A CASE STUDY OF RISKS OPTIMIZATION USING AHP METHOD

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Abstract- Worldwide Competitiveness today, means that the customer is Utmost. As the customer is supreme, only those enterprises are going to be prosperous which are able to provide goods and services to the customer in timely, cost effective manner and also provide quality, which not only satisfies him but also delights him. Considerable research has been carried out and literature available in the field of Supply Chain Management since 1990. Successful supply chains use integrated measurement systems as a tool to achieve their organizational objectives. A comparative analysis of various risks factors reduces the chance of its occurrence. It indicates that validity of many of the measurement frameworks need to be established through further study. The process of choosing appropriate supply chain performance measures is difficult as a result of the complexity of these systems. The main motive of this paper is risk identification and determining risk optimization, which are more severe for the Company.

The vital motive of this analysis to review the literature in the field of various risk factors for supply chains to understand current practices and to help Industry to sustain its continue win in flat market where the competition is cut throat these days.

To accomplish this objective following steps have been performed:

1) Literature review on supply risk as well as a series of industry interviews

2) From Risks factors, a Hierarchical Risk Factor classification structure is created

3) An Analytical Hierarchy Processing (AHP) method with enhanced Consistency to rank risk factor for suppliers is created for getting risks optimization requirement.

Index Terms- Supply Chain, Analytical Hierarchy Process (AHP), Risk, Supply Chain Management, Optimization

I. Introduction

Risk management is a critical component of strategy development and execution, and a driver of firm success. A survey of researchers found that 74.2% of respondents believe supply chain risk management (SCRM) is a subset or extension of ERM (Sodhi et al., 2012). While there has been an increasing amount of SCRM research, there is no consensus on the definition or scope of SCRM (Sodhi et al., 2012). For example, a three-step SCRM process has been proposed: (1) specifying sources of risks and vulnerabilities, (2) assessment, and (3) mitigation (Kleindorfer and Saad, 2005). Other researchers proposed a four-step processes (Hallikas et al., 2004; Juttner et al., 2003), while others propose a five-step process (Manuj and Mentzer, 2008). Though common elements appear across all these frameworks, there is not yet agreement on what components and definitions constitute a “standard” SCRM process. Even without agreement on broad SCRM frameworks, a variety of supply risks and risk management strategies have been identified. Supply risks have been classified as supplier, market and item risks (Zsidisin, 2003) for example. Specific risks include order fulfillment errors, information distortion,labor disputes, natural disasters, capacity shortages, supplier bankruptcy, exchange rate risks,government regulations, single sourcing, and port delays for example (Blackhurst et al., 2005;

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Manuj and Mentzer, 2008; Tummala and Schoenherr, 2011; Zsidisin and Hartley, 2012). Different risks require different SCRM processes (Zsidisin and Wagner, 2010). Supply chain risk management strategies include environmental scanning (Zsidisin et al., 2004), use of capable suppliers (Manuj and Mentzer, 2008), dual sourcing (Khan and Burnes, 2007), contingency planning (Kleindorfer and Saad, 2005), supplier credit analysis (Kern et al.), inventory buffers (Tang, 2006),integration of information systems and supply chain modeling (Giannakis and Louis, 2001), and speculation, hedging and forward buying (Zsidisin and Hartley, 2012) for example. Firms face multiple supply risks, whether in combination or isolation. Each risk might require a specific SCRM technique (Zsidisin & Wagner, 2010). SCRM treatment options include evaluation and trust building (Laeequddin, Sardana, Sahay, Abdul Waheed, & Sahay, 2009), use of dual sources (Khan & Burnes, 2007), environmental scanning (Zsidisin, Ellram, Carter, & Cavinato, 2004), combined capacity reservation contracts and spot markets (Inderfurth & Kelle, 2011), qualification and use of capable suppliers (Manuj & Mentzer, 2008), supplier quality management initiatives (Holschbach & Hofmann, 2011), buffer inventory (Tang, 2006), contingency plans (Kleindorfer & Saad, 2005), credit analysis (Kern, Moser, Hartman, & Moder),strategic sourcing and flexibility (Chiang, Kocabasoglu-Hillmer, & Suresh, 2012), forward buying or hedging (Zsidisin & Hartley, 2012) and supplier development (Matook, Lasch, & Tamaschke, 2009) for example. Despite the plethora of risks and risk management approaches, few firms have a structured SCRM approach (Martin, Mena, Khan, & Yurt, 2011).

In this paper, presenting a model for assessing risk in supply chains based on the Analytic Hierarchy Process (AHP). The AHP supports managers in prioritizing/optimization the supply chain objectives, identifying risk indicators, put all the risk on severity scale to identifying risk optimization requirement. It is followed by the discussion of AHP methodology and prioritization of factors for coordinated supply chain. Eventually, it discusses results and conclusion.

II. METHOD AND PROCEDURE

In this Paper, AHP (Analytical Hierarchy Process) methodology has been applied to the evaluation of risk related to supply chain management in a manufacturing firm. Five risks for the company are evaluated and defined. The criteria weights can be more precisely defined by the AHP methodology using “Saaty scale” than using the digital logic method. However, subjectivity is playing a great role in both of methods. Subjectivity is included to the comparison of alternatives by the original AHP methodology, also. Contrary, by using other method there is no subjectivity concerned of alternatives comparisons because of dealing with transformed values of criteria. The ranking of all alternatives can be performed, by obtaining the priorities. Criteria (sometimes called objectives or attributes) are the quantitative or qualitative data (judgments) for evaluating the alternatives. In AHP methodology, the term properties is equivalent to the term criteria. The weights of the criteria present the relative importance of each criterion compared to the goal. Finally, alternatives present the group of feasible solutions of the decision problem. Alternatives are evaluated against the set of criteria.

Different phases of method are as follow:

1. Structuring the problem and building the AHP model.
2. Collecting the data from expert interview.
3. Pairwise comparison of each factor.
4. Calculation of consistency index to rank Optimization requirement of each risk.

Note: All the Calculations/Tables are below in Appendix

III.RESULT ANALYSIS

The AHP model in this study is formed to prioritize the various risks within the organization. Pairwise compa rison is done according to the table of scale 1 to 5 (see in table1). Consistency ratio (CR) is calculated to the degree of consistency of pair wise compression Risks are ranked according to highest Principal Vector**.** If CR is less than 10%, judgments are considered consistent. And if CR is greater than 10%, the quality of judgments should be improved to have CR less than or equal to 10%. In this study, the CR is 0.0141 which is less than 10% .It implies that decision taken by expert is satisfactory for further analysis. Thus the firm has consistent risk by the use of AHP method. Here the most critical risks are industrial risk and then product related risk according to their principal vector value (see in table 3) that require optimization at maximum level. The industrial risk must be dealt with to reduce the losses to the supply chain management. The sub factors associated with the industrial risk should be solved according to their ranking.

Therefore it is advised to the company to deal with reducing the most ranked risks so that the supply chain of the firm can function without loss.

IV.CONCLUSION

The AHP concepts in manufacturing supply chain should be studied with precision which is the need of the hour, as manufacturing supply chain is becoming less vertically integrated and the manufacturer is focusing on its core competency. Using AHP method the study of various risks is done here that which risk is more critical here for any industry. Therefore, a structured, simple and efficient proposed decision framework is proposed and has the ability to show the direction to determine the degree of impact level of each RF (Risk Factor). The degree of impact level of each RF of the firm will give idea for optimally allocating the efforts to gain maximum benefit. A case situation is revealed in order to reinforce the salient features of the proposed framework. The results indicate that the industrial risk and then product risk have got the highest impact on successful implementation of SC. Further research is suggested to develop a decision framework that can able to find out optimal number of solutions for identifying and mitigating the most influencing factors of the supply chain in a specific environment.

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Appendix

Phase 1.Structuring the hierarchy model of factors

This phase involve formulating the hierarchy of AHP model consisting of goal ,factors & sub factors, the goal of our problem is risk management/optimization and various risk factors as planning risk, product risk, environment risk, industrial risk ,productivity risk and those are father divided into several sub factors.

Phase2. Collecting the data through expert interview:

After building the AHP model the next step is measuring and collecting the data, which involves the group of expert and assigning pair wise comparison to the various risks, using the table of five point scale (this scale is called the Saaty Scale), a questionnaire set is prepared that consists of all the factors and sub factors .The expert will assign a score to each risk compare to other risk from the range of 1 to 5 (Table 1).

Table-1 Scale for Rating

Intensity of importance	Definition	Explanation
1	Equal importance	Two factors contribute equally to the objective.
2	Somewhat more important	Experience and judgment slightly favor one over

		the other.
3	Much more important	Experience and judgment strongly favor one over the other.
4	Very much more important	Experience and judgment very strongly favor one over the other. Its importance is demonstrated in practice.
5	Absolutely more important	The evidence favoring one over the other is of the highest possible validity.
	Reciprocal	While comparing reversely one risk to other, value would be 1/original comparison.

The risk factors (RF) are identified through literature review and in consultation with expert opinions from managers, senior engineers and engineers from Indian Manufacturing Industries. In order to prioritize the RFs, RFs should be compared among themselves on the basis of the questionnaire. Therefore, AHP is used for prioritization of RFs as it has the ability to capture both quantitative and qualitative decision criteria. Analytic Hierarchy Process (AHP) was developed in 1972 as a practical approach in solving relatively complex problems. The AHP allows decision maker to model a complex problem as a hierarchical structure that shows the relationship between the goal, primary criteria, sub-criteria and alternatives. It is used for multi-criteria problems in a number of application domains. The step by step algorithm used is shown below.

Step 1: The pair-wise comparisons among the RFs are developed on the basis of expert judgments. A scale of 1 to 5 as shown below Table 2 is used for pair-wise comparisons. The pair-wise comparisons are done in terms of which a RF dominates another. These judgments are then expressed as integers. If RF A dominates over RF B, then the whole number integer is entered in row A, column B and reciprocal is entered in row B, column A. If the RFs being compared are equal, a one is assigned to both positions.

Step 2**:** Construct a set of pair-wise comparison matrices for RFs on the basis of the opinions of all pre decided number of experts.

Step 3: There are several methods for calculating the eigenvector. By making each column of matrix normalized by dividing each value of column by sum of column, this would normalize the values.

Step 4: The next stage is to calculate λmax (max Eigen Value), multiply on the right the matrix of judgments by the eigenvector, obtaining a new vector. The product Aω and the AHP theory says that Aω = λmaxω (For such a Aω Square matrix, ω is said to be an eigenvector (of order n) and λ is an eigenvalue) so we can now get estimates of λmax by the simple expedient of dividing each component, by the corresponding eigenvector element,check consistency the pair-wise comparison matrix using the Eigen value.

Step5: In Analytic Hierarchy Process (AHP) method Finally, a Consistency Index can be calculated using formula **(λmax- n)/(n- 1)**. That needs to be assessed against judgments made completely at random and Saaty has calculated large samples of random matrices of increasing order and the Consistency Indices of those matrices. A true Consistency Ratio is calculated by dividing the Consistency Index for the set of judgments by the Index for the corresponding random matrix. Saaty suggests that if that ratio exceeds 0.1 the set of judgments may be too inconsistent to be reliable. In practice, CRs of more than 0.1 sometimes have to be accepted. If CR equals 0 then that means that the judgments are perfectly consistent.

Phase 3. Pairwise comparison of each factor.

Table 2 - Pair wise compression matrix

	PPR	PR	ENR	INR	DMR
PPR	**1.00**	**1/3**	**2.00**	**1/4**	**1/2**
PR	**3.00**	**1.00**	**4.00**	**1/2**	**2.00**
ENR	**½**	**1/4**	**1.00**	**1/5**	**1/3**
INR	**4.00**	**2.00**	**5.00**	**1.00**	**3.00**
DMR	**2.00**	**1/2**	**3.00**	**1/3**	**1.00**
SUM OF COLM	**10.5**	**4.08**	**15**	**2.28**	**6.83**

Table 3 – Normalized matrix

	PPR	PR	ENR	INR	DMR
PPR	**0.10**	**0.08**	**0.13**	**0.11**	**0.07**
PR	**0.29**	**0.25**	**0.27**	**0.22**	**0.29**
ENR	**0.05**	**0.06**	**0.07**	**0.09**	**0.05**
INR	**0.38**	**0.49**	**0.33**	**0.44**	**0.44**
DMR	**0.19**	**0.12**	**0.20**	**0.14**	**0.15**

Phase 4. Calculation of consistency index to rank Optimization requirement of each risk

Table 4- Average value matrix

Factors	Eigen Vector	Principle Vector	Optimization Ranking
PPR	**0.10**	**0.23**	IV
PR	**0.26**	**0.62**	II
ENR	**0.06**	**0.15**	V
INR	**0.42**	**1**	I
DMR	**0.16**	**0.38**	III

Table 5- Average Eigen value

FACTORS	New Vector	λ (New Vector/PV)
PPR	**0.49**	**5.02**
PR	**1.34**	**5.10**
ENR	**0.31**	**5.03**
INR	**2.13**	**5.11**
DMR	**0.81**	**5.06**

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Consistency Index (CI) = (λ max - *N*) / *N* – 1

Consistency Ratio (CR) = CI/RI corresponding to *N*

λmax = average of the RFs of λ.(see table 5)

Where RI: Random Consistency Index (see Table 6) and *N*: Number of RFs

Table 6-Random consistency index

N	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
RI	**0**	**0**	**0.58**	**0.9**	**1.12**	**1.24**	**1.32**	**1.41**	**1.45**	**1.49**	**1.51**	**1.48**	**1.56**	**1.57**	**1.59**

λ_{MAX}

= 5.06

N = 5

$$\mathbf{CI} = \frac{\lambda_{MAX} - N}{N - 1} \qquad \mathbf{CI} = 0.0158$$

$$\mathbf{CR} = \frac{CI}{RI} \qquad \mathbf{CR} = 0.0141$$