Risk Factors Analysis in Apparel Supply Chain Management

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Abstract

The number of items having perishable attributes is increasing as science and technology improve, as well as rising customer expectations, affecting a wide range of enterprises. Because of its unique characteristics, such as short life cycle goods, variable demand, limited forecasting, a higher level of impulsive buying, high market competitiveness, and global sourcing, this study focuses on the rapid changes in fashions in the garment industry and the risks that apparel industry owners must face. For examining the behavior and links of the fast-fashion clothing business, a systematic process with supply chain stages is recommended. The Bayesian Belief Network approach is used to analyze the risks associated with all of these goods' supply chain processes, as well as to determine the expected value of losses and their likelihood. For successful strategic decision-making and decision-making, many firm scenarios have been designed. The prioritized levels among the challenges that the apparel industry would confront when implementing the entire SCM are shown in this study using recognized mathematical techniques. Risk variables are prioritized using the Bayesian Belief Network (BBN), which uses conditional probability criteria to rank them.

Keywords
Supply Chain, Bayes belief Method, Apparel Industry, Risk Factors.

1. Introduction

Due to the growing advent of globalization and outsourcing, several manufacturing industries are entrusting important sections of their operations to vendors in emerging nations. These phenomena result in a loss of supply chain control and visibility, raising the risks associated with any potential changes or interruptions. External occurrences, such as governmental limits or natural calamities, are not the only causes of risk; the influence of internal changes in strategy, business models, and interactions with supply network players is also a factor(Tang 2006). Clothing supply chains are becoming increasingly exposed to both predictable and unpredictable threats. Reduced vertical integration, supply chain fragmentation, short product life cycles, constantly altering customer expectations, competitive pressures, environmental regulations, and quick technical obsolescence are all possible causes of this dilemma. These threats have a direct influence on the garment supply chain's efficacy and responsiveness. As a result, clothing supply chain managers must identify and comprehend the risks that their supply chains face in order to develop effective mitigation strategies that will improve supply chain performance. The Apparel Supply Chain is being investigated to see if there are any potential dangers. This will serve as a platform for identifying hazards in the garment supply chain. The focus of our research is on risk factors in the garment industry's supply chain management. We begin by identifying the factors and developing a research strategy. Using the method, we hope to find a way to limit the variables. Garment supply chains work in a fast-paced environment that requires higher quality, more product availability, a broader range of miscellaneous goods, and shorter delivery times. Effective Supply Chain Management can thus mean the difference between market success and failure. This research looks at the unique characteristics of this industry at various phases of development. This research gives a framework for defining and modifying real and informational flows, beginning with a review of the whole Supply Chain with the goal of identifying the most important areas and activities and their risk.

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2. Literature Review

The influence of lead times and late delivery on supply chain performance (inventory, cost, bottleneck, and risk) is investigated, as satisfying customers' expectations in the quickest period are the key to success in this industry (Mehrjoo and Pasek 2016). Finding acceptable suppliers for their operations is a problem that US textile/apparel firms face in worldwide commercial rivalry. To retain their competitiveness in today's marketplace, US textile/apparel manufacturers must carefully pick and evaluate their worldwide vendors in order to achieve the aim of establishing effective and efficient supply chain operations and increasing their market position field (Gary Teng and Jaramillo 2005). Structural changes, relationships, and technology have operated like a miniature of global rapid industrialization in the garment business field (Oxborrow and Brindley 2014). Upstream in the fashion clothing supply chain, build implementation methods for producers in terms of moving toward a more coordinated, efficient, and responsive processed (Pan and Holland 2006). The fast-fashion sector has been characterized by widespread operations in both developing and developed countries in recent decades. Because of the economic, social, and environmental issues that plague developing nations, businesses are increasingly focusing on sustainability and attempting to maintain consistent quality and standards in working and manufacturing environments across their supply chains (Turker and Altuntas 2014). The most pressing worry for companies competing in today's global economy is supply chain interruptions and the related operational and financial risks. Existing research has not only proved the high cost of supply chain disruptions, but it has also provided useful insights into associated concerns such as supply chain risks, vulnerability, resilience, and continuity. We ask and explain how and why one supply chain interruption might be more severe than another in this conceptual essay, which focuses on a largely neglected problem (Craighead et al. 2007). Due to the various ties linking a large network of enterprises, global supply networks are more dangerous than local supply chains. Disruptions, bankruptcies, breakdowns, socioeconomic and political shifts, and calamities all put these linkages at risk, making risk management challenging (Manuj and Mentzer 2008). Because customers are becoming more environmentally conscious, sustainability is becoming increasingly crucial for the fashion industry. The fundamental linkage when a fashion firm wants to promote sustainability is to build a sustainable supply chain (Shen 2014). The economic basis for operating a sustainable global supply chain is established. According to marketing, finance, and production theories, participating in socially responsible conduct will boost sales, lower costs, minimize financial risk, and improve profits, all of which will result in higher returns to shareholders (Mefford 2011). In today's global marketplaces, which are characterized by extraordinarily rapid changes in technology and consumer demand, as well as shorter and shorter product life cycles, a single business cannot compete unless it is part of a network that can react to demand dynamism and volatility as a single entity (McMaster et al. 2020). Supply chain cooperation (SCC) among independent enterprises sometimes yields more benefits in terms of meeting end-customer demands than operating alone (Ramesh, Banwet, and Shankar 2010). Considering the abundance of supply chain risk management (SCRM) research, it is uncommon to find a theoretically supported and experimentally verified study supporting the causes and quantitative aspects of the supply chain resilience (SCRE)(Chowdhury and Quaddus 2016). Based on existing literature, the unexpected supply chain dynamics can be caused by a range of internal and external factors, including suppliers, operating systems, customers, and rivals (Yi, Ngai, and Moon 2011). The choice of risk management solutions for production outsourcing is based on what clothes merchants consider to be the most significant value their products deliver to customers. The market context in which the clothes merchants functioned was connected to product values (Hon Kam, Chen, and Wilding 2011). The model aids fashion clothing suppliers in making decisions about allocating manufacturing orders to various production plants with varying lead times and production prices, as well as correct time scheduling and sequencing of these orders (Ait-Alla et al. 2014). To be competitive in today's increasingly complicated business environment, supply chain managers must reduce both upstream (supply-side) and downstream (demand-side) constraints. Failure to address both supply and demand-side constraints has far-reaching effects that can negatively influence the whole supply chain's performance (Chowdhury, Umme, and Nuruzzaman 2018). The supply chain of China's garment trading firms is under severe strain as a result of the fast expansion of overseas commerce. The crisis brought on by domestic and international circumstances has hastened the process of allowing the effects to flourish while removing the inefficient (Yake and Jing 2009). Political instability, currency rates, transportation capacity, shelf life, and consumer demand are all risks that exist across supply chains. For more than six decades, outsourcing in the textile sector has played a significant role in the global economy. Due to the multiple complexities involved in supply chain management, restoration has recently been a popular practice. Fast fashion items are complicated in their own right when compared to basic textile and garment products. With uncertain demand and tight timelines, a single assortment encompasses multiple new designs, colors, and sizes (Sardar and Lee 2015). Corporate performance is directly influenced by supply chain management. Nowadays, establishing and executing a networked, flexible supply chain that combines all partners (manufacturers, retailers, suppliers, transporters, and vendors) into a seamless unit is the critical step in fulfilling continuous client demand and preserving a competitive advantage. This study attempts to develop a

framework for Risk Factor Analysis in Apparel Supply chains. In this paper, some established mathematical processes are used to show the priority levels among the barriers that an Apparel Industry will face while implementing overall SCM. With the help of the Bayesian Belief Network (BBN), risk factors are prioritized on the basis of their respective weighted criteria.

2.1 Objectives

Our study focuses on the examination of risk variables in the garment industry's supply chain management. We begin by identifying the factors and formulating a study approach. We aim to solve a route to minimize the factors using the technique.

1. Developing a BBN model to predict Apparel supply chain risk
2. Predicting Apparel supply chain risk rate
3. Application of the model to predict Apparel supply-chain risk and rate of the apparel industry.

3. Methods

To identify the risks, we have sorted risk factors on basis of their effects on the supply chain and we have gone for a survey after identifying these risk factors, below table 1 is part of our methodology where we elaborated on why these factors are having an impact. We have taken surveys from 100 different industrial experts. The below table shows the descriptions. All of these are directly connected to our apparel supply chain, and we have measured their impacts by collecting data and categorizing their impacts using conditional values using the Bayesian Method.

Table 1. Methodology

Types of Risk Factors	Description
Globalization	Globalization offers several benefits. It does, however, have one disadvantage. Sweatshops have sprung up as a result. There's been the creation of a new type of exploitation. Corporate behemoths are profiting from emerging countries' poverty and enriching already wealthy nations. Textile producers should export their labor to other nations, but not at the expense of paying their foreign labor even the minimum wage.
Scarcity of resources	The threat of resource shortage is a serious problem for every business. The resource is necessary for the supply chain to function. Scarcity of information is a major aspect of existence doubt. Because of the scarcity of cotton, the garment sector may face a loss of customers as the price of finished items rises. It will also compel the company to look for another resource or provider.
Lack of Co-ordination	When the aims of separate phases clash or communication travelling between stages is misunderstood, there is a lack of coordination.
Behavioral aspect of employees	There are eight essential levers that may ensure certainly boost if human behavior accepts them, such as upfront supply chain department and supplier participation, cost and process improvement, organizational effectiveness, and so on.
Infrastructure risks	Infrastructure's principal financial benefits flow to consumers over the asset's lifetime.
Demand and supply uncertainty.	Whether there are ambiguities regarding consumer demand, a worldwide optimization (a global perimeter of DM) remains more potent than just a local optimization (a local perimeter of DM).
Lower responsiveness performance	A responsive supply chain is nonetheless attentive to the needs of its customers.
Poor quality or process yield at supply source	Quality management in such disjointed supply networks is undoubtedly difficult. When discussing quality, the difference between quality and performance is frequently made.
IT and information sharing risks	Amongst the most important ways to improve supply chain performance has been to share information. It enables businesses to better coordinate their activities among their members of the supply chain, resulting in enhanced productivity.
Lack of sustainable knowledge/technology	The Sustainable Development Goals (SDGs) are a worldwide agreed-upon proceeding with the project, and it is anticipated that everybody in the society is aware of, informed about, and motivated to help achieve them.

Inflation and currency exchange rates	As the foreign exchange rate rises, local goods become more affordable to overseas consumers, resulting in an increase in exports, overall demand, and prices. The rate of inflation rises as the foreign exchange rate rises.
Long-term horizon	The possibility of your costs and expenses incurred may indeed be cut short due to an unanticipated incident. This may compel you to liquidate investments you had decided to hold for a long time. You may lose a lot of money if you do have to sell while the prices are lower.
High number of intern Competitors	A unified internship monitoring system for the overall network would be beneficial.
Poor brand recognition abroad	Clients may respond favorably or badly whenever they learn about a package's COO.
Different purr. Behavior in each area	This is the level of client acceptance of a goods in several sectors.
Bullwhip effect	As one advances up the supply chain, the bullwhip effect occurs, wherein demand unpredictability rises.
Limited use of excess fabrics	Our industries are using less extra cloth. We call it jhut. It may, however, be utilized in a variety of ways.
Consumer preferences	It refers to the type of goods that consumer’s desire, which leads to quick fashion.
Demand for apparel products in the global market	Push and pull marketing are examples of customer preferences. Which is determined by market conditions and consumption patterns.
Increase in labor costs	The proportion of a garment's retail value that is compensated for by labor costs is a key data point in determining the expected influence on pricing. While variations exist by product and manufacturing region, it is obvious from statistics provided by the apparel industry and published academic studies that labor expenses account for a relatively modest percentage of retail price: approximately 1-3 percent for a garment stitched in the developing world.
Supplier performance	This is critical in the workplace. Because if a supplier fails to match T&A, the supply chain would be messed up.
Transportation	In the distribution chain, mobility is crucial. Since there are traffic congestion, accidents, and other factors that hinder and put people at risk.
Inventory	A company's inventory is its collection of completed items or products utilized in operation. Warehouse is a current asset that acts as a buffer between production and demand execution on a balance sheet of a company. Whenever an inventory item is sold, its holding charge is transferred towards the revenue statement's cost of goods sold (COGS) category.
Supply chain network design	Supply networks are an important but sometimes overlooked aspect of our daily lives. More or less everything we buy in a store originates from a supply chain, and maintaining these systems is a difficult and always changing process.
Price fluctuation	Price volatility refers to the frequent fall and rise of commodity market prices as a result of changes in market conditions. Price fluctuation can also be cyclical, with prices of commodities changing during specific seasons of the year owing to the increasing supply and demand.
Environment & Safety	As an open platform, Supply Chain is mostly reliant on the surroundings. It can have an effect on the environment or be impacted by it.
Machine breakdown & facility failure	Unexpected and unexpected physical damage to specified machinery that necessitates repair or replacement is referred to as a breakdown. Breakdowns caused by fatigue failure, progressive degradation, or a lack of servicing or repair are among the sorts of breakdowns which are not protected by insurance policies.
Job Dissatisfaction and Employee Turnover	The quantity or proportion of employees that leave a company and are replaced with new employees is known as employee turnover.
Organizational Factors	A precise recognition and knowledge of organizational elements, including various factors, is needed for optimal Green Supply Chain Management (GSCM) implementation.

Relationships and Decision Making	The garment supply chain is influenced by consumer-supplier interactions and timely decision-making.
Regulatory capacity of governments	Regulation is one of the most important tools used by governments in Oecd nations to implement their policy aims. The importance of control in modern governance forces us to better comprehend who possesses and uses regulatory control, as well as how and to what effect.
Dependency of political changes.	Political unrest poses a significant danger to enterprises working inside the global supply chain. Enterprises with worldwide sourcing requirements must be aware of the possible negative effects of political unrest on productivity, quality, and relationships, and devise risk mitigation techniques.
Economic problems	The economic issue, often known as the basic or primary economic problem, states that a country's economic limited assets are inadequate to satisfy all desires and requirements.
Social problems	Product- or method features of operations that influence human safety and community development are referred to as social concerns in the supply chain.
Lean Production	Lean manufacturing implies that the production process must be able to react fast to changes in market conditions.
Price Margin	The difference between your cost and the price at which you sell the goods to your consumers is the pricing margin on any product you offer.
Brand Equity	Brand equity is a marketing phrase that refers to the worth of a brand. Consumer perceptions and relationship with the product determine its worth.
Technological Innovation	The effective application of a technical notion that is fresh to the organization that created it is known as technological innovation. Innovations, tech, and research are not the same thing, yet they may all promote creativity.
System automation	However, supply chain automation goes beyond developing more effective ways to choose and transfer things. Automation began with the collection of data for decision-making.
Reduced stock-out	Stock outs are caused by a variety of circumstances, including variable consumer demand, faulty projections, and lead time variations. Maintaining a safety stock level of goods is one strategy to reduce the risk of stock outs for your company.
Improved inventory data collection	Advanced data systems can improve inventory accuracy and provide real-time monitoring. For such technologies to operate, basic process control processes must still be in place.
Reduced complexity in inventory	This industrial concept is founded on the notion that inventory is a result of inefficiency and hence a hint that something is wrong. Just In Time, or JIT for short, is a closely similar idea.

3.1 Bayesian Belief Method

A Bayesian network, also known as a Bayes network, belief network, decision network, Bayes(ian) model, or probabilistic directed acyclic graphical model, is a probabilistic graphical model that uses a directed acyclic graph to describe a collection of variables and their conditional relationships (DAG). Bayesian networks are perfect for forecasting the chance that any of a number of known causes contributed to an event that occurred. For example, might be used to depict the probability correlations that exist between illnesses and symptoms. The network may be used to calculate the likelihood of certain illnesses being present based on symptoms. In Bayesian networks, efficient algorithms may infer and learn. Dynamic Bayesian networks are Bayesian networks that model sequences of variables (such as speech or protein sequences). Influence diagrams are generalizations of Bayesian networks capable of representing and solving decision problems under uncertainty (figure 1).

BBN- A directed graph consisting of nodes and arcs associated with a set of probability tables consists of:
1) Nodes
2) Links
3) Conditional Probability Table (CPT)
Probability updating based on Bayes's Rule:
P(A | B) = (P(B|A)P(A))/P(B)

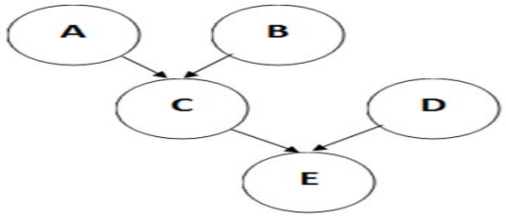

Figure. 1. Bayes' Theorem

4. Data Collection

In Apparel Supply Chain Management, a survey is conducted based on the risk factor analysis. The questions used to identify risk variables, their likelihood, and effects make up the survey component. Expert knowledge, historical data, and supply chain structure are used to identify potential hazards. By combining the predicted values of risk characteristics, the detected risks are measured. The flaws in present project risk management procedures, tools, and techniques are outlined, and a case is made for using knowledge management philosophies and practices in project risk management. During two stages of fieldwork, project managers were interviewed and a survey employing questionnaires was used to collect data on their experiences with project risk management. The survey Sheet is given in A**PPENDIX-1**

5. Results

After collecting all the data and linking them based on their relation to one another we made seven different Parent nodes having their child notes (shown in figure 2) which make an impact on the supply chain and are directly connected to Supply chain risk. The seven Parent nodes are Competitive Market Risk, Co-ordination Risk, Sustainable Risk, Manufacturing Risk, Organizational Risk, Downstream Risk, and Upstream Risk. All these parent nodes have different child nodes. Impacts of child notes on Parent nodes are shown in **APPENDIX-2**.

Determination of Parent Node Influence on Child Node

- Influence denotes the relative impact the state of a parent node has on a particular state of its child node
- Can be calculated using the following formula-

$$p_x = \frac{\bar{I}_x}{\sum_{x=1}^{n} \bar{I}_x}$$

Where, $\bar{I}_x$ is the average weight of parent node x

$$\bar{I}_x = \sum_{k=1}^{n} I_{kx} W_k$$

Where,

I_{kx} is the weight of parent node x provided by expert k
Wk is the credibility of expert k's opinion (table 2)

- Example: Disturbance Frequency

$$\bar{I}_{ei} = (1 \times 0.95) + (3 \times 0.47) + (1 \times 0.8) + (1 \times 1) = 4.16$$
$$\bar{I}_{fi} = (3 \times 0.95) + (2 \times 0.47) + (3 \times 0.8) + (2 \times 1) = 8.19$$
$$\bar{I}_{hi} = (2 \times 0.95) + (1 \times 0.47) + (2 \times 0.8) + (3 \times 1) = 6.97$$

$$p_{ei} = \frac{4.16}{4.16+8.19+6.97} = 0.215 \qquad p_{fi} = \frac{8.19}{4.16+8.19+6.97} = 0.424 \qquad p_{hi} = \frac{6.97}{4.16+8.19+6.97} = 0.361$$

Table 2. Factors

Factors	Weight				Average Weight	Impact
	Expert 1	Expert 2	Expert 3	Expert 4		
Reduced Complexity in Inventory	1	3	1	1	4.16	0.215
Reduced Stock-out	3	2	3	2	8.19	0.424
Improved Inventory Data collection	2	1	2	3	6.97	0.361

We have used Divorcing method to reduce the computational complexity in BBN

- Separates parents using mediating variables
- Mediating variables act as children of parent nodes and parent of the child node
- Divorcing developed links between mediating variable and parent variables

Using Conditional Probability Table (CPT) calculation we linked the connection of risk factors and made the link between them to make final BBN Model of it

Conditional Probability Table Calculation:

a. Subjective opinion used
b. Two problems addressed
c. Discomfort of experts in providing exact conditional probability
d. Huge amount of input required
e. Solution provided
f. Elicitation of limited number of anchor conditional probabilities from expert opinion using rank-based method
g. Calculation of remaining conditional probabilities using Functional Interpolation method

Steps:

a. Selection of the experts and evaluation of their credibility.
b. Data Collection from Experts.
c. Assessment of the influence each parent node on the child node.
d. Calculation of the anchor conditional probability distributions from these influences.
e. Approximation of the anchor CPDs as normal function and determination of parameters.
f. Calculation of the parameters of the intermediate CPDs using linear interpolation.
g. Calculation of the remaining conditional probabilities by converting the parameters into discrete probability distributions.

Accumulation of Opinions:

a. Experts asked to rank the parent nodes of each child node based on their importance in child node
b. Weights are extracted from the ranks using rank-sum method

$$w_i = n - r_i + 1$$

Where,

w_i is the weight of a variable i
n is the total number of variables
r_i is the rank of variable i out of n variables

Figure 2. Parent and Child nodes connection

5.1 Numerical & Graphical Results

Using BBN formula, we have generated below model to get final output (figure 3).

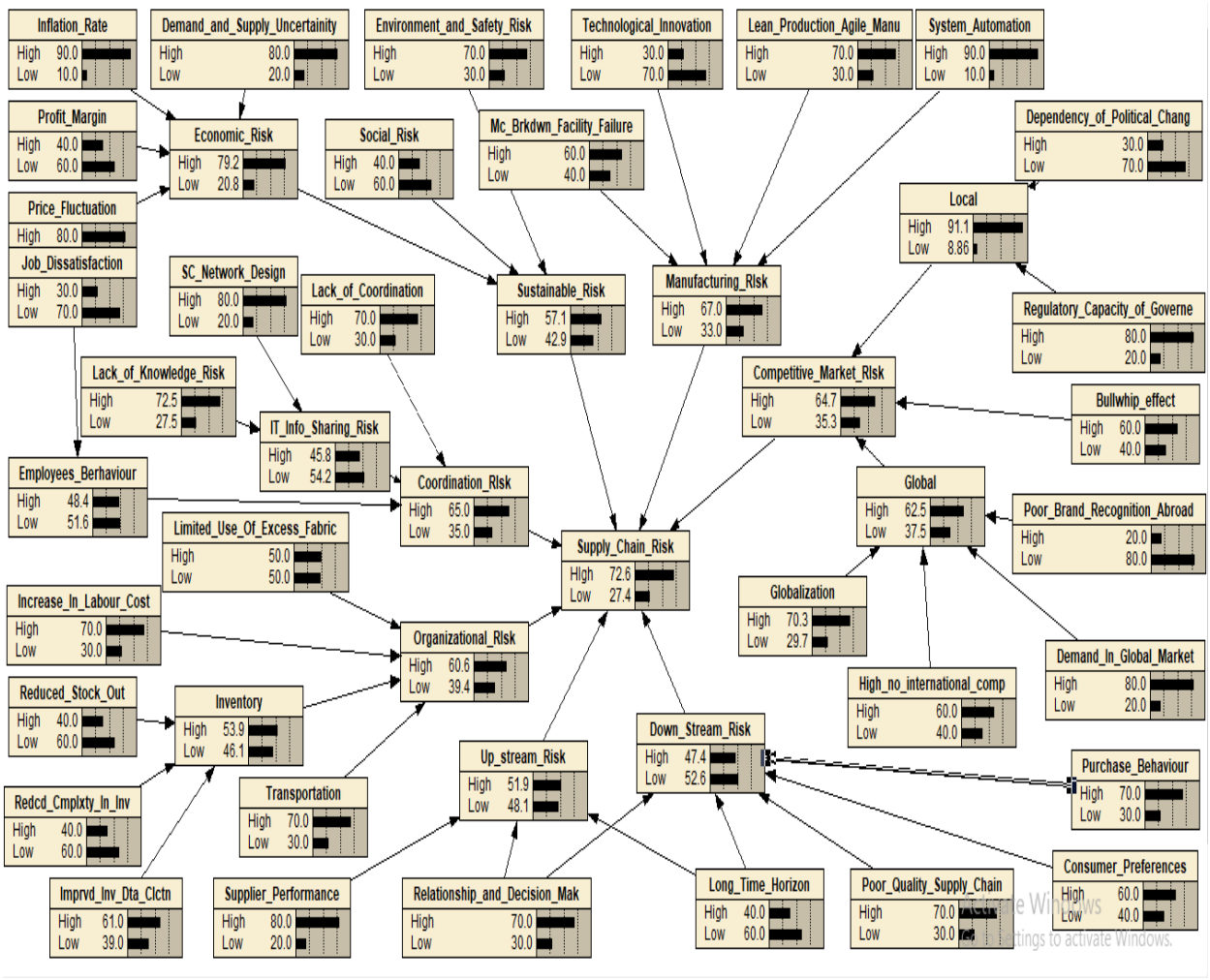

Figure 3. Final BBN Model of Risk Factors impact in Apparel Supply Chain

6. Discussion

Based on this result we can say below points as our discussion

Supply Chain Risk Factor prediction model

- Assistance to Operation and Supply Chain Department
- Incorporation of different categories of variables and their probabilistic effect
- Opportunity for data analytics

User friendly expert elicitation method

- Relieves burden on experts

Customization of model

- Factor Analysis customizes the no of factors
- Divorcing customizes the no of CPT

7. Conclusion

By analyzing all those risk factors in the apparel supply chain, we found that those factors affect the managerial process highly. Using Bayesian Belief Network, we came to a result that the overall supply chain procedure is getting hampered by seven major factors. The seven major factors are - 1) Competitive Market Risk, 2) Co-ordination Risk, 3) Sustainable Risk, 4) Manufacturing Risk, 5) Organizational Risk, 6) Downstream Risk, and 7) Upstream Risk. For these factors affecting the result has come to High-72.6% & Low-27.4% .

With this project analysis, we can say that in an apparel industry the whole supply chain management is such an important issue where many types of factors can easily make the whole process a destructive way. By using the Bayesian Belief Network, it can easily measure the probabilistic value of risk factors and we can focus on those areas to improve to reduce their risk rank from high to low to maximize the smooth supply of operation.
As this survey is focused on Bangladeshi industry so there are some limitations like-Surveys on the pertinent working population, Influence considered to be different for each parent factor, Applicability of new elicitation methods, CPT development using subjective opinion and normality assumption, learning from evidence and not all inter-relationships considered, difficulty in the elicitation of expert opinions, difficulty in extraction of a large number of CPTs. Lack of guidelines for modeling with dimensionality reduction and precision maximization. Future scopes are deeper study & Cross-discipline research.

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Biography:

Mohammed Raihan Uddin has completed his B.Sc. in Industrial and Production Engineering, Faculty of Textile Management and Business Studies at the Bangladesh University of Textiles. He is a Certified Supply Chain Analyst (CSCA). His research interest includes supply chain management, quality management, lean six sigma operation management, CAD/CAM, Operation Research, Operation Management, Wastage Management Material Handling, Maintenance Management, Ergonomics, Safety Management, Artificial Intelligence, Industrial 4.0, Machine Learning, Project Management, Data Science, Nano Technology, Sustainability and E-Textiles development. Besides he is having 3 Years of Job experience in different Apparel industries as a Merchandiser and Currently Working in a Swedish MNC named Lindex.

Md Mamunur Rashid is an Assistant Professor in Industrial and Production Engineering at Bangladesh University of Textiles (BUTEX). He received his B.Sc. degree in Industrial and Production Engineering from Bangladesh University of Engineering and Technology (BUET), in 2013. He acted as corporate professional in both Textile and Garments units of DBL Group to apply Industrial Engineering tools and techniques prior to starting his academic career as a Lecturer at BUTEX in 2015. He has been involved in different research projects in multidisciplinary optimization, CAD/CAM, artificial intelligence application, industry 4.0, supply chain management. He is Lean Six Sigma Green Belt certified practitioner of lean manufacturing in the Textile and Garments Industries. Mr. Rashid is a life member of the Bangladesh Society for Total Quality Management (BSTQM).

APPENDIX-1

Survey Sheet for Experts Opinion to Identify Risk Factors Level			
Serial	Risk Factors	Rank	Experts Opinion
1	Globalization	High	
		Low	
2	Scarcity of Resources	High	
		Low	
3	Lack of Co-ordination	High	
		Low	
4	Behavioral aspect of employees	High	
		Low	
5	Infrastructure Risks	High	
		Low	
6	Demand and Supply Uncertainty	High	
		Low	
7	Lower responsiveness performance	High	
		Low	
8	Poor Quality or Process Yield at Supply Source	High	
		Low	
9	IT and Information Sharing Risk	High	
		Low	
10	Lack of Sustainable Knowledge/Technology	High	
		Low	
11	Inflation	High	
		Low	
12	Long Term Horizon	High	
		Low	
13	High Number of International Competitors	High	
		Low	
14	Poor Brand Recognition in Abroad	High	
		Low	
15	Different Purchase Behavior in Each Area	High	
		Low	
16	Bullwhip Effect	High	
		Low	
17	Limited Use of Excess Fabric	High	
		Low	
18	Consumer Preferences	High	
		Low	

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19	Demand for Apparel Products in the Global Market	High	
		Low	
20	Increase in Labor Cost	High	
		Low	
21	Supplier Performance	High	
		Low	
22	Transportation	High	
		Low	
23	Inventory	High	
		Low	
24	Supply Chain Network Design	High	
		Low	
25	Price Fluctuation	High	
		Low	
26	Environment & Safety	High	
		Low	
27	Machine Breakdown and Facility Failure	High	
		Low	
28	Job Dissatisfaction and Employee Turnover	High	
		Low	
29	Organizational Factors	High	
		Low	
30	Relationships and Decision Making	High	
		Low	
31	Regulatory Capacity of Governments	High	
		Low	
32	Dependency of Political Changes	High	
		Low	
33	Economic Problems	High	
		Low	
34	Social Problems	High	
		Low	
35	Lean Production / Agile Manufacturing	High	
		Low	
36	Price Margin	High	
		Low	
37	Brand Equity	High	
		Low	
38	Technological Innovation	High	
		Low	
39	System Automation	High	

		Low	
40	Reduced Stock-out	High	
		Low	
41	Improved Inventory Data collection	High	
		Low	
42	Reduced Complexity in Inventory	High	
		Low	

APPENDIX-2

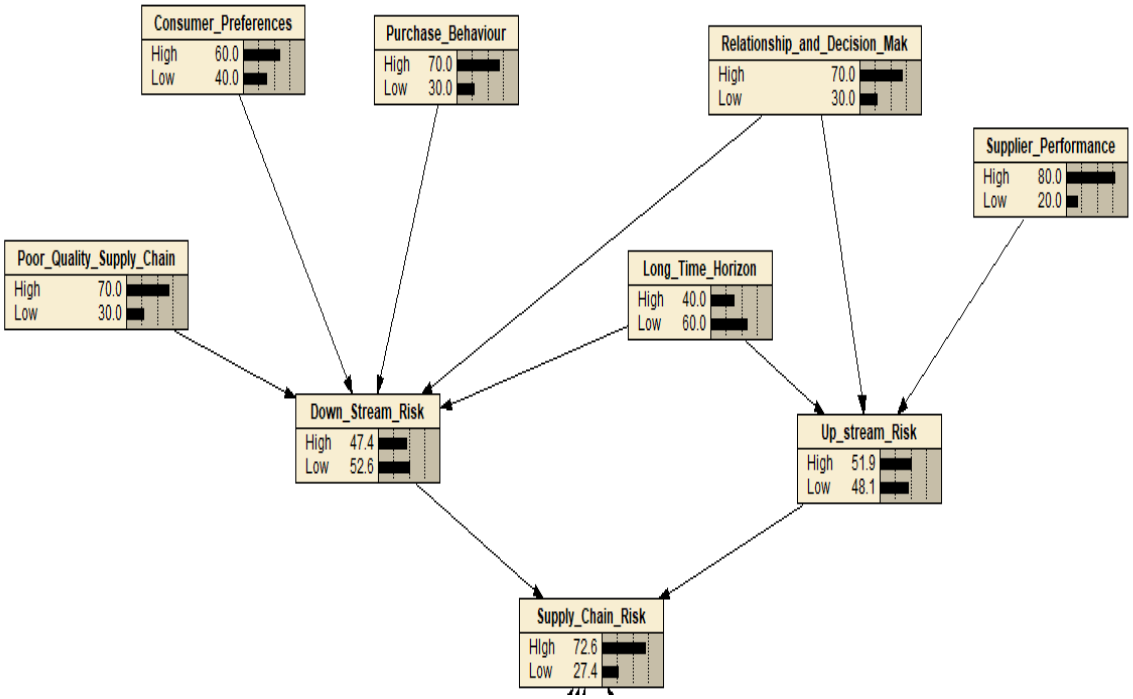

Figure 4. Down and upstream risk analysis by Bayesian belief Method

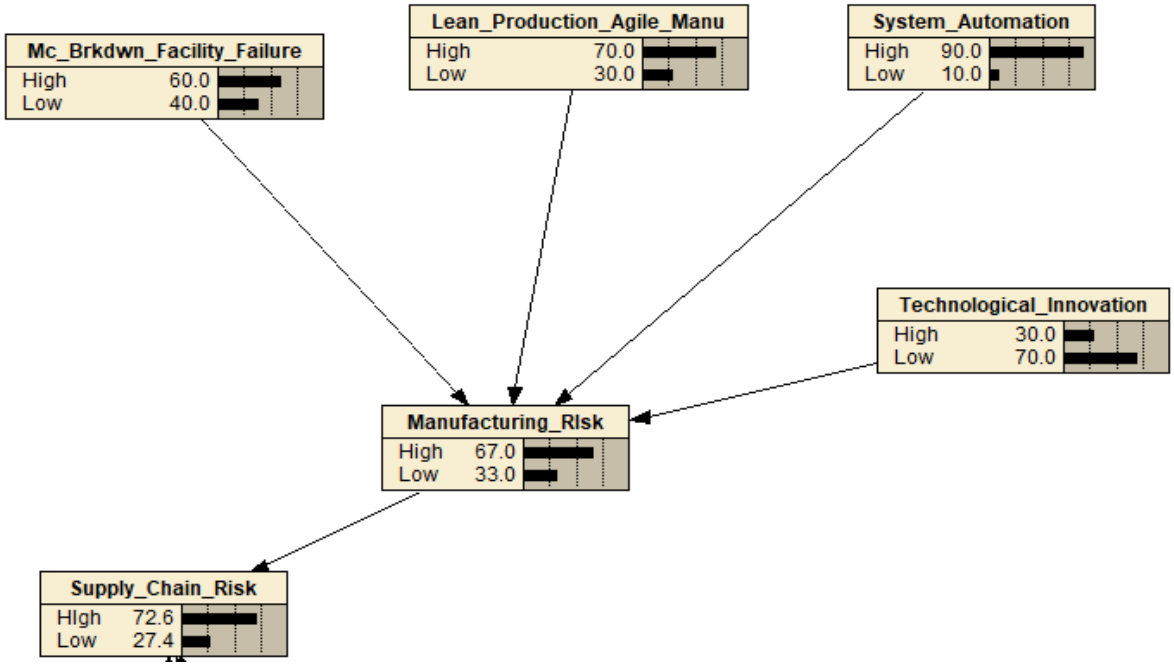

Figure 5. Manufacturing risk by Bayesian belief Method

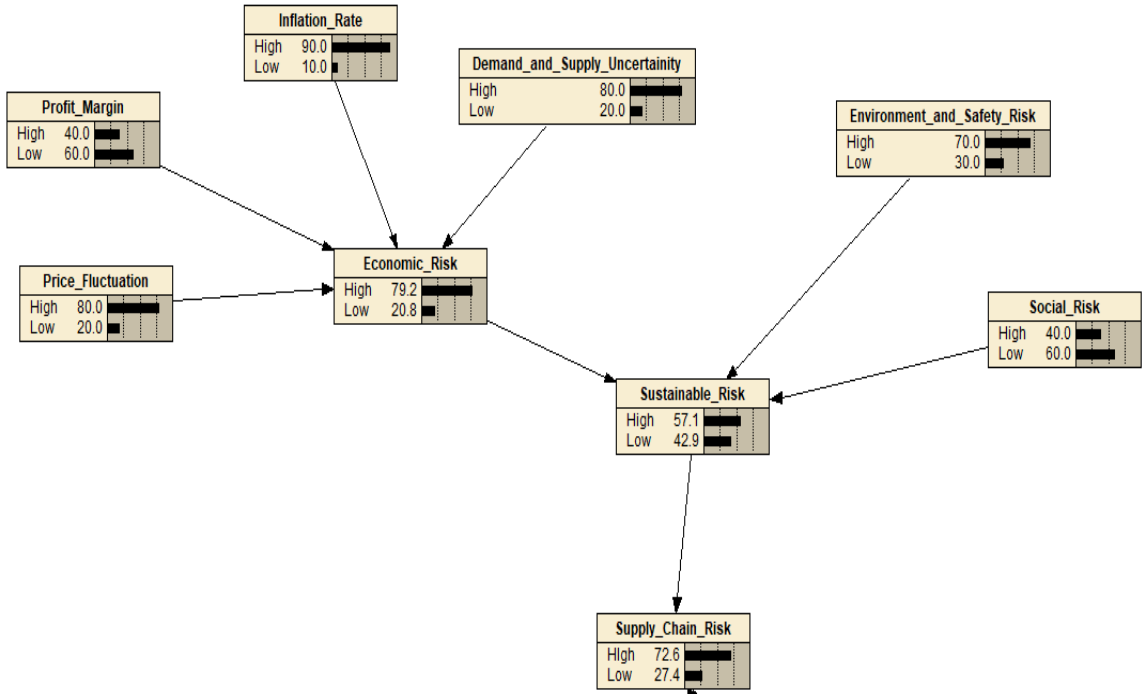

Figure 6. Sustainable risk analysis by Bayesian belief Method

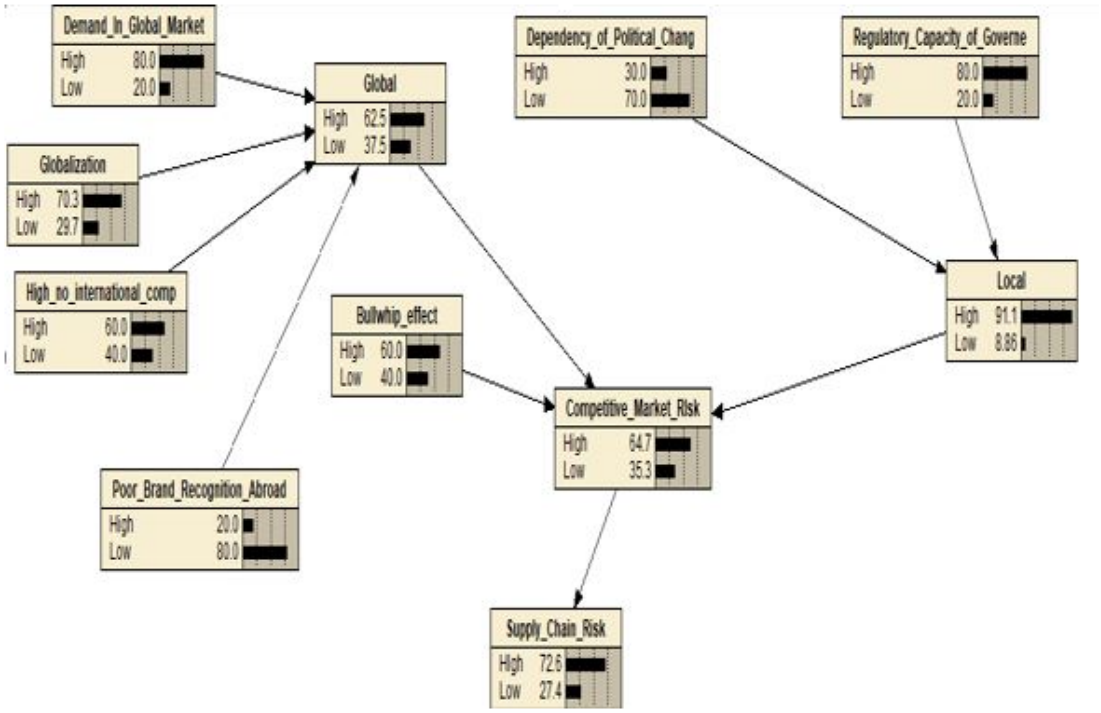

Figure 7. Competitive market risk analysis by Bayesian belief Method

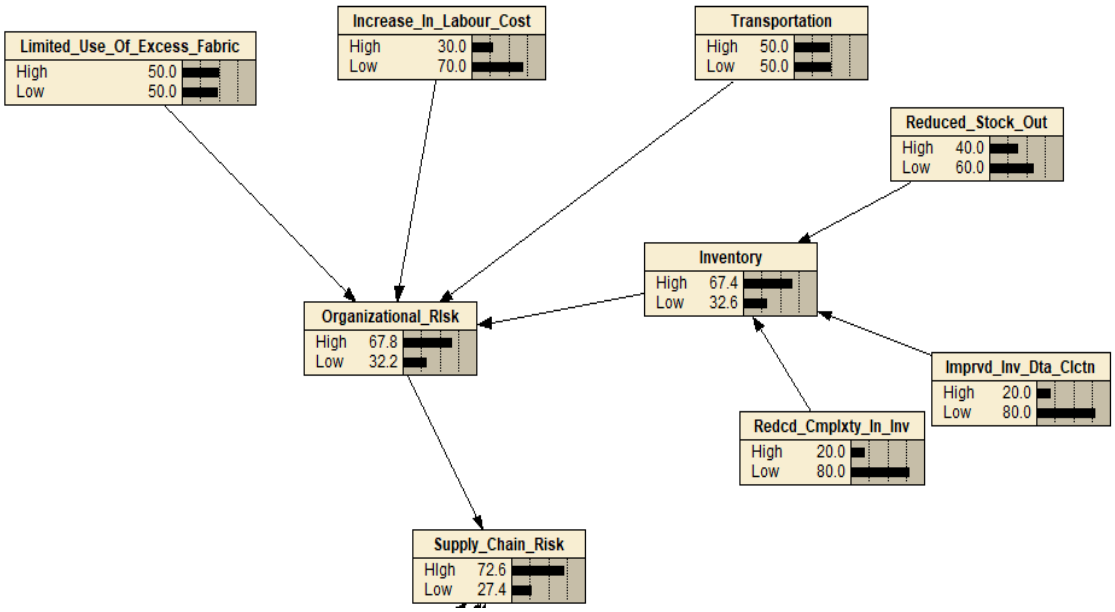

Figure 8. Organizational risk analysis by Bayesian belief Method

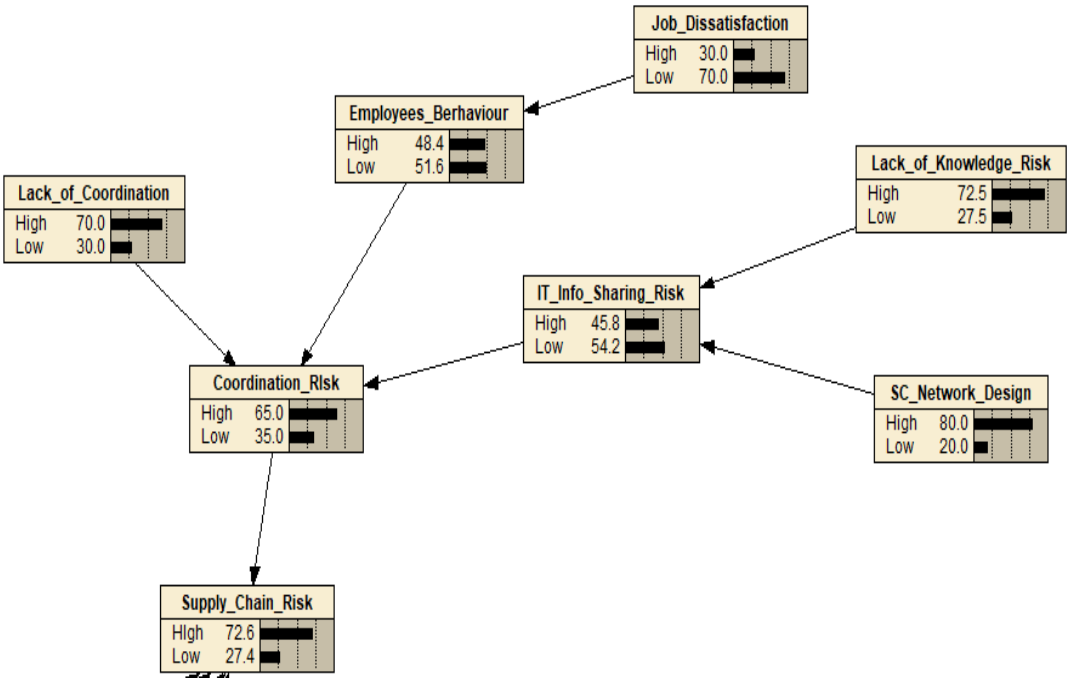

Figure 9. Coordination risk analysis by Bayesian belief network