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A New Two-Stage Fuzzy Decision Making Model in Supply Chain Risk Management

Hossein Rikhtehgar Berenji [1+], R.N. Anantharaman [2], Mojtaba Karegar [3]

[1] Graduate School of Management, Multimedia University, Cyberjaya, Malaysia

[2] Faculty of Business and Law, Multimedia University, Melaka, Malaysia

[3] Research And Development Department, MAPNA Company

Abstract. In recent years, supply changes have been becoming more complicated and sophisticated widespread. Supply chain management has faced much uncertainty (due to lack of trust to chain rings), resulting in some risks. This study looking forward to identify and assessing the risk in supply chain using Fuzzy Analytic Network Process (for allocating weights to risk factors) and Fuzzy TOPSIS (for ranking the supply chain members). Finally the model is checked by doing case study.

Keywords: supply chain risk management, fuzzy supply chain risk assessment, MAPNA Boiler Company, Fuzzy Analytic Network Process (FANP) and Fuzzy TOPSSIS.

1. Introduction

Organisations operate with the aim to achieve competitive advantages and gaining more market share. Therefore, activities such as providing materials, production planning, warehousing, inventory control, distribution, delivery and customer service, which previously were performed at the company level, have moved to supply chain level. In recent years, supply changes have been becoming more complicated and widespread. This supply chain management has faced much uncertainty (due to lack of trust to supply chain rings), resulting in some risks. Finally, achieving confident and successful management is not possible without supply chain management risk and trust among the members.

Christopher [1] generally defined supply chain management as managing up- and downstream relations with suppliers and customers so as to deliver maximum value to customers and to achieve least cost for supply chain. It seems that there is a consensus about this conclusion that in its simplest form, supply chain has three components: the company, supplier and customer [2]. These components are directly engaged in up- and downstream flows of products, services, financial resources and information. The key property is coordinating activities between independent organizations and Consistent with the understanding of risk, the key property of supply chain risk is that the risk extends beyond boundaries of company and highly increased transactions can be a source of supply chain risks [3]. Current business trends that may increase vulnerabilities to risk are the followings [4]:

- Reduction of precautionary savings (Buffer) and delivery time
- Increased strategic outsourcing by companies
- Fast demand in high volume at the beginning of products life cycle
- Emerging information technology that has made possible the controlling and organising of widespread supply chains and etc.

For identifying, categorizing and assessing the risks in supply chain we need to use a good and practical methods. In multi-criteria decision-making, people mentally consider different criteria in their decisions and

[+] Corresponding author. Tel.: +98-912-2303219.
E-mail address:h.rikhtehgar@gmail.com.

these criteria would cause the decision to be less timely and less accurate. It also depends greatly on the person who makes the decision. To solve this problem or to reduce its lateral effects, some methods for decision making with multi-criteria are designed with each one of them following special rules and principles. Researchers have been focused on Multi Criteria Decision making Model (MCDM) in recent decades in order to use for complicated decision makings in which multi criteria are used instead of one optimality measurement criterion in classic models of optimization. Decision makers often express their comments and views uncertainly. To resolve this problem, the fuzzy approach should be used [5]. In this research a Fuzzy Multi Criteria Decision Making Model (FMCDM) is developed to evaluate the risk in supply chain.

The objectives of this research are: (1) to identify supply chain risks using related literatures (2) to evaluate and index identified risks in the supply chain using Fuzzy Analytic Process (FANP) (3) implementing Fuzzy Technique for Order-Preference by Similarity to Ideal Solution (FTOPSIS) to rank supply chain members (4) establishing some new methods and suggestions for supply chain risk assessment and management.

2. Supply Chain Risk Management

In recent years, the term “risk” has been remarked in the researches about supply chain management. It must be noted that 100% security or 0% probability for supply chain risk is not possible in the real world. It is intended to determine a “controllable” risk/security level. The most important goal of supply chain risk management is to ensure that supply chains continue to work as planned, with smooth and uninterrupted flows of materials from initial suppliers through to final customers. It means decreasing the vulnerability of a supply chain, increasing its ability to withstand unexpected issues, improving sustainability or increasing resilience [4].

Chopra and Sodhi [6] introduced nine types of supply chain risk with the aim of developing strategies to reduce risks. These types include: disruptions, delays, networking and information systems defects, prediction, intellectual properties, logistics, customers (receipt risk), inventory, and capacity. Some findings noted that risks in supply chain are divided to supply (suppliers, production and distribution within the company) and demand (customers including end consumers) [7]. Another research introduced risks in long categories: Strategic, Natural, Political, Economic, Physical, Supply, Market, Transport, Products, Operations, Financial, Information, Management, Planning, Human, Technical, Criminal, Safety and Environment [4].

As it is seen, apparently there are different categorizations of supply chain risks equal to the number of mentioned authors and probably it is caused by their different views. Hence, it can be concluded that presented categorizations of supply chain risks are highly dependent on researcher perspective. But it is clear that despite of observed variety, natures of stated risks in the references are highly similar and we can extract relatively more integrated view of these factors.

According to Project Risk Management in Project Management Institution, Risk Management is as following:

- Risk Management Planning: first of all we should develop a plan for general issues and whole idea about the risk in our work.
- Risk Identification: Making a group of expert people to gather and identify the risks.
- Qualitative and Quantitative Risk Assessment: in this step, the group uses different methods for Risk Analysis, Prioritization and Assessment.
- Planning to respond the risks: the experts make decision for risk action planning and scheduling in order to react adequately to disruptions.
- Monitoring and controlling the risks: after doing all above steps, the team starts to monitor and control the risk behavioral factors and if the factors exist from control situation, again the risk management system turns on and does the cycle one more time.

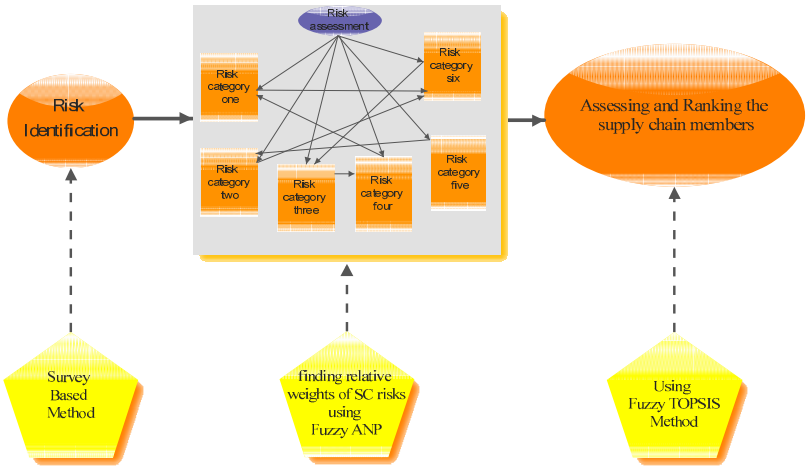

Fig. 1: Research Framework for Supply Chain

Considering reviewed literature and extracting findings of performed researches before, it is possible to express the risks in supply chain in 6 main categories.

These are supply risk, demand risk, process risk, control and planning risk, competitor-market risk, and social-political risk. These Risk Categories (clusters) contain 33 risk factors which are showed in Figure 2.

3. Proposed Methodology

In the supply chain risk management, we faced with two different important parts: Risk Assessment. (1) Risk Identification (2) Risk Assessment.

We proposed the below steps for doing these process as well as possible (Figure 1).

- Identifying risk factors through survey and classifying it.
- Assessment of each factor in relation to each other (within and outside of cluster) using FANP.
- Assessment of supply chain members based on factors which have been weighted in the previous step with FTOPSIS.

3.1. Fuzzy Analytic network Process (FANP)

Fuzzy ANP (FANP) algorithm is used to collective decision making and to determine importance degree of each priority indices. In this method, all inputs and outputs of FANP technique are fuzzy and in contrary to classic FANP defuzzifications are not used but paired comparison matrices between each row criteria are completed by triangular fuzzy numbers. Then values of parameters are calculated in triangular fuzzy numbers formats. In paired comparison of options (criteria), decision maker (expert) can use triangular fuzzy numbers to determine priority degree of options. Paired comparisons matrix completed by triangular fuzzy numbers (l,m,u) to assess priorities of decision maker [5]. For having more details about FANP, you can read [8].

ANP method has been preferred to the other multi criteria decision making methods because of the following items:

- ANP has a systematic approach to determine priorities and trade off between goals and criteria and importance and weight of criteria relative to each other is determined based on individual judgments not in an optional or determined way.
- ANP is able to put all tangible and intangible criteria into the model.
- ANP has a relatively simple and understandable approach which is accepted by managers and decision makers easily.

As we discussed in supply chain risk management section, always risks in supply chain is related to each others. So we need a network risk analysis and FANP will do it very well. As an example in a case the relations between clusters are shown in Figure 2.

3.2. Fuzzy Technique for Order-Preference by Similarity to Ideal Solution (FTOPSIS)

In 1981, TOPSIS technique was presented by “Huang & Yang” in 2004. TOPSIS technique is based on the fact that selected option has maximum distance to negative ideal solution (worst possible state) [9]. We will attempt to use fuzzy TOPSIS technique that introduced by Chen [10] in order to rank supply chain members.

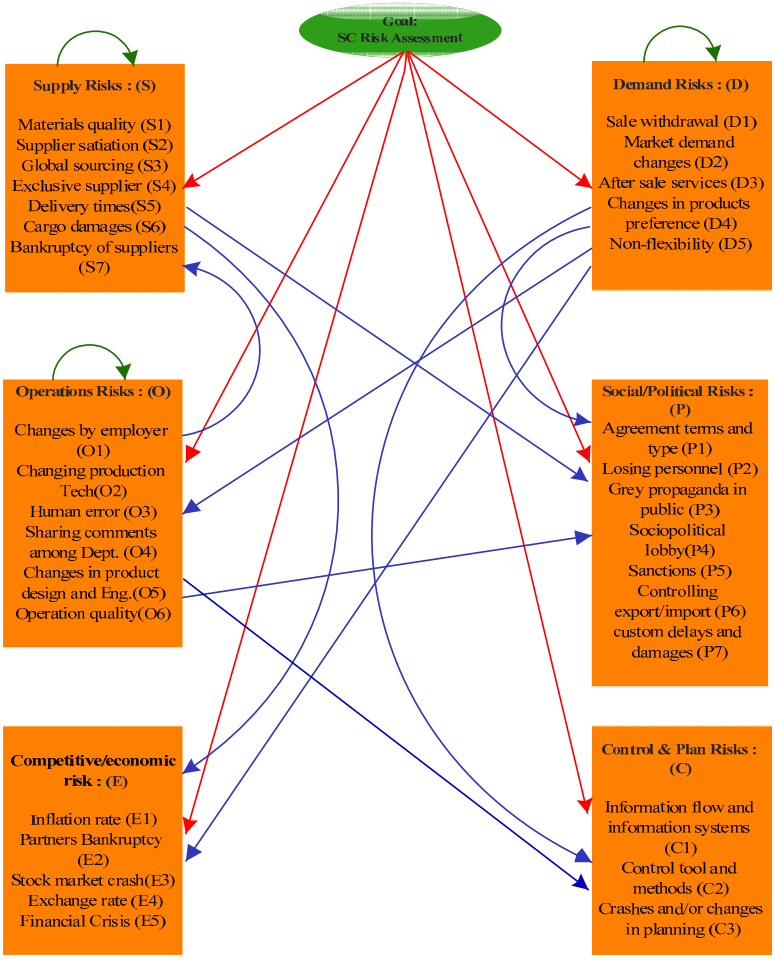

Fig. 2: Network Structure of the Supply Chain Risk Assessment

TOPSIS technique has been used because of these four benefits:

- Having a valid ratiocination to describe logic of individuals truly;
- Calculating numerical value for best/worst alternatives;
- Having simple computational process which is easily programmable in spreadsheets;
- Multifaceted performance of alternatives in criteria (at least in two faces) is imaginable.
- Steps for FTOPSIS are discussed in [11]. We will have the final ranking of supply chain members after doing these processes.

4. Case Study

MAPNA Boiler Company is chosen to test the proposed model. MAPNA Boiler Engineering & Manufacturing Company (MBC - one of the MAPNA Group’s subsidiaries which has been founded in the 1999) is responsible to design and manufacture boiler.

MAPNA Boiler mission is transferring and localization of boiler design, widespread use of manufacturing capacity within the country, and optimal management in the utilization of manufacturing resources under power plant pressure and in the absence of such a pressure. According to literatures review, the risk factors and relations between Risk Clusters are shown in Figure two. These findings are achieved after interview and observations of MAPNA Boiler supply chain. We developed 38 paired-comparison matrixes. As an example:

	Information flow and IS	Control tool and methods	Changes in planning
Information flow and IS	(1,1,1)	(1.9954,2.3180,2.6329)	(0.2744,0.3655,0.5402)
Control tool and methods	(0.4108,0.4666,0.5420)	(1,1,1)	(0.3470,0.3854,0.4374)
changes in planning	(2.2742,3.1888,4.1920)	(2.4728,2.8061,3.1174)	(1,1,1)

Table 1: Fuzzy-comparison matrixes of "Plan & Control" risks with respect to "Human error" (O3) factor.

The top five risk factors are: "Market demand changes (D2)", "Exclusive supplier (S4)", "Exchange rate (E4)", "Global sourcing (S3)" and "Losing personnel (P2)". The results of FANP after paired-comparison, by experts in the company, are as follows:

Supply Risk	(1.9614,2.1183,2.2643)
Operations Risks	(2.1950,2.5169,2.8356)
Demand Risks	(2.1113,2.2306,2.3430)
Competitive/economic risk	(2.0331, 2.1401,2.2397)
Control & Plan Risks	(1.9780,2.1998,2.4534)
Social/Political Risks	(1.9845,2.1540,2.3131)

Table 2: Final weights of Risk Categories

After we find out the weights of risks factors on different clusters, we formed a committee of five decision makers (D1 – D5) to select the most risky partner. According to supply chain of MAPNA Boiler Company, it has six important partners (members) in its supply chain: AZAR AB Company, MAPNA Manufacturing Plant, Hyosung Company, TAL Industries Company, ASTO Company and Sholeh Khavar Company.

After evaluation by FTOPSIS, members of the company's supply chain were prioritized in terms of to be risky as below:

	di*	di-	ccj	Supply chain Members Rank
Sholeh Khavar Co.	1.253	1.8781	0.5998	1
AZAR AB Co.	1.5496	1.6584	0.5170	2
ASTO Co.	1.5957	1.6095	0.5022	3
TAL Co.	1.7336	1.5401	0.4704	4
MAPNA. Plant	1.9069	1.4943	0.4393	5
Hyosung Co	2.0061	1.4099	0.4127	6

Table 3: Final Ranking of Supply Chain Members in MAPNA Boiler Co. With Respect To Supply Chain Risks

5. Conclusion

Considering the research result which is a pioneer of applying a fully functional model for supply chain management and assessment in its kind inside Iran the following recommendations are reported to improve supply chain performance and its risks management: Creating an integrated system for SCRM (supply chain risk management) and Identifying ways to mitigate or reduce effects of supply chain risk factors applying methods and creating an integrated system. The Company must form an integrated system in order to manage supply chain risk.

After recognizing and assessing risks, identifying ways to restrain and decrease effects of these factors on businesses is most important action. Thus it is recommended that different methods to identify, classify and prioritize the ways to face against supply chain risk are focused in the future projects.

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7. References

[1] Christopher, M.(2003) *understanding supply chain risk: A Self-Assessment Workbook*, Cranfiled University

[2] Mason-Jones, R., Towill, D.R., (1998) *Shrinking the supply chain uncertainty cycle*, Control, pp.17-22.

[3] Jüttner U. (2005) *Supply chain risk management: Understanding the business requirements from a practitioner perspective*. The International *Journal* of Logistics Management 16/1:120-141.

[4] Norman, A., Jansson U., (2004) *Ericsson's proactive supply chain risk management approach after a serious sub-supplier accident*, Journal of Physical Distribution and Logistics Management, Vol. 34, No. 5, pp. 434-456.

[5] Saaty, T. L. (1999). *Fundamentals of the analytic network process*. ISAHP 1999. Kobe, Japan.

[6] Chopra S. & Sodhi M. (2004) *Managing Risk to Avoid Supply Chain Breakdown*. MIT Sloan Management Review.

[7] Wagner, S.M. & Bode, C., (2008). *An empirical examination of supply chain performance along several dimensions of risk.* Journal of *Business* Logistics, 29(1).

[8] Momoh JA, Zhu JZ (1998), *Application of AHP/ANP to unit commitment in the power industry*, IEEE 1998;817–22.

[9] Yen, J., Langari, R. (1999), *Fuzzy Logic Intelligence, Control, and Information*, Prentice Hall, (1999).

[10] Chen, S. J. & Hwang, C. L. & Hwang, F. P. (1992). *Fuzzy multiple attribute decision making*. Lecture Notes in Economics and Mathematical System, 375.

[11] Wang, T. C., & Chang, T. H. (2007). *Application of TOPSIS in evaluating initial training aircraft under a fuzzy environment.* Expert Systems with Applications, 33(4), 870–880.