. In other words decisions on production and distribution are based upon forecasts or orders (which themselves do not necessarily reflect demand but rather tend to be based on arbitrary 'rules' such as re-order points and reorder quantities). The point to which real

demand penetrates upstream in a supply chain is termed the decoupling point. These decoupling points also tend to dictate the form in which inventory is held. Thus in the example in Figure 1 demand penetrates right to the point of manufacture, and inventory is probably held in the form of components or materials. In the lower example, demand is only visible at the end of the chain; hence inventory will be in the form of finished product (Christopher, 2000).

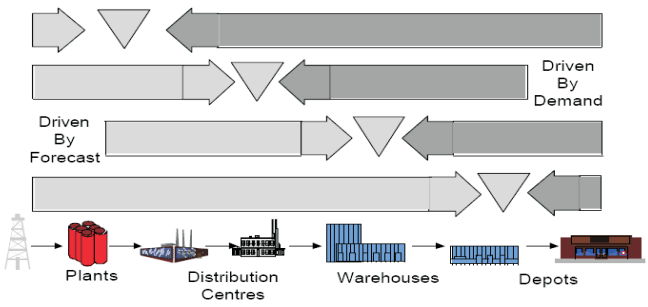

Figure 1 De-Coupling Point and Strategic Inventory

The foremost consideration in incorporating uncertainties into the planning decisions is the determination of the appropriate representation of the uncertain parameters. Two distinct methodologies for representing uncertainty can be identified. These are the scenario-based approach and the distribution-based approach. In the former approach, the uncertainty is described by a set of discrete scenarios capturing how the uncertainty might play out in the future. Each scenario is associated with a probability level representing the decision maker's expectation of the occurrence of a particular scenario. The distribution-based approach is adopted by modeling the demand as normally distributed with a specified mean and standard deviation (Gupta et al, 2003).

In order to help manufacturers of short-life cycle products subject to uncertain demand, a general planning approach termed as "quick response" was developed. This approach calls for firms to divide their production capacity into two distinct parts—speculative production capacity employed before the observation of early indicators of market demand, and reactive production capacity employed after early demand indicators are observed. Quick response is a risk-based production sequencing strategy whereby production of low-risk products employs speculative production capacity and production of high-risk products is postponed until additional market information has been gathered. Precious reactive production capacity is thus effectively reserved for products attended by the greatest risk of mismatched supply and demand, and provision is made for companies to update forecasts as market information is becomes available. The quick response model can be employed in the context of limited production capacity and minimum lot size requirements.

2. Data and Methodology

The uncertainty that arises in textile supply chains may be attributed to several causes. These may be due to the uncertainty in demand caused by changing product variety, rate of new product innovation, lead-time from design to production, and so on, or due to uncertainty in supply caused by the failure of the firms to deliver the products or raw materials to the final consumers or intermediate manufacturers, delayed delivery of critical materials, frequency of changing suppliers of critical materials, and so on. There is also an uncertainty in manufacturing caused by degree of interaction among components, process yield stability, manufacturing lead time, and so on.

This study investigates the different sources of uncertainty in textile supply chains in India, and the impact of these sources on supply chain variables. The factors affecting supply chain uncertainty which were considered are demand uncertainty, supply uncertainty, cost uncertainty, equipment failure, supply discontinuity, changing customer preference, new fashion, and government policy. The supply chain variables considered were: inventory placement (i.e. which stages should hold inventory in a supply chain), supplier redundancy (i.e. the value of adding an additional, backup supplier), decoupling point (i.e. the point to which real demand penetrates upstream), and cost of reliability (i.e. the cost associated with the planning for unexpected disruptions).

The data used in the study was collected on a sample of fifty textile manufacturing units, located in and around Bangalore city, using a structured questionnaire, in which the operations manager of the unit was asked to rate the importance of the different factors affecting textile supply chain uncertainty and their impact on the different supply chain variables. A simple Likert scale was used for the rating.

3. Findings

The relative importance of factors affecting uncertainty in the textile supply chain is presented in Table 1 below.

The most important factors were demand uncertainty (18.0%), changing customer preferences (16.6%), supply uncertainty (14.8%), new fashions (12.9%), and cost uncertainty (12.2%). The least important factors were equipment failures (6.9%) and government policies (8.7%). The factors can be regrouped into the following categories: customer-side factors (demand uncertainty, changing customer preferences, and new fashions, which together account for 47.5% of the total supply chain uncertainty), supply-side factors (supply uncertainty and supply discontinuities, which together account for 24.7% of the total supply chain uncertainty), production factors (cost uncertainty and equipment failures, which together account for 19.1% of the total supply chain uncertainty), and environmental factors (changing customer preferences, new fashions, and governmental policies, which together account for 38.2% of the total supply chain uncertainty).

Table 1 Importance of factors affecting uncertainty in the supply chain

Factor	Mean	Std. Deviation
Demand Uncertainty	18.0%	6.75%
Supply Uncertainty	14.8%	6.96%
Cost Uncertainty	12.2%	7.53%
Equipment Failures	6.9%	5.90%
Supply Discontinuity	9.9%	7.40%
Changing Customer Preferences	16.6%	8.24%
New Fashions	12.9%	7.90%
Government Policies	8.7%	7.02%
(Total)	100%	

The relative impact of different factors affecting uncertainty on the supply chain variables is presented in Table 2 below.

Table 2 Impact of factors affecting uncertainty on the supply chain variables

Factor		On inventory placement	On supplier redundancy	On decoupling point	On cost of reliability
demand uncertainty	mean	3.7800	3.4600	2.8800	2.4800
	std. dev.	0.9960	1.1290	1.4520	1.1110
supply uncertainty	mean	3.4400	3.1000	2.5800	2.5000
	std. dev.	1.1460	1.4180	1.3410	1.3130
cost uncertainty	mean	2.6400	2.6000	2.7600	2.6800
	std. dev.	1.4810	1.5390	1.5720	1.4350
equipment failures	mean	2.1200	2.0800	1.8200	2.1400
	std. dev.	1.6370	1.6140	1.5740	1.5780
supply discontinuities	mean	2.8000	2.6800	2.0800	2.4400
	std. dev.	1.7960	1.8560	1.5890	1.7280
changing customer preferences	mean	3.8600	3.4800	3.1800	2.6800
	std. dev.	1.1780	1.2660	1.5350	1.1680
new fashion	mean	3.2000	3.2800	2.5800	2.5400
	std. dev.	1.6500	1.7270	1.5790	1.5010
government policies	mean	1.6200	1.5600	1.6800	1.8200
	std. dev.	1.3980	1.2320	1.4630	1.5740
overall impact	mean	3.4956	3.2250	2.8322	2.7686
	std. dev.	0.4770	0.6271	0.6437	0.5153

Demand uncertainty had a very high impact on decisions regarding inventory placement and a moderate impact on supplier redundancy, while it had a low impact on cost of reliability and on decoupling point. This suggests a tendency of the bull-whip effect, i.e. slight changes in demand down the supply chain may cause inventory buildup further upstream the supply chain, but the decoupling point, the point at which real demand exists upstream in the supply chain, is relatively stable to this. Supply uncertainty had a moderate impact on inventory placement and supplier redundancy, and a low impact on cost of reliability and decoupling point. In particular, supply uncertainty had a lower impact than demand uncertainty on inventory placement, supplier redundancy, and decoupling point. Cost uncertainty had a moderate to low impact on all of the supply chain variables. The impact of cost uncertainty was highest on decoupling point, followed by cost of reliability and inventory placement. Equipment failure had a low impact on all of the supply chain variables. The impact of equipment failure was highest on cost of reliability, followed by inventory placement and supplier redundancy, and a very low impact on decoupling point. Supply discontinuity had a moderate to low impact on all of the supply chain variables. The impact of cost uncertainty was highest on inventory placement, followed by supplier redundancy and cost of reliability. Changing customer preference had a very high impact on decisions regarding inventory placement and a moderate impact on supplier redundancy and decoupling point, while it had a low impact on cost of reliability. This reflects the impact of demand uncertainty, except that changing customer preference had a higher impact on decoupling point than demand uncertainty. New fashion had a moderate impact on supplier redundancy and inventory placement, while it had a low impact on cost of reliability and on decoupling point. Government policy had a very low impact on all of the supply chain variables, reflecting its very low importance as a factor in textile supply chain uncertainty.

Inventory placement decisions were highly affected by changing customer preferences and demand uncertainty, and moderately affected by supply uncertainty and new fashion. Government policy and equipment failure, on the other hand, had a very low impact on inventory placement. Supplier redundancy was moderately affected by changing customer preferences, demand uncertainty, new fashion, and supply uncertainty. Government policy and equipment failure, on the other hand, had a very low impact on supplier redundancy. None of the factors had much of an impact on cost of reliability. Government policy and equipment failure, in particular, had a very low impact on supplier redundancy. Changing customer preferences and cost uncertainty had the highest impact on cost of reliability. Changing customer preferences had a moderate impact on decoupling point. None of the other factors had much of an impact on decoupling point. Government policy and equipment failure, in particular, had a very low impact on decoupling point.

Overall, there was only a moderate impact of supply chain uncertainty on all the supply chain variables. Inventory placement was the most affected by supply chain uncertainty, followed by supplier redundancy, decoupling point and cost of reliability.

Paired-samples t-tests were performed to assess the statistical significance of the above results. It was found that the impact on inventory placement was significantly higher than the impact on supplier redundancy, which in turn was significantly higher than the impact on decoupling point and on cost of reliability. There was no significant difference in the impact on decoupling point and on cost of reliability. In particular, this means that, when taking decisions regarding supply chain, inventory management plays a major role, followed by supplier decisions.

4. DISCUSSION

There is an increasing trend in the Indian textile and apparel industry moving towards more fashionable items. This change requires more product variety, generating demand uncertainty that is closely related to fashionability and seasonality of the apparel product. Uncertain demand leads to many managerial problems for the apparel company, such as production planning, forecasting, inventory management, production system, and timely distribution. To reduce the risk level due to uncertainty both in the demand and supply side, the supply chain in the apparel industry should undergo innovative changes.

Inventory placement, a major attribute that affects the efficient functioning of the supply chain, is the placement of the inventory in different stages of the supply chain. Due to the short life-cycle and the seasonal nature of fashion products, inventory management becomes very critical. The research carried out to identify the various factors affecting inventory placement shows that changing customer preferences has a very high impact on it. This poses a big problem to the retailers, distributors and all

the other players involved. Piling up of stock is costly as it involves holding cost, yet having less stock may ultimately end up in companies/businesses losing their sales in view of stock outs. Even if there is a requisite amount of stock, the customers' preferences might change causing the stock in hand to be obsolete. So this is a risk that must be managed properly. Uncertainty in demand may prompt the different players in the supply chain to hold more inventories. Last but not the least is the impact of new fashions. In the Indian scenario, new fashions are dictated by movie stars and cricketers. So any eye-catching and appealing new fashion trend may make the existing inventories a burden.

Supplier Redundancy: the cost of adding an additional/backup supplier, is also affected by changing customer preferences in a big way. New fashion trends, may necessitate the manufacturers to add additional suppliers to meet the demand. But the short lived trends may prove costly. When there is a demand uncertainty, the value of the backup suppliers is small—they fill in only when the demand exceeds the capacity, which happens infrequently. On the other hand, the backup suppliers play a vital role under supply uncertainty, since they can provide capacity both to meet demand during a disruption to the primary supplier and to ramp back up after a disruption. New fashions dictate the number of suppliers to hold.

The general trend of most companies is to plan either for demand uncertainty or supply uncertainty. This is so because the strategies to adopt for demand uncertainty and supply uncertainty are contradictory. For example, maintaining a higher level of inventory reduces the impact of supply uncertainty, but to reduce demand uncertainty it is advisable to maintain lower levels of inventory. The *cost of reliability* is the cost associated with sticking to a particular strategy.

The point to which 'real' demand penetrates upstream is called the *decoupling point*. In other words, decisions on production and distribution are based upon forecasts or orders (which themselves do not necessarily reflect demand but rather tend to be based on arbitrary 'rules' such as re-order points and reorder quantities). The decoupling point is affected by changing customer preferences moderately. Demand uncertainty and cost implications also have an impact but not as much as changing customer preferences.

The primary finding of this study is that the most important uncertainty factors impacting on the functioning of the supply chain are that of changing customer preferences, followed by demand and supply uncertainties. Some general recommendations that arise from the research are summarized as follows:

- Adopt quick response systems to respond faster to market conditions.
- Change from forecast-driven planning to market-driven planning. This will enable the companies to provide better products keeping in view the customers' preferences.
- Account for customer preferences and new fashions in the production planning and design stages.

There are some limitations inherent in the study. The sample size on which the study is based is relatively small, and the sample units were all located in Bangalore, thus the findings may not be generalisable. There is scope for more detailed further research in examining uncertainty in textile supply chains in other textile/apparel centres, such as Ludhiana, Coimbatore, Tirupur, Delhi, Mumbai, and Chennai and comparing uncertainty patterns. This would lead to the development of a model for uncertainty in textile supply chains.

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