SUPPLY CHAIN RISK MANAGEMENT USING ANP

Elena Rokou
School of Mechanical Engineering
National Technical University of Athens
Athens, Greece
E-mail: erokou@mail.ntua.gr

Konstantinos Kirytopoulos
School of Natural and Built Environments
Barbara Hardy Institute
University of South Australia
Adelaide, Australia
E-mail: Konstantinos.Kirytopoulos@unisa.edu.au

ABSTRACT

Supply chain risk management (SCRM) has recently gained interest both from the practitioners and the researchers due to the increased request for efficiency and the diminishing margins for deviations. Organizations aim to achieve their goals for varying levels and types of supply-chain risks. Identifying and dealing with supply chain risks involves a great amount of subjectivity and uncertainty. Analytical examination of the risks related to a specific supply chain is a tedious task due to the lack of available data. This difficulty is accentuated when there are significant variations of the environmental parameters and/or the amount of available information is not sufficient. The proposed approach aims at providing a method for qualitative risk analysis after the risk identification.
The risk identification utilizes the withstanding knowledge related to each echelon of the specific supply chain and to the supply chain as a whole. This data is used to form the risk break down structure that is the main input of the proposed approach. The Analytical Network Process is used for the risk analysis following a multi-criteria approach. The process is applied on the lower RBS level. The risks composing the specific level define the set of alternatives to be ranked. A number of criteria defined by the group of decision makers (supply chain managers and risk analysts) are used for comparing the alternative solutions. The ranking, results on the definition of priorities, for taking mitigation actions. Having in mind that the risk identification and the criteria definition are done once per supply chain and updated when needed, we get a quick way for analyzing supply chains risks. However, as it is expected the more knowledge we get about the specifics of the under question supply chain the higher accuracy has the proposed approach.

Keywords: papers, proposals, paper proposal.

1. Introduction

Shifting of competition from companies to supply chains, leads individual companies to pursue being members of competitive supply chains. At this point the identification of robust and competitive supply chains has become of outmost importance (Birou & Fawcett, 1993). Under these circumstances Supply Chain Risk Management (SCRM) has recently gained interest both from the practitioners and the researchers due to the increased request for efficiency and the diminishing margins for deviations. However, the existence of variant definitions and conceptualizations among the terms of risk, supply chain risk management, uncertainty vulnerability and sources of risks makes the whole effort tedious. Additionally, although several studies provide a wide list of risk management strategies (Jüttner, Peck, & Christopher, 2003), the way that risks should be prioritized, how managers should select the most appropriate strategy and when to take mitigation actions or not, are rarely discussed. In light of this gap, the purpose of this paper is to propose a simple but not simplistic approach, on how to identify risks related to each echelon of the supply chain and afterwards, make informed decisions on which risks and on what order should be taken care of even when the available data are mainly qualitative (Zsidisin, 2003a, 2003b).

2. Literature Review

First step toward the identification of the risks related to each echelon of the supply chain, is to have a clear definition of supply chain management to build upon that. It is defined as *"the management of material, information and financial flows through a network of organizations like suppliers, manufacturers, logistics providers, whole-salers/distributors, retailers etc. aiming at the production and delivery of products or services for the consumers, including the coordination and collaboration of activities and processes across different function"* based on Christopher (2004) and Ritchie and Brindley (2001).

Having defined the supply chain management we can move to the more specific definition of Supply Chain Risk Management (SCRM) as *"the management of supply chain risks through coordination and collaboration among the supply chain echelons so as to ensure profitability and continuity"* (Christopher & Lee, 2004). Looking a little more in depth on what a risk actually is, we could define it as the expected outcome of an uncertain event, risk source. In the case of supply chain related risks, beside the probability of appearance and the impact, there are two more risk dimensions that should be taken into consideration: the frequency and the speed of diffusion of the effects to the other echelons of the supply chain.
Therefore, a three phases approach for supply chain risk management is followed: 1) identification, 2) prioritization of risks and 3) mitigation approach of the selected subset of the identified risks based on the selected strategy and the case at hand.

The **risk identification** utilizes the withstanding knowledge related to each echelon of the specific supply chain and to the supply chain as a whole. Organizations aim to achieve their goals for varying levels and types of supply-chain risks. Identifying and dealing with supply chain risks involves a great amount of subjectivity and uncertainty. Therefore analytical examination of the risks related to a specific supply chain is a time consuming task with uncertain quality of results due to the lack of available data. This difficulty is accentuated when there are significant variations of the environmental parameters and/or the amount of available information is not sufficient. The proposed approach aims at providing a method for qualitative risk analysis after the risk identification. This approach is based on multi-criteria decision making. Decision-making is "a process by which a person, group or organization identifies a choice or judgment to be made, gathers and evaluates information about alternatives, and selects among the alternatives". In cases that the decision depends on more than one criterion we talk about multiple criteria decision analysis (MCDA). More specifically, "Multi-criteria Decision Analysis (MCDA) refers to making preference decision over the available alternatives that are characterized by multiple, usually conflicting, criteria" (Figueira, 2005). That is exactly our goal, to decide which risks should be taken care of and on what order based on the available information and the personal views of the decision maker.

Multiple criteria decision analysis has rapidly evolved since its birth back in the 1960s and it is being widely used to support decision making for problems that involve multiple criteria both quantitative and qualitative (Roy & Vanderpooten, 1996). One of the two most important families of MCDA methods is based on the multiple attribute utility theory (MAUT). The goal of MAUT methods is to aggregate all involved criteria into a function, which has to be maximized. This way a utility value is assigned to each possible alternative. This utility is a number representing how much the considered action is preferred in comparison to the rest of the provided alternatives (Figueira, 2005).

A well-known technique in this domain is the Analytic Network Process (ANP) (T. L. Saaty, 1996), which is a generalization of the Analytic Hierarchy Process (AHP) that can handle complex decision problems. It is a widely used multi-criteria decision analysis method that given the criteria and the alternative solutions of a specific problem, a graph structure is created and the decision maker is asked to pairwise compare the components, in order to determine their priorities. The reasons for selecting ANP, as the utilized MCDA method, concerned both the efficient way that it handles quantitative and qualitative criteria and the possibility to address both simple and complex problems without requiring deep knowledge of the underlying mathematical model and the corresponding calculations needed to get the final results by the decision makers. In addition, ANP provides an easy and accurate way to measure intangible factors by using pairwise comparisons with judgments that represent the dominance of one element over another with respect to a property that they share (Whitaker, 2007). It is based on the idea of analyzing the problem and extracting the critical factors that affect the decision along with the most viable alternative solutions. These factors, called criteria in ANP, should be grouped based on some common property in groups, which are called clusters, in order to ease the decision process. The relationships among all the objects of the model, both clusters and elements, are defined. The next step consists in asking the decision maker to compare pairs of elements with respect to some common property. From that point the computational part of the method begins, which should be automated through software tools (Carlucci, 2010; Yazgan, Boran, & Goztepe, 2010).

3. Hypotheses/Objectives

The Analytical Network Process is used for the risk analysis following a multi-criteria approach. The process is applied on the lower RBS level. The risks composing the specific level define the set of alternatives to be ranked. A number of criteria defined by the group of decision makers (supply chain managers and risk analysts) are used for comparing the alternative solutions. The ranking results on the definition of priorities for taking mitigation actions. Having in mind that the risk identification and the criteria definition are done once per supply chain and updated when needed, we get a quick way for analyzing supply chains risks. However, as it is expected the more knowledge we get about the specifics of the under question supply chain the higher accuracy has the proposed approach. Thus, the contribution of the current work concerns the presentation of a new formulation for determining optimal risk selection and its implementation using a generic ANP model.

4. Research Design/Methodology

4.1 Risk Identification

Recent qualitative studies (Lavastre, Gunasekaran, & Spalanzani, 2012) have revealed that supply chain managers are typically concerned with risks on the supply and demand sides of the supply chain. The logic behind this preference resides on the fact that operations risk management usually is being handled as corporate risk or financial risk and mitigated for example by buying insurance or hedging foreign exchange. However to get a better understanding of supply chain risks a general initial classification is required.

In Figure 1, a Risk Breakdown Structure (RBS) is used to show the main ramifications of supply chain risks, where risks are divided in those related to the global environment and are more generic as they usually apply to all the competitors belonging to the same industry and they are more difficult to handle and on the other hand we have risk related to the domestic environment (Manuj & Mentzer, 2008). Macroeconomic risks, policy and competition related risks as well as resource related risks fall in the first category. Supply, operations, demand and safety risks, clearly fall in the second category (Ritchie & Brindley, 2001).

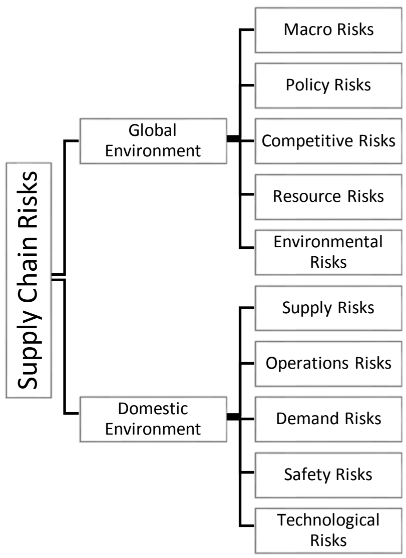

Figure 1 Supply Chains RBS

The risk sources of outmost importance to the supply chain managers as they appear in the literature are: currency, transit time variability, forecasts, quality, safety, business disruption, survival, inventory ownership, culture, dependency and opportunism, oil price fluctuation along with risk events affecting suppliers and customers (Birou & Fawcett, 1993; Cho & Kang, 2001; Chopra & Sodhi, 2004; Spekman & Davis, 2004; Zsidisin, Ellram, Carter, & Cavinato, 2004).

4.2 Risk Ranking

The first phase of the process results in an RBS structure containing the risk sources in a hierarchical structure. In the second phase the risks are organized in groups of risks and these groups are used as alternatives to an ANP model custom to the supply chain at hand in a fine-grained process, as shown in Figure 2.

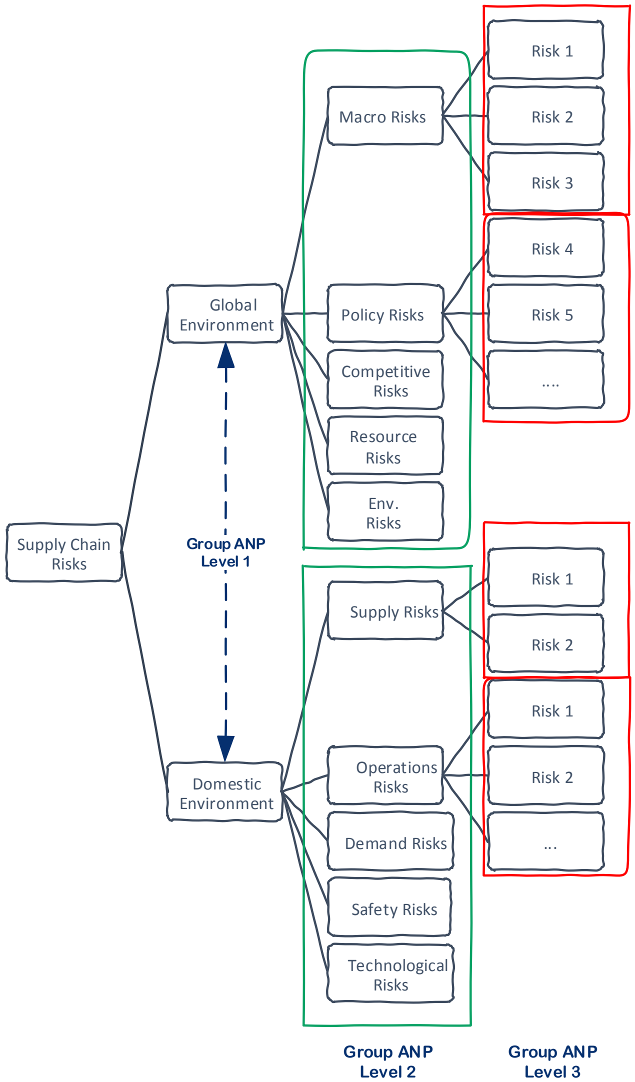

Figure 2 Applying group ANP to the RBS

Furthermore, this kind of decisions are to be taken by project team members, as an agreement among people coming from different departments, background and culture (Daim, Amer, & Brenden, 2012; Jugdev, 2004; Lee-Kelley & Sankey, 2008). Therefore, the risk ranking should be done at a group level.

A framework for group decision using the ANP method was initially proposed by Saaty and Shang (Thomas L. Saaty & Shang, 2007) in order to provide a method that brings about consensus and at the same time prevents one person from dominating a meeting. In this section the algorithm of group ANP is briefly presented (Rokou, Kirytopoulos, & Voulgaridou, 2012):

1st step: Development of an ANP model that describes the problem to be solved. This step includes the analysis and modelling of the problem, the identification of alternatives and criteria and their classification in clusters.

2nd step: The paths of influence among the elements should be described. This step leads to the creation of a network containing all the decision elements and their inner (within the same cluster) and outer relationships (among elements of different clusters).

3rd step: In group ANP we have a group of decision makers that each one gives his/her judgments independently, instead of having just one decision maker.

4th step: Taking as granted that each decision maker's individual set of judgments is within an acceptable level of consistency, all judgments are combined using an aggregation function to generate the Supermatrix and the Cluster matrix.

5th step: The Supermatrix is weighted by the Cluster matrix and thus transformed to the column stochastic Weighted Supermatrix.

6th step: The Weighted Supermatrix is limited by raising it to a sufficiently large power until it converges into a stable limit matrix. In the end, the weights of criteria and alternatives will lead to the final priorities.

4.3 Selection

In the last phase of the proposed approach the available budget for risk mitigation should be allocated based on the weights-priorities that were calculated in the previous phase using standard optimization techniques while taking into consideration the expected impact but not the probability or the frequency of the risks as these factors were already taken into consideration for the ranking.

5. Data/Model Analysis

The proposed model for ranking supply chain risks is a generic model that could be easily used for making decisions in any similar occasion without any need of extended economic analysis or complicated quantitative methods. Financial data are taken into consideration and although numerically are fewer they are not dominated by the qualitative, since it is upon the decision maker to weight the criteria according to his/her personal point of view.

Following the criteria used to form the ANP decision model and the way that are grouped in clusters are analyzed (Rokou, Voulgaridou, & Kirytopoulos, 2011). The criteria grouped under the **Financial** cluster are used to define express the opinion of the decision makers on the expected cost and impact of the risk alternatives under question but in a comparative fashion instead of requiring specific numbers and certainties about the values, that would most probably be unavailable.
Organizational cluster contains criteria related to the organization profile, like the opportunity to form synergies with other risks that were selected to be mitigated, required resources and their availability or constraints set by conflicting demand of the same resources by different proposed and ongoing risk related actions, and the impact of the under question risks on the strategic goals.

Market Related cluster is used to group together criteria like the effects of the alternatives on market shares, existing competitors in the field and demand forecast.

Expected Benefits for the organization like possible value for its customers and/or suppliers and overall strategic benefits.

Finally, the legislation that could reinforce the need to handle in specific ways some of the risks or define that some mitigation actions are mandatory, the expected social impact, the possible implications to the relationships with other supply chain echelons, the probability of appearance and each risk's frequency, are grouped under the cluster "Other". The resulting model is shown in Figure3.

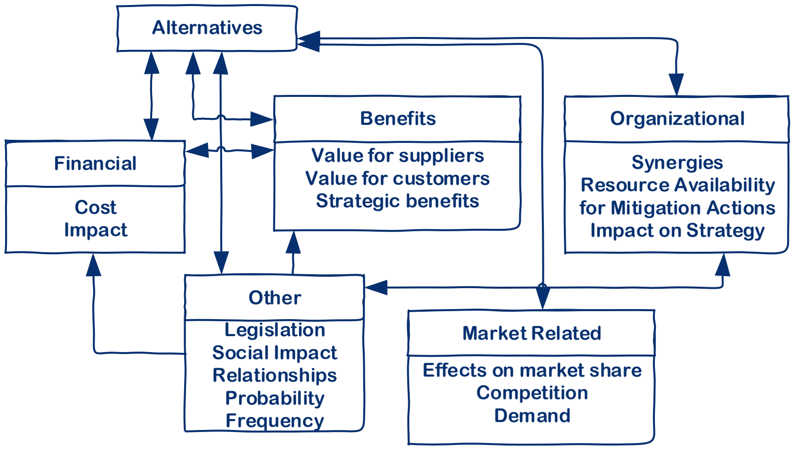

Figure 3 Supply Chain Risk Ranking ANP Model

Major importance is given to the paths of influence among the objects of the model. To view the relationships of a network a zero-one matrix of criteria against criteria can be constructed, where the number one will signify that there is a path of influence from the element of the corresponding line to the element of the corresponding column. Thus, the inner and outer relationships among the nodes are defined and the corresponding cluster relationships are computed.

6. Conclusions

Prioritizing supply chain risks to decide which one should be mitigated given a specific budget and supply chain setting, it is a difficult and tedious process which is further aggravated due to the limited data and the general uncertainty concerning risks, their probability of appearance and the corresponding expected impact.

In addition, the majority of the methods proposed by the researchers often reflect the financial perspective letting out important aspects like the social impact or the ways that competition would be affected by the selected risk management strategy. In this framework the present study proposes a simple ANP model, which offers a generic model that could be easily used to evaluate supply chain risks in a consistent manner.

Furthermore, the proposed ANP approach enables the decision maker to visualize the impact of various criteria in the final outcome. In such way that is very simple to communicate the results to all involved stakeholders, without time and place limitations and it is equally easy to have collaborative decision making processes by having more than one decision makers working on the same model. A secondary benefit of the research is that by using the proposed framework a valuable insight of the criteria that dominate the decision making process is given, providing value-added knowledge to the stakeholders.

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