

Selection of Best Supplier by Using AHP Tool for Managing Risk Factors in Logistics: A Case of Leather Products Industry

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Abstract

Risk management in logistics involves a variety of issues like selecting suppliers, performance of suppliers, third party logistics and outsourcing and so forth. Selecting the best supplier is one of the most crucial tasks for any production system as there are much external or internal vulnerability. This paper considers a leather products company's operational risk factors which is involved with its downstream partners and develops a simple model by using Analytic Hierarchy Process (AHP) toolbox which prioritizes the suppliers by considering various selection criteria for managing risk. AHP is a practical and useful Multi Criteria Decision Making (MCDM) tool which provides the foundation for making such evaluations in decision making. In this paper the main purpose is getting a prioritized list of alternative suppliers so that if one supplier is suddenly unavailable to supply raw materials for unavoidable reasons, company will get to choose another supplier quickly. Thus it will not halt the whole production system and minimize the risk factors in logistics management.

Keywords: Risk management; Supplier selection; Logistics; Leather products industry; AHP

Introduction

Success in today's highly competitive manufacturing environment depends on the effective selection of suppliers. Nowadays, strategic sourcing is one of the fastest growing areas of supply chain management [1]. For example, raw materials and components are purchased from external suppliers. Appropriate supplier selection is important for any organization because it helps to achieve high-quality products at relatively lower costs with greater customer satisfaction and ultimately assists in increasing profitability [2-4].

Modern trend of purchasing management is to reduce the number of vendors, and establish the long-term and stable partnership of mutual trust, benefit and support. These trends aggravate the risk of vendor selection. So enterprises in selecting vendors should measure all aspects of the performance of candidate vendors, not only the product quality, price, vendor performance and services, but also the risk factors of vendor selection [5,6].

Supplier risk management is defined as the process of predicting and preparing for the probability of variables which may adversely or favorably affect the supply chain. Logistics risk management is not a new concept; however, the type of risk that can affect the supply chain and the way in which these risks are managed and mitigated has evolved significantly. The need for proactive and predictive strategic policy is ever present in business today [7-10].

Risk will always be inherent in the logistic system of a company. Risk is a sore reality in manufacturing today and even the most sophisticated companies used to face the different types of risk. Logistics risk management includes disruption risk, operational risk, disaster emergency, logistics service risk management. The disruption is an unexpected event that disturbs normal flows of products and materials within a supply chain. Presence of uncertainties on supply, demand, market price, transportation time cause operational risk in logistics [11,12]. In the logistics service industry, third party logistics (3PL) service providers and transportation and shipping companies face risks in their business operations.

Previous research focused on logistic risk management and vendor selection respectively, however the research of vendor selection based on logistics risk management is very little [13-15]. For this reason the decision makers of a company must consider multiple criteria in selecting the best supplier. They also should emphasize not only the traditional factors but also the risk factors. So, a logical and mathematical model for selecting suppliers can be very convenient and useful to the manufacturing industry.

To identify the best supplier among them is very challenging. Suppose best supplier has been selected by using various mathematical models. But if any uncertainties like fire explosion, earthquake, strikes etc. will occur in supplier's place what will happen. So, we have formulated the following general research questions for the study:

1. What will happen if the best supplier becomes unavailable?
2. Does the second supplier of the prioritizing list suitable in that circumstance?

To address this research question, following two objectives have been proposed.

1. Identify the most important attribute to supplier selection during supplier become unavailable.
2. Selection of most suitable supplier with the help of AHP tool by prioritizing supplier.

This paper presents an analysis using AHP models and approach to

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provide a better way of decision making on prioritizing the suppliers that will dictate which supplier should be selected first and also will find the best alternative supplier for that raw material to meet the uncertainties [16,17]. The factors which are important while any accident happen to the first supplier like responsiveness, keeping promise, technology etc. are taken into account in modeling the problem. The result shows that the prioritization of suppliers varies with the variations in the considered situation. The outcome of those models will represent a distinct numerical ranking value for each of the suppliers. As avoiding risk factors is quite complex, hopefully this modeling approach will be an outstanding helping hand to face the uncertainties.

The rest of the paper is structured as follows: Section 2 depicts the details literature on supplier selection and risk minimization. Section 3 shows the details of AHP methodology. Section 4 presents the real life case example. Section 5 describes the discussion and conclusion of the study. Finally, Section 6 shows the managerial implications direction of study.

Literature Review

The selection of a supplier for partnership is perhaps the most important step in creating a successful alliance. The selection of an appropriate supplier is an important factor affecting eventual buyer-supplier relationship. If the process is done correctly, a higher quality, longer lasting relationship is more attainable [18]. Supplier selection is defined in as the “process of finding the suppliers being able to provide the buyer with the right quality products and/or services at the right price, at the right quantities and at the right time [19]. To choose the right supplier, different methods can be used. In this paper we used AHP to determine the best supplier.

In literature, there some studies that use AHP for supplier selection. These studies can be summarized below [20]. Akarte et al. [21] developed a web-based AHP system to evaluate the casting suppliers with respect to 18 criteria. In the system, suppliers had to register, and then input their casting specifications. To evaluate the suppliers, buyers had to determine the relative importance weightings for the criteria based on the casting specifications, and then assigned the performance rating for each criterion using a pair wise comparison. Muralidharan et al. [22] proposed a five-step AHP-based model to aid decision makers in rating and selecting suppliers with respect to nine evaluating criteria. People from different functions of the company, such as purchasing, stores, and quality control, were involved in the selection process. Chan FTS [23] developed an interactive selection model with AHP to facilitate decision makers in selecting suppliers. The model was so-called because it incorporated a method called chain of interaction, which was deployed to determine the relative importance of evaluating criteria without subjective human judgment. AHP was only applied to generate the overall score for alternative suppliers based on the relative importance ratings.

Chan et al. [24] applied AHP to evaluate and select suppliers. The AHP hierarchy consists of six evaluating criteria and 20 sub-factors, of which the relative importance ratings were computed based on the customer requirements. Liu et al. [25] applied AHP to evaluate and select suppliers. Similar to Chan, (2003) the authors did not apply the AHP's pair wise comparison to determine the relative importance ratings among the criteria and sub factors. Instead, the authors used Noguchi's voting and ranking method, which allowed every manager to vote or to determine the order of criteria instead of the weights. Chan et al. [26] developed an AHP-based decision making approach to solve the supplier selection problem. Potential suppliers were evaluated based on

14 criteria. A sensitivity analysis using Expert Choice was performed to examine the response of alternatives when the relative importance rating of each criterion was changed. Hou et al. [27] developed an AHP-based decision support system for the supplier selection problem in a mass customization environment. Factors from external and internal influences were considered to meet the needs of markets within the global changing environment. Lee et al. [28] investigated the green supplier selection problem for high-tech industry, and identified six criteria, namely quality, technology capability, pollution control, environmental management, green production and green competency. In the automobile industry, Govindan et al. [29] developed a framework to identify and rank the associated criteria, for instance asset specificity and supplier performance. Aksoy et al. [30] explored the problem of supplier selection in just-in-time (JIT) production environments.

Selection and management of the right supplier is the key to obtaining the desired level of quality, on time, and at the right price; the necessary level of technical support; and the desired level of service. Buyers must take six important supplier-oriented actions in order to satisfy this responsibility. These are develop and maintain a viable supplier base, address the appropriate strategic and tactical issues, ensure that potential suppliers are carefully evaluated and that they have the potential to be satisfactory supply partners, decide whether to use negotiation as the basis of source selection, select the appropriate source [31]. Dargi et al. [32] constructed a multi-objective programming model to select the optimal suppliers and determine the optimal order quantity. Five criteria were proposed to evaluate the performance of suppliers. Before solving the model to optimality, the relative importance weightings of five criteria were derived in advance. The authors suggested that AHP could be one of the possible ways for generating the weightings.

Finally, it can be concluded that a number of studies and researches are conducted on Supplier selection with multiple criteria, but there is not enough research and studies done on Prioritizing suppliers with logistics risk factor. All the efforts were done to find the appropriate way to select alternative when selected supplier becomes unavailable. That is why here we have tried to solve this kind of important topic using the method named Analytic Hierarchy Process (AHP).

Solution Methodology

Analytic hierarchy process (AHP)

The Analytic Hierarchy Process (AHP) is a multi-criteria decision-making approach and was introduced by Saaty [16,17,33,34]. AHP organizes the basic rationality by breaking down a problem into its smaller constituent parts. By decomposing the problem, the decision-maker can focus on a limited number of items at the same time. The AHP is carried out in two phases: the design of the hierarchy and the evaluation of the components in the hierarchy [35].

AHP is especially suitable for complex decisions which involve the comparison of decision elements which are difficult to quantify. It is based on the assumption that when faced with a complex decision the natural human reaction is to cluster the decision elements according to their common characteristics. It is a technique for decision making where there are a limited number of choices, but where each has a number of different attributes, some or all of which may be difficult to formalize [36,37]. It is especially applicable when a team is making decisions. It involves building a hierarchy (Ranking) of decision elements and then making comparisons between each possible pair in each cluster (as a matrix). This gives a weighting for each element

within a cluster (or level of the hierarchy) and a consistency ratio (useful for checking the consistency of the data) [38].

The steps involve in AHP process are given below:

Step 1: Determining decision hierarchy with Attributes (criteria) and Alternatives (Suppliers) where clearly shown their relationship.

Step 2: Determining pair wise comparisons of attributes and alternatives with the help of pairwise comparison scale. This is used to determine the relative importance of attributes and alternatives and also compared how well the options perform on the different attributes. The pairwise comparison judgment obtains from experts or specialist in the relevant area. Pairwise comparison scale for AHP preferences is given in Table 1.

Step 3: Find out the weights, Maximum Eigen value (λ max) and C.I (Consistency Index) of attributes and alternatives.

Step 4: Calculate the value of C.R (Consistency Ratio)=C.I/R.I where R.I (Randomly Generated Consistency index) is taken from Table 2.

Step 5: Follow step 4 find out all the weights, collect all and put them in excel sheet. Then normalize the weights and find out the best supplier.

Step 6: After finding the best supplier then cut off the best supplier and considering others suppliers another side adds or removes some criteria which are risk related criteria. Selecting all of this the full calculation repeated and prioritizing another best supplier which is best when any uncertainty is occurred with best supplier

A Case Study

A supplier selection is a principal part of the order processing element of the entire order fulfillment process. Traditional factors to select suppliers are cost, quality, and responsiveness. But these are not only important factors that affect the overall performance but also some others factors. Some special factors have to be considered to overcome risks. Those are: Technology, Price, Service, Keeps Promise, Standardization, Packaging and Transportation cost. Suppliers must be prioritized on each of these factors because they all affect the total profitability and effective functioning of the industry.

ABC Company is one of the leading leather products company offering customers a high quality and versatile items of leather products from a single source. With global expertise in express, air and ocean freight, overland transport and contract logistics, ABC Company combines worldwide coverage with in-depth understanding local

Numerical Rating	Verbal Judgments of Preferences
9	Extremely preferred/important
8	Very strongly to Extremely
7	Very strongly preferred/important
6	Strongly to very strongly
5	Strongly preferred/important
4	Moderately to strongly
3	Moderately preferred/important
2	Equally to moderately
1	Equally preferred/important

Table 1: Pair-wise comparison scale for AHP preferences.

Size (n)	1	2	3	4	5	6	7	8	9	10
R.I	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Table 2: Randomly Generated Consistency Index for different size of matrix.

markets. ABC Company has international network links with more than 12 countries throughout the world. ABC company work with over 1500 dedicated members, guarantees fast and reliable services aimed at exceeding customers' expectations.

ABC leather Products Company in Bangladesh produces various types of products like ladies purse, wallet, ladies bag, card holder, travel bag etc. For its smooth production, the company has many suppliers in different countries of the world. Here, one particular item has considered for example. The item is a ladies bag which is made of 10 types of raw materials. Sewing materials such as thread, lining, seam tape, D-ring, studs, snaps, and zippers are generally purchased from outside vendors and stored in the factory. Specifically, for zippers multiple numbers of suppliers are available. The suppliers are situated in different countries such as Singapore (S1), Sri Lanka (S2), Malaysia (S3), and Japan (S4).

Risk management process

A supplier selection decision inherently is a multi-criterion problem [16]. First step is identification of quantitative and qualitative selection criteria to select the best supplier. For this purpose AHP is a useful tool because it considers multiple criteria which are really vital for supplier selection. However, its limitations are that it only works on matrices that are all of the same mathematical form and becomes complex with increasing numbers of criteria and alternatives. The main objective of this paper is to develop a simple and easy supplier selection model which considers relevant criteria for managing supply risks so that anyone can use it quickly without difficulty. Eight selection criteria that have significant effects on supplier selection are identified and taken as input factors to the AHP to evaluate the supplier ranking index which is considered the output. Finally, the ranking index for a specific supplier is calculated by entering the value of all the inputs of that supplier. The supplier with the highest ranking index is given the most preferences for selection. Now the same processes have to be performed again to select the best alternative supplier. But this time selection criteria will be changed with consideration of crucial risk factors. Also the weight age of criteria will be changed if same criteria have been considered.

The proposed modeling approach is organized to deal with the company's logistics risks and then utilize the AHP tool to determine the best supplier and also best alternative supplier when necessary.

Types of risks in studied networks: Risks of the companies are related to their objectives. The main objective of the owners is usually that the company should be profit-making. For this reason the company needs a smooth production. However, this is possible if company can maintain a good relationship with suppliers and get the supply in time. The risks initiate from uncertainty. A major uncertainty for companies arises from supplier. If the suppliers will not deliver the product in time the production will be halted. Delivery uncertainties are connected to the ability to manage the costs, time and quality of the company's production system.

In this study we considered 11 types of risk factors. Among them eight factors were used to get best supplier. Factors are given in below:

1. Quality (C1) [39]

2. Delivery (C2) [5]
3. Technology (C3) [20]
4. Price (C4) [40]
5. Service (C5) [41]
6. Keeps Promise (C6) [42]
7. Standardization (C7) [5]
8. Packaging (C8) [42].

Others factors are considered to select best alternative supplier.

1. Quality
2. Demand flexibility
3. Adequacy of transportation
4. Supplier's lead time
5. Technological change

These factors are important when selected supplier suddenly become unavailable. When we get to know that our main supplier cannot deliver product that time main concern becomes to get the raw material somewhere else. Company starts looking for the alternative supplier who can give delivery quickly. If any supplier shows more flexibility to produce large amount, can produce quickly and have strong communication system that supplier becomes the desirable supplier for the company. Figure 1a and 1b shows the factors that have been considered to select suppliers.

In this study, considering Singapore supplier is "Supplier 1", Sri Lanka supplier is "supplier 2", Malaysia supplier as "Supplier 3, Japan supplier as "Supplier 4".

Evaluation at level 1 for attributes: By using AHP tools and with the help of experts calculate the relative weights of multiple attributes and finally select the best supplier. The total procedure is given here. Pairwise comparison matrix for main attributes is shown in Table 3.

Pairwise comparison matrix for quality is shown in Table 4.

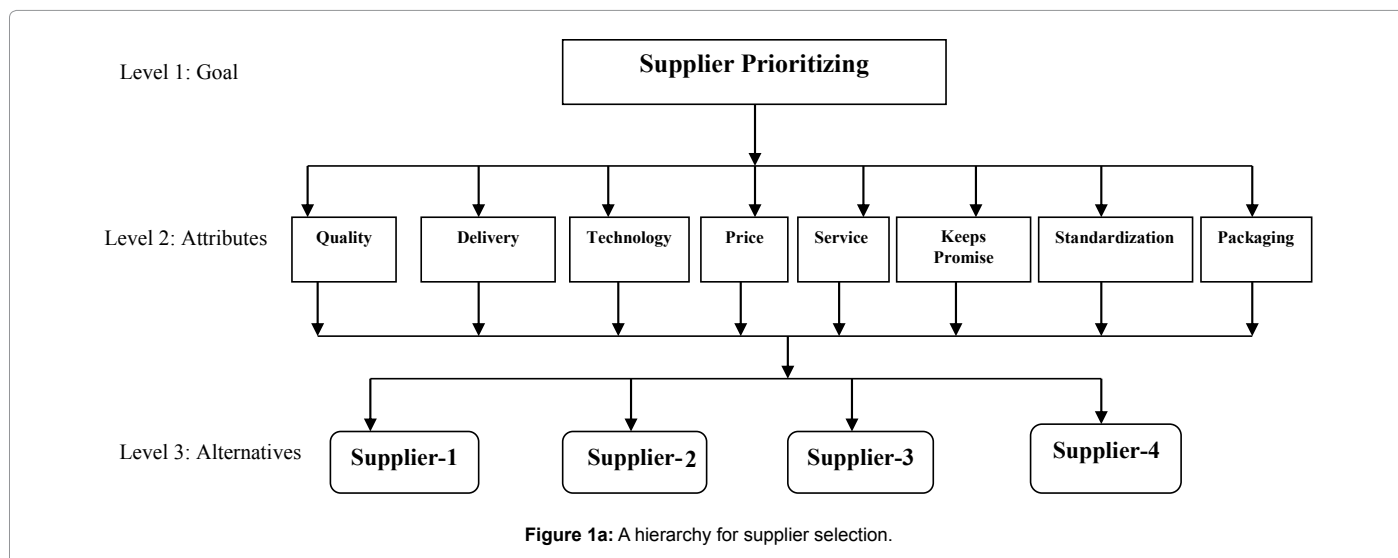


Figure 1a: A hierarchy for supplier selection.

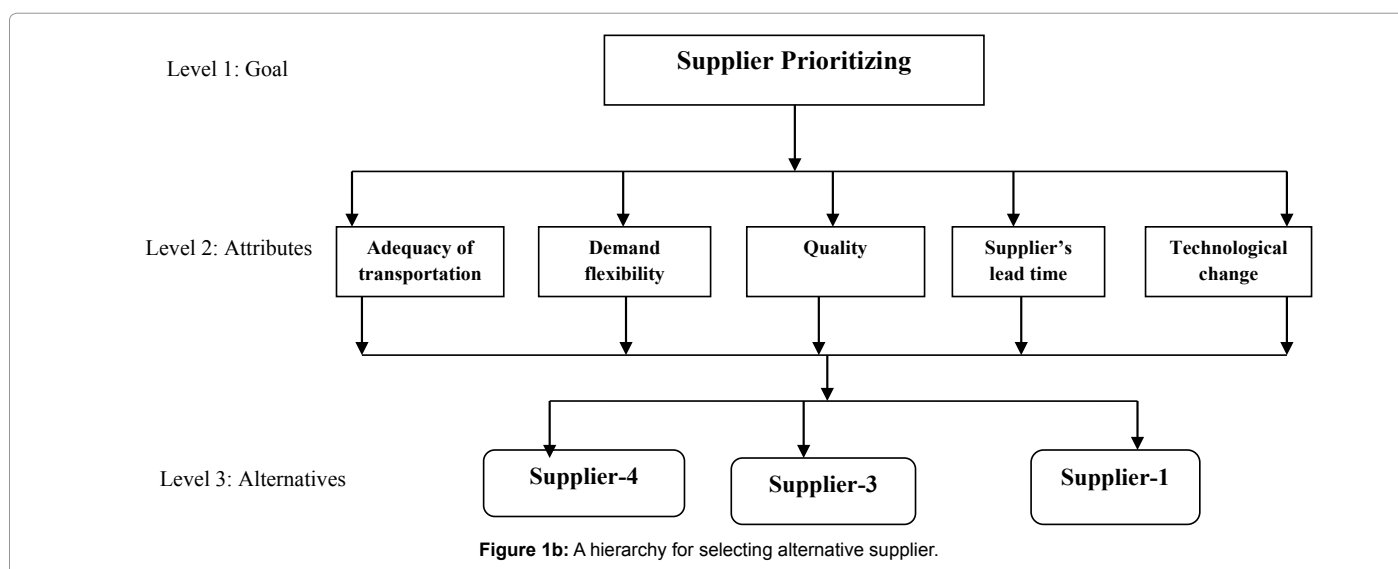


Figure 1b: A hierarchy for selecting alternative supplier.

Attributes	C1	C2	C3	C4	C5	C6	C7	C8	Weights
C1	1	1/2	1	1	1/2	1	1/2	1	0.0810
C2	2	1	2	2	1	2	1	1/2	0.1573
C3	1	1/2	1	1	1	1/2	1	1	0.0983
C4	1	1/2	1	1	2	1	1/2	2	0.1300
C5	2	1	1	1/2	1	2	2	1	0.1454
C6	1	1/2	2	1	1/2	1	1	2	0.1234
C7	2	1	1	2	1/2	1	1	1/2	0.1236
C8	1	2	1	1/2	1	1/2	2	1	0.1320

Table 3: Pairwise comparison matrix for main attributes.

C1	Supplier 1	Supplier 2	Supplier 3	Supplier 4	Weights
Supplier 1	1	2	1	1/2	0.236799
Supplier 2	1/2	1	1/2	1	0.179609
Supplier 3	1	2	1	1/2	0.236799
Supplier 4	2	1	2	1	0.346792

Table 4: Pairwise comparison matrix for quality.

Alternatives	Attributes and their weights								Composite weights	Ranking
	C1	C2	C3	C4	C5	C6	C7	C8		
	0.089967	0.157298	0.0982985	0.130005	0.145443	0.123368	0.123637	0.131982		
Supplier 1	0.23679	0.244839	0.337351	0.155642	0.198101	0.340454	0.176826	0.237716	0.23726131	2
Supplier 2	0.17960	0.253612	0.126079	0.658856	0.570919	0.279187	0.433577	0.291966	0.36371801	1
Supplier 3	0.23679	0.167183	0.263113	0.0859281	0.102505	0.192019	0.194799	0.299752	0.1868794	4
Supplier 4	0.34679	0.334366	0.273457	0.0995738	0.128474	0.18834	0.194799	0.170566	0.21213704	3

Table 5: Final Evaluation.

Attributes	A1	A2	A3	A4	A5	Weights
A1	1	1/3	1	1/3	1/3	0.09591
A2	3	1	2	1	2	0.295098
A3	1	1/2	1	1/2	1	0.13815
A4	3	1	2	1	2	0.295098
A5	3	1/2	1	1/2	1	0.175744

Table 6: Pairwise comparison matrix for attributes.

A1	Supplier 4	Supplier 3	Supplier 1	Weights
Supplier 4	1	3	3	0.6
Supplier 3	1/3	1	1	0.2
Supplier 1	1/3	1	1	0.2

Table 7: Pairwise comparison matrix for quality.

Alternatives	Attributes and their Weights					Composite weights	Ranking
	A1 0.09591	A2 0.295098	A3 0.13815	A4 0.295098	A5 0.175744		
Supplier 4	0.6	0.4	0.547216	0.47423	0.549809	0.487753048	1
Supplier 3	0.2	0.2	0.263074	0.149373	0.0821306	0.173058907	3
Supplier 1	0.2	0.4	0.189709	0.376397	0.36806	0.339187837	2

Table 8: Final evaluation.

Similarly other comparison matrices are formulated and calculated relative weights which is given in Annexure 1 in Tables A1.1-A1.7. Finally, we have got the final weights for four suppliers which are given in Table 5.

From the above results, it is observed that “Supplier 2” Sri Lanka supplier is ranked 1 among 4 suppliers. Thus, the decision is to select supplier 2.

Evaluation at level 2 for alternatives: When some risk is happened with Supplier 2 then the rest of 3 suppliers and considering some new attributes like

1. Quality (A1)

2. Demand Flexibility (A2)
3. Adequacy of Transportation (A3)
4. Supplier’s lead time (A4)
5. Technological Change (A5).

Therefore, we evaluate the best supplier when logistics risk is occurred and the evaluation process in Table 6.

The comparison matrix for quality is given in Table 7.

Similarly other comparison matrices are formulated and calculated relative weights which is given in Annexure 2 in Tables A2.1-A2.4.

Finally, we have got the final weights for three suppliers which are given in Table 8.

From the results in Table 8, it is observed that "Supplier 4" means Japan supplier is ranked 1 among 3 suppliers. Thus, the decision is to select Supplier 4 when risk is occurred with Supplier 2.

Discussion and Conclusions

After conducting such case study, it is known that every company has a lot of logistics risks. But such kinds of risk are always creating opportunities. It only depends on how we can handle them or not. Using risk management methods, it can identify all risks clearly and point out related solution at all.

Prioritization of the supplier is undoubtedly crucial for any company and it becomes harder when selected supplier becomes unobtainable. In Bangladesh, many companies use thumb rule and their past experiences to decide about such complex situation and the decision might be wrong that's why company didn't achieve their profit properly. Also, it costs a lot of time, mental pressure and there is no scientific and logical method to make decisions on it. This uncertain characteristic affiliated with the prioritization of the suppliers leads to the utilization of AHP model, which facilitates the prioritization process by making it credible and accurate.

From results it can be showed that rank of suppliers will be changed with the importance of considered factors. Factors will not remain same in every situation. Uncertainties are a common thing which brings change in normal situation. To deal with all these changes proactive strategies must be followed. For this reason we have to consider risk factors in our calculation before it occurs. This study reveals that when selected supplier suddenly stops their delivery we cannot manage to run the production of the company smoothly. There remains no sufficient time to get another supplier immediately. To prevent this problem proactive strategies have to be taken. We need to find a best alternative while selecting a supplier. Thus it will save our time to get immediate supplier when selected supplier will stop cooperating. Also keeping relation with multiple supplier helps to minimize dependency and logistics risks. But managing the multiple suppliers is not that easy. It can make the situation more complex like performance tracking, design collaboration, and synchronization becomes complicated.

The main objective of this paper was to develop a simple and straightforward supplier selection model by considering relevant criteria for managing logistics risks. 11 different selection criteria used to determine the supplier ranking index. An AHP was applied to obtain aggregated optimized results based on some developed rules. Risks due to uncertainty were also incorporated in this model by considering some special criteria. When selected supplier will be unavailable for some unavoidable reasons then best alternative can be found out in this way. Anyone can easily use this model to select the best supplier and best alternative. Also it can be applied in any company where a complex supply chain has to be maintained and selecting the most suitable suppliers is very important.

Managerial Implications and Future Direction of Study

Our expectation is that this study will be helpful for formulating managerial decision making process in other manufacturing companies. Supplier selection is key issue for managing risk and sustains their business in competitive global market. This study shows the way of supplier selection and also finds the best supplier during risk is occurred in supply chain network. The practical implication of this

study is tested in leather products company supply chain. The manager of leather products company will be beneficial to evaluate the best supplier also can able to select best supplier during risk is occurred. Other company of Bangladesh like, footwear, leather, chemical, pharmaceutical etc. can get idea from this research for practical implications for best supplier selection. In future other multi criteria tools Fuzzy-AHP can be used to evaluate best supplier.

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