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Procedia - Social and Behavioral Sciences 58 (2012) 1448 – 1457

Procedia
Social and Behavioral Sciences

8th International Strategic Management Conference

The selection of global supply chain risk management strategies by using fuzzy analytical hierarchy process – a case from Turkey

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Abstract

Many developments associated with globalization have forced companies to manage their supply chains effectively and to mitigate various kinds of chain risks in them. In this study, Fuzzy Analytical Hierarchy Process is used to determine the most important supply chain risks and the corresponding risk management strategies. The research is conducted with the supply chain management of a company operating in the iron and steel industry. Findings indicate that supply risks and operational risks are quite important compared to environmental risks. Also, control/sharing/transfer strategy is followed by hedging, speculation, and postponement strategies in terms of the scope and intensity of their effects on different risk types.

Keywords: Global supply chain management, Fuzzy analytical hierarchy process, Supply chain risks

1. Introduction

Today, many companies operate and compete in a global environment. Companies operating in a global competitive environment have some advantages such as cheaper workforce and raw materials, better financial opportunities, arbitrage opportunities, wider product markets and incentives offered by host countries (Manuj and Mentzer, 2009). The increasing internationalization of production and marketing activities allow firms to develop a product in one country, produce it in a different one and sell it in another. That boosts flows of material and components along with final products among countries. Companies should be alert to the changes in external factors like economic trends and technological innovation in other countries. Also, these companies have to change the ways in which they manage their operations and supply chains. One of the new approaches called for by the new competitive landscape is Global Supply Chain Management (GSCM).

This study begins with a brief literature review of supply chain risks and supply chain risk management strategies. Then, we will give some information about Fuzzy Analytical Hierarchy Process method (FAHP) and its applicability

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in Global Supply Chain Risk Management Strategies. A Turkish company case will be provided regarding how the method can be used in supply chain risk mitigation strategies. The paper will end up with a discussion of key findings of the research and the literature review.

2. Literature Review

2.1. Supply Chain Risk

A supply chain is the combination of the interrelated organizations, resources, and processes that create and deliver products and services to end customers (Russelland Taylor, 2001). When it comes to global supply chains, the approach has a global focus, meaning that customers or chain elements can be anywhere in the world. One problem about GSCM is that there are some uncertainties and risks that managers face in global supply chains. Risk is defined as potentially important or disappointing results of to be implemented decisions (Sitkin and Pablo, 1992) and supply chain risk is defined as an event that adversely affects supply chain operations and hence its desired performance measures like cost, chain-wide service levels and responsiveness (Tummala and Schoenherr, 2011). Even though consequences are usually negative, they have the potential to produce positive outcomes if appropriate risk-taking is performed (Blume, 1971 in Ritchie and Brindley, 2007).

The literature on supply chain risks suggests a number of different risk classifications. For example, Tummala and Schoendherr (2011) cite the following as supply chain risks: Demand risks, Delay risks, Disruption risks, Inventory risks, Manufacturing (process) breakdown risks, Physical plant (capacity) risks, Supply (procurement) risks, System risks, Sovereign risks, and Transportation risks. Kleindorfer and Saad (2009) categorized these risks into two groups, those arising from coordinating complex systems of supply and demand and those arising from disruptions to normal activities. Similarly, Cucchiella and Gestaldi (2006) preferred to categorize them into two groups: Internal Risks (e.g., capacity variations, information delays, and organizational factors) and External Risks (e.g., market prices, competitors' actions, supplier quality, and political issues). According to another useful and comprehensive risk classification, there are four categories of risks (Christopher and Peck, 2004; Manuj and Mentzer, 2008):

a. **Supply risk** is the potential variation of outcomes related to adverse events in inbound supply that affect the ability of a firm to meet customer demand adequately in terms of cost, time, quality, and etc. Supply risk may threaten customer life and safety.

b. **Demand risk** is the potential variation of outcomes related to adverse events in the outbound flows that affect customer orders in anyway like their likelihood, volume and assortment.

c. **Operational risk** is the potential variation of outcomes related to adverse events within the firm that affect a firm's internal ability regarding production in terms of profitability, quality, timeliness, and etc.

d. **Security risk** is the potential variation of outcomes related to adverse events that threaten human resources, operations integrity, and information systems. Tang (2006) points to the fact that not only our world is becoming more uncertain and vulnerable as frequency of unpredictable disasters like terrorist attacks, wars, earthquakes, tsunamis, hurricanes, economic crises, contagious diseases, strikes, computer virus attacks increase, but also average cost of each disaster has risen dramatically for the last few decades.

2.2. Global Supply Chain Risk Management

Motwani et al. (1998) indicate that GSCM has become a hot topic in manufacturing due to the increasing homogenization of needs and markets globally, the need for centralized research and development, and the mounting pressure on manufacturers to deliver raw materials, components, and products quickly. As global competition intensifies, companies search for ways of obtaining competitive advantage and supply chains become longer and more complex, it becomes harder to achieve the desired supply chain performance (Jüttner, 2005; Tummala and Schoenherr, 2011). However, ensuring the delivery of products in the right quantity and to the right place efficiently is a prerequisite of success in supply chains and failing to do that has severe consequences (Faisal, 2009). By adopting GSCM, firms can make full use of intellectual capital and knowledge base for R&D, engineering, and market research and take advantage of diversity in the international environment by recognizing and exploiting regional differences in input factor costs, local tax rates, vendor capabilities, and technology expertise (Cohen and Mallik, 1997). It is obvious that an important issue in GSCM is managing risks in global supply chains.

Failing to managing supply chain risks may be detrimental to a firm's financial and operational performance. Thus, the firm has to find ways of mitigating supply chain risks. Supply chain risk management (SCRM) is defined as "*the process of risk mitigation achieved through collaboration, co-ordination and application of risk management tools among the partners, to ensure continuity coupled with long term profitability of the supply chain*". It is basically an action plan specifying the potential risks and the ways of addressing them (Faisal, 2009).

2.3. Supply Chain Risk Management Strategies

SCRM strategy classifications offered in the literature resemble classifications of supply chain risk types suggested in terms of variety and content similarity. For example, demand management, supply management, product management, and information management are classified as risk mitigation approaches by Blos and et al. (2009). Faisal (2009) suggest prioritizing and choosing among 18 best practices introduced by Elkins et al. (2005) to mitigate supply chain risks. Kleindorfer and Saad, 2005 introduces a framework called SAM in which sources of risks and vulnerabilities are specified, risks are assessed and tried to be mitigated by using a set of 10 principles derived from industrial risk management and supply chain literatures. Some of these principles are putting a company's house in order; applying portfolio theory in sourcing options, logistics, and operational modes; focusing on prevention rather than cure; establishing backup systems, contingency plans, and maintaining reasonable slack; collaborative sharing of information and practices among supply chain partners; applying TQM principles like Six-Sigma Approach. Depending on a literature review and the results of a qualitative study, Manuj and Mentzer (2008) suggested the following grouping for risk management strategies:

1. **postponement** (delaying the actual commitment of resources to maintain flexibility and delay incurring costs; may benefit concepts like standardization, commonality, modular design and operations reversal, to delay the point of product differentiation (Tang, 2006).
2. **speculation** (the opposite of postponement; also called as selective risk taking)
3. **hedging** (having a globally dispersed portfolio of suppliers and facilities)
4. **control/share/transfer** (take the form of vertical integration, contracts, and agreements)
5. **security** (encompasses information systems security, freight breaches, terrorism, vandalism, crime, and sabotage)
6. **avoidance** (exiting through divestment of specialized assets, delay of entry into a market or market segment, or participating only in low uncertainty markets)

3. Methodology

3.1. Research Goal

In this study, we try to determine the most significant global supply chain risks and risk mitigation strategies for a company operating in the iron and steel industry. Also, we focus on the relationship between the risk types and regarding strategies. Even though there are many studies in the literature dealing with supply chain risk types and risk management strategies, these studies do not address the link between risk types and strategies at all as Manuj and Mentzer (2008) point out. By providing empirical findings on this relationship, this study not only helps filling the gap in the literature but also be one of the pioneer studies in Turkey on the subject.

3.2. Fuzzy Analytic Hierarchy Process (FAHP)

In this study, Fuzzy Analytic Hierarchy Process (FAHP) which is one of the decision making techniques is used to estimate the weights of the risk factors in a supply chain. The importance of each of the risk mitigation strategies is also estimated accordingly. One of the advantages of AHP is its ease of use in assessing multiple criteria simultaneously. Even though AHP is based on expert opinion, traditional approach of the method can not reflect the human mind in a realistic way (Kahraman et al., 2003; Panagiotis and Giannikos, 2009). In the traditional AHP technique, it is doubtful to use integer values while the alternatives are compared to each other. Besides, judgement scale in this method is criticized for not being capable of understanding the uncertainties and negligence in the comparison process (Deng, 1999). In order to eliminate all these shortcomings, FAHP method is used in this study. FAHP can be seen as a synthetic extension of the classical AHP method by taking into account the fuzziness of

decision makers (Özdağoğlu and Özdağoğlu, 2007). In order to show how calculations are made in the empirical part of this paper, the key steps of this method are described as follows (Akman and Alkan, 2006):

Step 1: A hierarchical structure is created by defining multi-criteria decision problem. The structure consists of an overall goal, alternatives for reaching the goal and criteria that relate the alternatives to the goal. Each criterion can be divided into sub-criteria depending on the complexity of the decision problem.

Step 2: Experts' opinions and views are very crucial in the solving of the decision problem. A question form is structured involving pairwise comparisons of criteria or alternatives and filled by the experts of the subject. These pairwise comparisons are transferred into a comparison matrix through a preference scale developed by Saaty (1980). A good decision-making model needs to tolerate vagueness or ambiguity sincefuzziness and vagueness are common characteristics in many decision-making problems. Due to the fact that uncertainty should be considered in some or allof the pairwise comparison values, the pairwise comparison under traditional AHP,in which discrete values are selected in the process, may not be appropriate (Yu,2002). Hence, the preference scale is converted into linguistic scale as proposed by Akman and Alkan (2006) and Angnostopoulos *et al.,* (2007). The preference scale and linguistic fuzzy scale are shown in Table 1.

Step 3: Chang's extent analysis method is used to calculate fuzzy synthetic values. This calculation is explained as follows (Chang, 1996):

A triangular fuzzy number can be denoted as $M= (l, m, u)$. Where$l<m<u$,$l$and $u$stand for the lower and upper value of the support of M respectively, and $m$is the mind-value of M.$G = \{g_1, g_2, \dots\dots g_n\}$

Let $X = \{X_1, X_2, \dots\dots X_n\}$is a criteria set and$G = \{g_1, g_2, \dots\dots g_n\}$is a goal set. According to this method, for each criterion and for each objective, Chang's **extent** analysis is applied. Thus, for every criterion, m number of **extent** analysis value is obtained. These values are shown as follows:

$M_{gi}^{1}, M_{gi}^{2}, \dots\dots, M_{gi}^{m}$

Here, each value ofM_{gi}^{j}($i=1, 2, \dots, n$ and $j = 1, 2, \dots, m$) is a triangle fuzzy number. According to criteria i, the fuzzy synthetic value is defined as the following;

$$S_i = \sum_{j=1}^{m} M_{g_i}^{j} \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^{j} \right]^{-1} \quad \dots\dots (1)$$

Here, in order to obtain value of $\sum_{j=1}^{m} M_{g_i}^{j}$ fuzzy addition is used for m extent analysis value.

$$\sum_{j=1}^{m} M_{g_i}^{j} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j \right) \quad \dots\dots (2)$$

$$\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^{j} = \left(\sum_{i=1}^{n} l_i, \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i \right) \quad \dots\dots (3)$$

Then reverse of the vector (4) is obtained as the following;

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^{j} \right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i} \right) \quad \dots\dots (4)$$

Table 1. AHP and Fuzzy AHP Scales (Angnostopoulos *et al.,* 2007; Akman and Alkan, 2006)

Linguistic Variables	SCALE	RECIPROCAL SCALE	TRIANGULAR FUZZY SCALE	TRIANGULAR FUZZY RECIPROCAL SCALE
Equally Preferred	1	1	(1,1,1)	(1/1,1/1,1/1)
Equally to Moderately Preferred	2	½	(1,2,3)	(1/3,1/2,1)
Moderately Preferred	3	1/3	(2,3,4)	(1/4,1/3,1/2)
Moderately to Strongly Preferred	4	¼	(3,4,5)	(1/5,1/4,1/3)
Strongly Preferred	5	1/5	(4,5,6)	(1/6,1/5,1/4)
Strongly to Very Strongly Preferred	6	1/6	(5,6,7)	(1/7,1/6,1/5)
Very strongly Preferred	7	1/7	(6,7,8)	(1/8,1/7,1/6)
Very Strongly to Extremely Preferred	8	1/8	(7,8,9)	(1/9,1/8,1/7)
Extremely Preferred	9	1/9	(8,9,9)	(1/9,1/9,1/8)

Step 4: Liou and Wang's method is used to estimate the relative weights of each criterion. (The defuzzification process).

The extent analysis method of Chang is the technique that is widely used in the literature for FAHP problems. However, Wang et al. (2008) state that the extent analysis method estimate the true final weights from a fuzzy comparison matrix and that has led to quite a number of misapplications in the literature. Therefore, in this study, after calculating the synthetic values by Chang's method, the final weights are calculated from weighted index values of integral values according to Liou and Wang's method (Aktepe and Ersoz, 2011). Total integral value for triangular fuzzy number is defined as;

$$I_T^{\alpha}(\widetilde{M}) = \frac{1}{2}\alpha(m+u) + \frac{1}{2}(1-\alpha)(l+m) = \frac{1}{2}[\alpha u + m + (1-\alpha)l] \quad \ldots\ldots\ldots\ldots\ldots\ldots(5)$$

Here, α is an index of optimism that represents the degree of optimism of the decision-maker and $0 \leq \alpha \leq 1$. A bigger value of α indicates a higher degree of optimism (Moon and Kang, 2001). Then, the weight of each criterion is calculated by normalizing the indexes of optimism.

3.3. Analyses and Findings

The empirical research is conducted with a company operating in the iron and steel industry. The company is located in Turkey and has a large portfolio of customers and suppliers overseas. Having a vision of being a leader in its field and gaining worldwide recognition, the company has a special interest in building outstanding relations with its partners in the value delivery network and managing its supply chain effectively. The mesh between that vision and the main goal of this study has made this research possible. The manager responsible for the company's procurement and supply chain management has been very cooperative in meetings and very careful in FAHP evaluations, which is of utmost importance for the application of such a methodology. The name of the company is not given in the paper due to the confidentiality principle.

In the first step of the empirical study, we grouped all supply chain risks we gathered based on our literature review under the four basic dimensions (supply risks, demand risks, operational risks and security risks) suggested by Manuj and Mentzer (2008). The total number of risks at first was 32 but it was reduced to 21 after a depth interview with the supply chain manager to elicit the ones that are relevant to the company's operations. Two of these were new risk types added to the form at this step by the manager.

In the second step, the supply chain manager performed pairwise comparisons to sort four basic risk categories according to their importance. In order to make pairwise comparisons among the basic risk categories, the linguistic scale proposed by Akman and Alkan (2006) and Angnostopoulos et al. (2007) is used. Then the manager is asked to make pairwise comparisons for the sub-risks under the basic risk categories to sort them by their importance.

In the third step, pairwise comparisons made by the manager are evaluated by using the methodology explained before. The manager's pairwise comparisons have been transferred into a preference scale by using the triangular fuzzy scale in Table 1. Then, the weight of each criterion is calculated through FAHP. The salient risk types under each of the four dimensions are determined by ranking them according to their weights. Here, we applied Pareto analysis (risks with higher weights claiming cumulatively the 80% of weights in each risk group were chosen) to determine the most important risk types which will be used in the next stage of analysis.

Table 2 and the following section show the calculations done only for supply chain risk groups to give a better picture of the quite complex Fuzzy Analytic Hierarchy Process. Similar calculations are made for supply chain risk types and risk management strategies.

Table 2. Fuzzy Comparison Matrix of Global Supply Chain Risk Groups

	Supply Risks (SR)			**Operational Risks (OR)**			**Demand Risks (DR)**			**Environmental Risks (ER)**		
Supply Risks	1.000	1,000	1.000	0.143	0.167	0.200	6.000	7.000	8.000	7.000	8.000	9.000
Operational Risks	5.000	6.000	7.000	1.000	1.000	1.000	1.000	1.000	1.000	6.000	7.000	8.000
Demand Risks	0.125	0.143	0.167	1.000	1.000	1.000	1.000	1.000	1.000	6.000	7.000	8.000
Environmental Risks	0.111	0.125	0.143	0.125	0.143	0.167	0.125	0.143	0.167	1.000	1.000	1.000

Calculation of fuzzy synthetic values for supply chain risk groups as explained in Equation 1;

$S_{SR} = (0.297,\ 0.388,\ 0.491)$ $S_{OR} = (0.273,\ 0.360,\ 0.459)$

$S_{DR} = (0.171,\ 0.219,\ 0.275)$ $S_{ER} = (0.029,\ 0.034,\ 0.040)$

As explained in Equation 5, calculation of each supply chain risk group;

$I_{SR} = 0.391$ $I_{OR} = 0.363$ $I_{DR} = 0.221$ $I_{ER} = 0.034$

Finally, the weight of each group is calculated by normalizing the indexes of optimism;

$$W_{OR} = \frac{0.363}{1.009} = 0.360 \qquad W_{DR} = \frac{0.221}{1.009} = 0.219 \qquad W_{ER} = \frac{0.034}{1.009} = 0.034$$

Finally, the manager performed pairwise comparisons regarding risk management strategies. The strategy classification which is introduced by Manuj and Mentzer (2008) and explained in the literature review part of this paper is used to make comparisons. These strategies are grouped as postponement, speculation, hedging, control/share/transfer, security, and avoidance. Since not every strategy is suitable for all risk types, another depth

interview is conducted with the manager to select the strategies suitable for each risk type. During the interview, each strategy is explained in detail to the manager and the number of risks relevant to at least one of the six strategies is reduced to 15. Afterwards, pairwise comparisons are performed again by the manager and the weights of each strategy for different risk types are calculated through FAHP. The findings of all the analyses can be found in Table 3. Specifically, they show (1) the weight (importance) of each supply chain risk group, (2) the weight (importance) of each supply chain risk type in all groups, (3) and the weight (importance) of each supply chain management strategy.

Table 3. Important Supply Chain Risk Groups & Risk Types & Risk Management Strategies for the Firm

Risk Group (W_i)	Risk Type (W_{ij})	Risk Management Strategy
Supply Risks (W_{SR}=0.391)	**Working with wrong or inappropriate suppliers (W_{SR1}=0.232)**	Hedging Strategy (0.632)
		Control /Sharing/Transfer Strategy (0.316)
		Avoidance Strategy (0.052)
	Suppliers being late to submit documents to banks (W_{SR2}=0.219)	Speculation Strategy (0.470)
		Control /Sharing/Transfer Strategy (0.460)
		Hedging Strategy (0.070)
	Port capacity and congestion (W_{SR3}=0.185)	Speculation Strategy (0.643)
		Hedging Strategy (0.243)
		Avoidance Strategy (0.114)
	Custom clearances at ports (W_{SR4}=0.167)	Postponement Strategy (0.791)
		Hedging Strategy (0.135)
		Security Strategy (0.073)
	Transit time (W_{SR5}=0.112)	
	Dependency and opportunism (W_{SR6}=0.072)	
	Financial stability of the supplier (W_{SR7}=0.012)	
Operational Risks (W_{OR}=0.363)	**Higher costs of transportation (W_{OR1}=0.209)**	Control /Sharing/Transfer Strategy (0.644)
		Hedging Strategy (0.308)
		Avoidance Strategy (0.048)
	Production related capacity problems (W_{OR2}=0.188)	Control /Sharing/Transfer Strategy (0.496)
		Speculation Strategy (0.205)
		Avoidance Strategy (0.172)
		Hedging Strategy (0.127)
	Quality of service, including responsiveness and delivery performance (W_{OR3}=0.174)	Hedging Strategy (0.461)
		Control /Sharing/Transfer Strategy (0.461)
		Avoidance Strategy (0.077)
	Supplier fulfillment and costs of holding inventory (W_{OR4}=0.171)	Control /Sharing/Transfer Strategy (0.368)
		Hedging Strategy (0.368)
		Speculation Strategy (0.221)
		Avoidance Strategy (0.044)
	Poor product quality (W_{OR5}=0.166)	Control /Sharing/Transfer Strategy (0694)
		Hedging Strategy (0.155)
		Avoidance Strategy (0.151)
	Human resources risk (W_{OR6}=0.077)	
	Information technology failures (W_{OR7}=0.016)	
Demand Risks (W_{DR}=0.221)	**Excessive demand of consumers (W_{DR1}=0.333)**	Speculation Strategy (0.680)
		Control /Sharing/Transfer Strategy (0.252)
		Hedging Strategy (0.068)
	Consumer demand volatility (W_{DR2}=0.333)	Postponement Strategy (0.471)
		Control /Sharing/Transfer Strategy (0.471)
		Hedging Strategy (0.059)
	Risks related to purchase order revisions (W_{DR1}=0.333)	Control /Sharing/Transfer Strategy (0.393)
		Hedging Strategy (0.288)
		Postponement Strategy (0.280)

Risk Group (W_i)	Risk Type (W_{ij})	Risk Management Strategy
		Speculation Strategy (0.039)
Environmental Risks (W_{ER}=0.034)	Economic risks (W_{ER1}=0.504)	Control /Sharing/Transfer Strategy (0.487)
		Security Strategy (0.337)
		Speculation Strategy (0.103)
		Avoidance Strategy (0.074)
	Natural disasters (W_{ER2}=0.235)	Security Strategy (0.568)
		Hedging Strategy (0.360)
		Speculation Strategy (0.072)
	Legal, government and regulation (W_{ER3}=0.232)	Hedging Strategy (0.371)
		Avoidance Strategy (0.302)
		Security Strategy (0.280)
		Speculation Strategy (0.072)
	Social uncertainties (W_{ER4}=0.032)	

4. Conclusion

Even though the research conducted in this study is about a company in the iron and steel industry and generalizations should be avoided, the findings shown in Table 3 still reveal important insights for managers of supply chains regarding supply chain risk types, risk groups, and risk management strategies. Nevertheless, findings and their discussions given here should be considered as valid for the company examined.

First of all, supply risks and operational risks seem to be highly important as a risk group, followed by demand risks. On the other hand, the weight for environmental risks is minimal. Instead of looking at the whole picture for risk management strategies, it is better to look at the effects of each one on different risk types. Yet, Control/Sharing/Transfer strategy overrides other risk mitigation strategies in general. The company managers can engage in vertical integrations, contracts, and alliances to share their risks. They adopt this strategy especially to prevent operational risks of production related capacity problems, quality problems of supplier service, and costs of holding inventory. Besides, they try to control cost escalation in transportation through doing outsourcing right.

Company managers think that both Control/Sharing/Transfer strategy and Postponement strategy have similar utility for the risks arising from consumer demand volatility. In that sense, having close supplier relations and improving production processes are thought by managers to provide the flexibility needed for demand volatility in international markets. Vertical integration is another option to this end.

An important risk type defined and emphasized by the management is the risks related to purchase order revisions. When that happens, materials and components related to previous orders are usually on the road, in production or in inventory. Control/Sharing/Transfer strategy is seen as the best way to eliminate that kind of risk. It is also considered as the best alternative to deal with economic risks and natural disasters. Contracts and alliances allow managers to have flexible options and to avoid economic risks.

Hedging strategy is the best solution for working with wrong or in appropriate suppliers. Having established good quality and process controls, the company managers can rely on Hedging strategy, which means using a portfolio of suppliers, as much as they rely on Control/Sharing/Transfer strategy for the following operational risks: Problems related to supplier's service quality and supplier fulfillment and costs of holding inventory. Hedging strategy is also very useful for some environmental risks with regards to legal, government and regulations. To a lesser extent, it helps avoiding the risk of natural disasters.

Speculation strategy, referring to early commitment of resources and forward action in the supply chain in order to reduce marketing costs, is the best alternative for the following situations: Excessive demand of consumers requiring more goods to be supplied and suppliers being late to submit documents to banks, and finally problems of port capacity and congestion. All these risks threaten timely production and delivery of products and speculation may be the cure. Unfortunately, these risks are likely to occur for the firm at hand due to red tape common in customs and customers' unwillingness to place orders in advance.

Postponement strategy which is the reverse of speculation is preferred when consumer demand volatility is high and custom clearences at ports take longer times. In the second case, which seems a little

unexpected, firms may wait in order to avoid a problematic custom and look for an alternative solution. The use of postponement strategy depends on the distribution time and frequency of distribution of products demanded by consumers. If the frequency is high and the duration is short, postponement strategy may not be very attractive. Security strategy, involving many acts such as cooperating with government and port officials or using GPS systems, is beneficial in varying degrees for the three types of environmental risks: Economic risks, Natural disasters, and the risks related to Legal, government and regulations. Finally, avoidance strategy is ineffective as a risk mitigation strategy since none of its weights is above 0,20.

In short, in the last few decades, supply chains have become more complex and hard to manage in terms of information, financial, and product flows on both supplier and customer sides. Maintaining continuous flows in supply chains is a prerequisite for the success of those chains. Each flow carries its own risks and requires specific risk management strategies. The right strategy differs from firm to firm and especially depending on managers'subjective evaluations of a firm's current position in the market and its main characteristics. Thus, AHP is among multi-decision criteria methods used in finding that right strategy.

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