Interrelationships of risks faced by third party logistics services providers: A DEMATEL based approach

Abstract

This paper analyses the interrelationships between risks faced by third party logistics service providers (3PLs) in relation to one of its customers using DEMATEL. Novel analysis of both within and between risk categories and generation of threshold value to prioritize risks generate useful insights. Results show that arms-length relationship between the customer and the 3PLs have strong influence on other risks and there is a need for collaborative relationships between 3PLs and its customers. Moreover, analysis indicates that the 3PLs need to improve internal processes related to quality management, flexibility of its operations and also geographical coverage of their services.

Key words: interrelations between risks, 3PLs, DEMATEL, supply chain collaboration; emerging economy

1. Introduction

Risk management is “the identification, analysis and control of those risks which can threaten the assets or earning capacity of an enterprise (Dickson, 1989). Risk management can be considered as an integral part of supply chain design (Christopher and Lee, 2004) to avoid negative impact of risks on supply chain performance.

Logistics risk management is part of supply chain risk management which also includes sourcing risk management, risk management in production operations apart from logistics risk management. Supply chain risk management is in turn part of the overall discipline of risk management. The position of logistics risk management with respect to supply chain risk management and risk management is shown in figure 1 below:

Figure 1: Position of logistics risk management with respect to supply chain risk management and risk management

Logistical risks have been considered as an important category of risks faced by firms. Such risks can be related to transportation, storage and inventory (Cavinato, 2004). Many organizations outsource entire or some parts of the logistics activities leading to the emergence of third party logistics service providers (3PLs) (Langley et al., 2003; Hong et al., 2004). Outsourcing logistics services to 3PLs can improve the performance of the customer organizations (Handfield and Nichols, 1999; Leuschner et al., 2014) and the portfolio of services provided by 3PLs do have an impact on the performance of the clients using the 3PL services (Rajesh et al., 2011). But, there has been reports of less than successful partnerships with 3PLs due to expectation mismatch, poor contracting etc (Ackerman, 1996; Greco, 1997). Power et al. (2007) reports that 3PLs provides opportunities for customers to improve multiple performance elements simultaneously like cost and flexibility and thus help to overcome trade-offs between those measures. But, outsourcing of logistics activities also has its own challenges. Lack of responsiveness to customer needs is cited as a problem of outsourcing of logistics functions (van Damme and Amstel, 1996). Disruption to inbound flows, inadequate provider expertise, inadequate employee quality, and inability of 3PL providers to deal with special product needs and emergency circumstances, incompatibility of information systems between shipper and 3PL, the failure of 3PL to meet a shipper's future growth needs, and lack of security are some risks associated with using services provided by 3PL (Ellram and Cooper, 1990; van Laarhoven et al., 2000; Svensson, 2001; Selviaridis and Spring, 2007; Ansari and Modarress, 2010; Tsai et al., 2012). At the same time 3PLs themselves face risks from their own operations, due to financial constraints as well as from shippers who transfer those risks to 3PLs (Vitasek et al., 2015).

Supply chain risk management literature has primarily focussed on management of risks from the point of view of the focal firm or considering its immediate component suppliers. Supply chains are incraesily being subjected to catastrophic events like the 2011 Tōhoku earthquake and tsunami or common events like inability of logistics service providers to cater to the spike in demand during holiday seasons. But, in research on the logistics triad involving the supplier, customer and the logistics service provider, the role of the carrier is often considered to be passive or marginal (Mason and Lalwani, 2004)and there is limited research on analysis of risks faced by logistics service providers. Moreover, relationships between such risks faced by logistics service providers are not known. The 2015 Third Party Logistics study mentions that "it would be useful to better understand the roles that 3PLs may play in partnership with their customers to identify and then mitigate, eliminate or deal with the types of risks that may affect the overall supply chain process" (Langley Jr. et al., 2015). But, we are unaware of any academic research in which a collaborative approach has been followed by a 3PL and its customers to better understand the logistics risks.

In this research, we address the above gaps in the literature by identifying risks faced by a third party logistics service provider (3PL) and by analysing the interrelationships between those risks by collaboration between 3Pls and one of its customers using a multi-criteria decision making approach called Decision Making Trial and Evaluation Laboratory (DEMATEL). The key research question addressed in this study is how are the different risks faced by a 3PL related to each other. The specific objectives are to identify the cause and effect groups within the broad categories of risks as well as within and between each category. Such an understanding of the relationship between various risks is necessary to prioritize the risks and take necessary corrective action. Our novel analysis based on DEMATEL using threshold value to prioritize risks and analyzing influence of risks between categories generated useful insights and actionable points for the participating organizations. The results showed the debilitating effect of lack of trust and arms length relationship and pointed for coordination and collaboration of efforts of the customer and its logistics service providers. The research also pointed out that the 3PLs also need to develop processes for managing quality, improve flexibility of their operations and extend the geographical ceoverage of their services.

The paper is organized as follows: Section 2 will introduce a literature review on supply chain risks and risks faced by logistics service providers. The methodology is discussed in section 3 followed by analysing the interrelationships between risks faced by a 3PL in section 4. The results are discussed in section 5. The managerial implications are discussed in section 6 followed by conclusion in section 7.

2. Literature Review

In this section, we provide a brief overview of supply chain risk management followed by classification and sub-categorization of risks faced by 3PLs and application of multi-criteria decision techniques in supply chain risk management. Our review results in a comprehensive classification of risks affecting logistics service providers.

2.1 Supply Chain Risk Management

Proactive risk management approaches have been suggested by many researchers (Zsidisin, 2003; Norrman and Jansson 2004; Christopher and Lee, 2004; Faisal et al. 2006; Gaudenzi and Borghesi, 2006; Tang, 2006; Manuj and Mentzer, 2008). Important steps in proactive risk management are to identify the risks and to analyze the interrelationship between those. Spekman and Davis (2004) suggested that interdependency carries risks in the supply chain, but these can be managed. Hence, identifying cause-effect relations between individual risks is important, because "hidden influences" of a certain risk in connection with other risk(s) may cause substantial damages (Chopra and Sodhi, 2004). The direct and indirect interrelations of a large numbers of risk variables impact all supply chain partners (Elmsalmi and Hachicha 2013). Pfohl, et al. (2011), Diabat et al. (2012) and Srivastava et al. (2015) conducted structural modeling and analysis of supply chain risks to analyse interrelationships between risks. Large parts of logistics functions are outourced to logistics service providers (Langley et al., 2003; Hong et al., 2004) and logistics risks are key drivers of supply chain risks (Cavinato, 2004; Manuj and Mentzer, 2008). Logistics risks can impact the overall supply chain performance. Thus, it is important to analyse the risks faced by the logistics service providers as such risks not only impact those service providers but also cascade to the firms using those services and eventually through the supply chain.

2.2 Risks faced by 3 PLs

Risks involved in logistics were identified through literature review, which were validated by the experts from industry. This risk identification exercise was carried out in two stages. In the first stage, our research team reviewed papers, published in scholarly journals, related to logistical risks in the leading reputed publishers like Springer, Elsevier, Emerald, Taylor & Francis and databses like ABI Inform, Scopus and EBSCO. At the end of the review, the research team identified 48 different risks out of which seven were deleted after discussion with the experts and three additional ones were added by them resulting in a final list of 44 risks. These 44 risks were classified into 3 broad categories-internal, financial and customer related and 22 sub-categories. The 22 sub-categories were again validated by the experts and used for the purpose of this research.

2.2.1 Risks in internal operations of logistics service providers

Risks in internal operations of logistics service providers are those risks which prevent them to perform their operations satisfactorily and hence impact the service they provide to their customers. The sub-categories of risks in internal operations of logistics service providers are process design and planning risks, quality risks, lead time risks, breakdown and hazard risks, IT and information sharing risks, lack of flexibility related risks, sociopolitical risks, sustainability related risks, packaging/storage and inventory related risks, disruption, lack of expertise, lack of coverage and catastrophic risks. These risks are indicated by R1 to R13 in table 1 below.

Process design and planning risks include risks associated with lack of processes for vehicle routing and scheduling, lack of supporting processes to ensure quality control, unreliable cycle times in logistics processes, quality risks include shipping errors, damages in transit, while lead time risks include transport delays and variability in transport times. Breakdown risks include breakdown of vehicles or equipments, IT and information sharing risks include IT infrastructure breakdown, failure to update delivery status to customer etc. Flexibility risks include inability to handle changes in volume or changes in route plans, socipolitical risks include shortage of labour, labour strikes, changes in regulations etc while high fuel and energy costs, health and safety concerns etc. Disruption risks involve strikesor delays in transportation due to accidents, natural disasters, customs delays etc, lack of expertise include lack of capabilities to handle specific logistics requirements, lack of appropriate skills or lack of knowledge of industry regulations. Lack of coverage implies inability to cater to different geographical regions while catastrophic risks involve risks due to natural disasters, epidemics, geopolitical events etc.

2.2.2 Financial Risks

The financial risks are those risks which either impact the liquidity and access to capital to the firm or impact their operating costs due to changes in the external economic environment. The two sub-categories of financial risks identified are risks due to exchange rates, taxes and fuel prices and risks due to debtors and lack of access to capital. While risks due to exchange rates influence international logistics, taxes and fuel prices impact both domestic and international operations. Lack of access to capital sometimes create liquidity problems for 3PLs. These risks are shown as R14 and R15 in the table 1 below.

2.2.3 Customer related risks

The customer related risks are those risks which the logistics service providers face from their customers. The sub-categories of customer related risks faced by 3PLs are planning and forecasting risks, lack of trust and opportunism, dependency risk, intellectual property rights risk, information sharing risks, cultural/language risk and payment related risk. These risks are shown as R16 to R22 in table 1 below.

The different sub-categories of risks are shown in Table 1.

Table 1: Sub-categories of risks

No.	Risk	Denotation	Reference

1	Process design and planning risks	R1	Bandaly et al. (2013); Canbolat et al. (2008), Chan and Wang (2013), Deleris and Erhun (2011), Giunipero and Eltantawy (2004), Kull and Talluri (2008), Micheli et al. (2009), Rao and Goldsby (2009), Tang and Musa (2011), Wagner and Bode (2008), Waters (2007), Wu et al. (2006), Zsidisin (2003), Zsidisin et al. (2008)
2	Quality risk	R2	Danielis et al., 2005; Giunipero et al., 2004; Skorna et al., 2009
3	Lead time	R3	Deleris and Erhun, 2011; Manuj and Mentzer, 2008; Pujawan and Geraldin, 2009; Selviaridis et al., 2008;Tummala and Schoenherr, 2011,
4	Breakdown and hazard risks	R4	Deleris and Erhun, 2011; Ghiani et al., 2003; Pujawan and Geraldin, 2008
5	IT and information sharing risks	R5	Lai and Cheng, 2003; Sanchez-Rodriguez et al., 2010a; Sanchez-Rodriguez et al., 2010b; Selviaridis et al., 2008
6	Flexibility related risks	R6	Morash and Clinton, 1997; Sharma and Bhat, 2014
7	Sociopolitical risks	R7	Deleris and Erhun, 2011; Pujawan and Geraldin, 2008; Sanchez-Rodriguez et al., 2010b
8	Sustainability Risks	R8	Bolis et al., 2014; Mangla et al., 2014a; Spekman and Davis, 2004
9	Packaging, Storage/Inventory related risks	R9	Pujawan and Geraldin, 2008
10	Disruption	R10	Harland et al., 2003; Sawhney and Sumukadas, 2005; Manuj and Mentzer, 2008, Pujawan and Geraldin, 2009; Sanchez-Rodriguez et al., 2010b; Deleris and Erhun, 2011
11	Lack of expertise	R11	Deleris and Erhun, 2011; Jharkharia and Shankar,2007; Jiang et al., 2008; Rao and Goldsby, 2009; Selviaridis et al., 2008; Tsai et al., 2012
12	Lack of coverage	R12	Jharkharia and Shankar,2007; Selviaridis et al., 2008
13	Catastrophic risks	R13	Ahmadi-Javid and Seddighi, 2013; Canbolat et al. ,2008; Chopra and Sodhi, 2004; Deleris and Erhun, 2011; Rao and Goldsby, 2009; Tummala and Schoenherr, 2011; Wagner and Bode, 2008
14	Risks due to exchange rates, taxes and fuel prices	R14	Cuchiella and Gastaldi, 2006; Deleris and Erhun, 2011; Harland et al., 2003; Manuj and Mentzer, 2008, Pujawan and Geraldin, 2009; Rao and Guldsby,2009; Sanchez-Rodriguez et al., 2010b

15	Risks due to debtors and lack of access to capital	R15	Harland et al., 2003; Rangel et al., 2014
16	Planning and forecasting	R16	Pujawan and Geraldin, 2008; Sanchez-Rodriguez et al., 2010a
17	Lack of trust and opportunism risk	R17	Khan and Burnes, 2007; Tsai et al., 2012
18	Dependency risk	R18	Cuchiella and Gastaldi, 2006; Tsai et al., 2012
19	Intellectual property rights risk	R19	Chopra and Sondhi, 2004
20	Information sharing risks	R20	Li et al., 2015; Sanchez-Rodriguez et al., 2010a; Tsai et al., 2012; Zhang et al., 2012
21	Cultural/language risk	R21	Manuj and Mentzer, 2008
22	Payment	R22	Smeltzer and Siferd, 1998

The comprehensive set of risks identified from the above literature review have not been considered to analyse risks faced by logistics service providers. Failure to develop a thorough understanding of the above risks and interrelationships between them will not only affect the performance of the logistics service providers but also their customers and will thus create inefficiencies and lack of responsiveness in the entire supply chain because of the interconnected nature of modern day supply chains (Kleindorfer and Wassenhove, 2004; Srivastava et al., 2015). Thus, all players in the logistics industry i.e shippers, carriers, logistics service providers, and port and terminal operators have been urged to rigorously analyse and manage the risks affecting their operations (Elkins et al., 2005; Wagner and Bode, 2009). But, there is limited research on thorough analysis of risks faced by 3PLs which we are trying to address through this research.

2.3 Multi-criteria decision making applications in supply chain risk management

Several authors attempted to analysis the risk involved in the supply chain environment using various multi criteria decision making (MCDM) techniques. This section summarizes the most relevant and important[1] literature related to the application of MCDM techniques for the supply chain risk management. Radivojevic and Gajovic (2014) ranked the supply chain risk categories and also determined the share of each individual risk among the total risk involved using Analytic Hierarchy Process (AHP) and Fuzzy Analytic Hierarchy Process (FAHP) methods. Mangla et al., (2014) proposed a flexible decision model to evaluate the risks associated with the implementation of green supply chain practices using FAHP and Interpretive Ranking Process

[1] We have used the keywords ((“Multicriteria decision making” or “MCDM” or “MCDA” or “Multicriteria decision analysis”) AND “Supply chain risk management”) to search the MCDM related supply chain risk management papers. Then the papers are shortlisted based on relevance and importance.

(IRP). In their study, initially they used AHP to rank the risks identified and finally, for the analysis of risk, IRP was used. The proposed model was validated using a case from poly plastic manufacturing company in India. Pradhan and Routroy (2014) proposed a four phase methodology for analyzing the supply chain risks in a manufacturing environment. Additionaly, some relevant mitigation strategies were proposed for the same. In the first phase, the supply chain risks (SCRs) related to a manufacturing environment were identified, followed by identification of the relevant risks using cause effect analysis , prioritization of risks using AHP in the third phase and finally using the Strength –Weakness-Opportunity and Threat (SWOT) analysis a feasible SCR mitigation strategy was proposed. Viswanadham and Samvedi (2013) proposed a two step approach to identify both performances-based and risk-based decision criteria to the supplier section problem using FAHP and Fuzzy Technique for order of preference by similarity to ideal solution (FTOPSIS). Chen and Wu (2013) proposed a modified Failure Mode Effect Analysis (FMEA) method to select suppliers from the supply chain risk's perspective using AHP approach. The proposed model was validated using a case from an integrated circuit assembly company. Venkatesan and Kumanan (2012) proposed a hybrid approach to prioritize the SCR using AHP and Preference ranking organisation method for enrichment evaluation (PROMETHEE) approach. The performance of the proposed approach was illustrated using a case from the plastic industry. Chand et al., (2015) studied risk assessment in supply chain under four categories (transportation risks, operations risks, supplier related risks and market related risks) using Analytic Network Process (ANP) and Multi-objective optimisation by ratio analysis (MOORA). Diabat et al., (2012) analyzed the various risks involved in a food supply chain using Interpretive Structural Modeling. The developed model was validated with the help of a case study from a food products manufacturing firm. Srivastava et al. (2015) analyses interrelationship between risks and performance measures for fresh food retail firms using ISM while Chaudhuri et al. (2015) uses fuzzy ISM to analyse the impact of risk propagation on performance for food processing supply chains. Other relevant literature related to the study has been summarized in below table. Based on the above review, its evident that, none of the previous work considers analyzing the risks related to logistics firms using a real case and application of DEMATEL. Thus, this study addresses the apparent gap in the supply chain risk management literature by considering risks faced by 3PLs.

Table 2: Application of MCDM in supply chain risk management

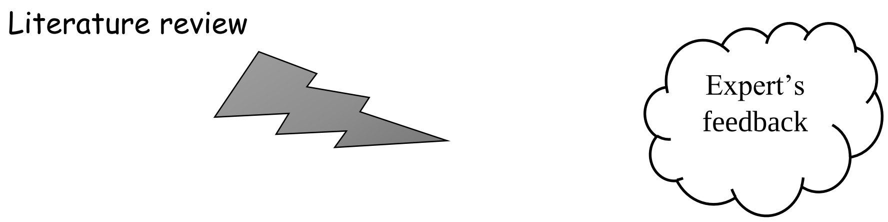
Author	**Domain of application**	**Methodology used**

Aqlan and Lam (2015)	High-end server manufacturing environment	Survey, Bow-Tie analysis, and fuzzy inference system (FIS)
Diabat et al., (2012)	Food industry	ISM
Faisal et al., (2007)	Four different small and medium enterprises (SMEs) industries (brass, lock, leather and the ceramic)	Graph theory and ISM
Mangla et al., (2014b)	Poly plastic manufacturing company	FAHP and IRP
Moeinzadeh and Hajfathaliha (2009)	Power, oil & gas industry	ANP and fuzzy VIKOR
Pradhan and Routroy (2014)	Manufacturing supply chain case environment	Cause effect analysis, AHP and SWOT analysis
Rajesh et al., (2015)	Indian electronics manufacturing company	Digraph-matrix approach and grey theory
Samvedi et al., (2013)	Indian textile and steel industry	FAHP and FTOPSIS
Schoenherr et al., (2008)	US manufacturing company	Action research combined AHP
Wang et al., (2012)	Fashion industry	FAHP
Xing and Zhao (2013)	Chinese agricultural industry	AHP and fuzzy comprehensive evaluation

3. Methodology

Our methodology consists of literature review to identify the relevant risks, finalizing the set of risks based on feedback from experts and then classifying the risks into different categories. These categories of risks are also shared with the experts and were finalized after obtaining their approval. This was followed by selection of the appropriate methodology for analyzing the inputs from the experts about the interrelationships between the different types of logistics risk categories. We then analysed the interrelationships between the risk categories and again validated our results with the experts which was used to obtain further insights. This process is shown in figure 2.

Analysing logistics related risks is complex as there are multiple risks involved with interrelationships between them. The interactions between the risks make it difficult to prioritize the risks for mitigation (Samvedi and Jain, 2013). In order to address the complexity associated with multiple interrelated risks a, multi-criteria decision making methodology (MCDM) was adopted. Among MCDM tools, this research uses the Decision Making Trial and Evaluation Laboratory (DEMATEL) as a solution methodology since DEMATEL is the methodology which is best suited for analysing the interrelationship and interdependencies by neglecting the limitation of sample size (Lee et al., 2013). DEMATEL was first proposed in the Battelle Memorial Association in Geneva by Gabus and Fontela, 1973, in order to deal with the relationship and the influential strength among complicated issues like racial discrimination, labour protection, hunger, race and so on (Li et al., 2014; Lee et al., 2013). This method was proposed with the aim of analysing the intertwined cluster problems with the assistance of influence map (Hsu et al., 2013). The main advantage of the DEMATEL is to assist the decision makers in understanding the core driving factors of the specific problem based on the analysed interaction influences and casual relationships (Ren et al., 2013). Since the intervention of the DEMATEL into the research realm, many studies (for an instance, Xia et al., 2015 (remanufacturing barriers); Senvar et al., 2014 (supply chain performance); Tadic et al., 2014 (city logistics concept selection); Dou et al., 2014 (green government procurement); Hsu and Lee, 2014 (carbon based supplier selection); Govindan et al., 2014a (corporate social responsibility drivers); Govindan et al., 2014b (green manufacturing practices) successfully applied this method in various applications to explore the relationship between factors.



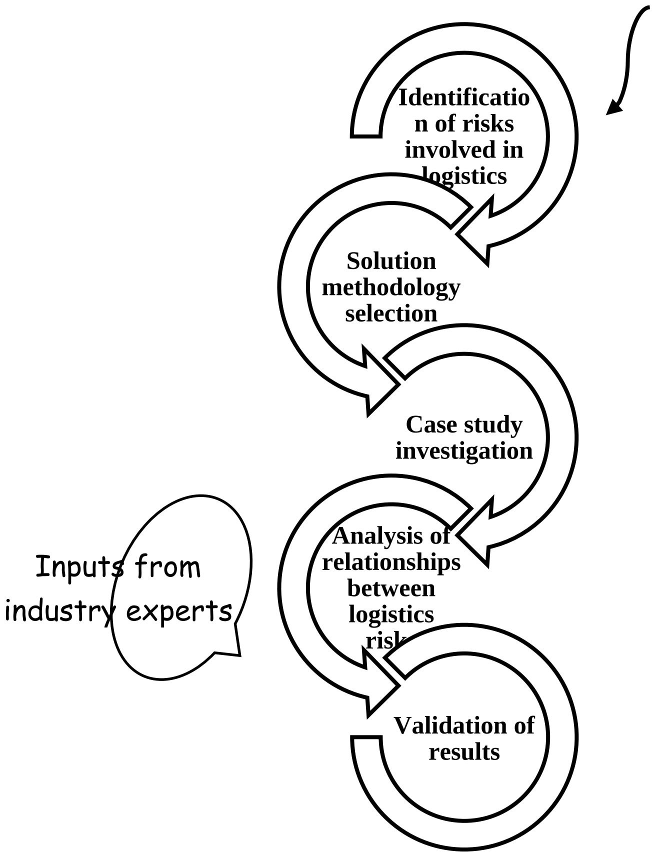


Fig 2: Framework of the proposed study

The basic steps of DEMATEL are shown below: (adapted from Govindan et al., 2014a)

Step 1: Calculate direct relation matrix "A"

Using the inputs of the decision makers the direct relation matrix can be created by comparing the factors with each other. The scale ranges from 0 to 4 where 0 indicates 'No influence' '1' indicates 'very low influence', '2' indicates 'low influence', '3' indicates 'high influence' and '4' indicates 'very high influence'. The mathematical formulation of direct relation matrix is shown in Eqn 1.

$$\mathbf{A} = \begin{bmatrix} 1 & a_{12} & a_{13} & \dots & a_{1(n-1)} & a_{1n} \\ a_{21} & 1 & a_{23} & \dots & a_{2(n-1)} & a_{2n} \\ \dots & \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots & \dots \\ a_{(n-1)1} & a_{(n-1)2} & a_{(n-2)3} & \dots & 1 & a_{(n-1)n} \\ a_{n1} & a_{n2} & a_{n3} & \dots & a_{n(n-1)} & 1 \end{bmatrix} \qquad \mathbf{(1)}$$

Step 2: Normalization – normalized direct-relation matrix "S"

In this step, the direct relation matrix is normalized with the assistance of Equations (2) and (3) in which all elements should lie between 1 and 0.

$$K = \frac{1}{max_{1 \le i \le n}} \sum_{j=1}^{n} a_{ij} \quad \textbf{(2)}$$

$$S = K \times A \quad \textbf{(3)}$$

Step 3: Calculate total relation matrix "M"

From the normalized matrix, total relation matrix M is obtained using Equation (4) in which I denotes identity matrix.

$$\mathbf{M = S\,(I - S)^{-1}} \quad \textbf{(4)}$$

Step 4: Calculate sum of rows and columns

Sum of rows and sum of columns are then calculated using equations (5) and (6) and denoted as D and R respectively.

$$r_i = \left[\sum_{j=1}^{n} mij\right]_{n\times1} \quad \textbf{(5)}$$

$$s_i = \left[\sum_{i=1}^{n} mij\right]_{1\times n} \quad \textbf{(6)}$$

$M = m_{ij}$, $i, j = 1, 2, \ldots, n$

Step 5: Causal and effect graph

In the final step of DEMATEL the cause and effect graph is generated using D and R. The graph is constructed using ($\mathbf{r_i + s_i}$) as the horizontal axis and ($\mathbf{r_i - s_i}$) as the vertical axis. This diagraph clearly defines the relationship between the factors and most influential ones among all the factors.

4. Interrelationships between risks faced by a 3PL : case illustration

Indian economy has grown at a fast pace post economic liberalization but its quality of infrastructure has not kept pace with its economic growth. According to the Global Competitiveness Index report 2014-15 published by World Economic Forum, out of 148 countries India ranks 90th in terms of overall infrastructure, 76th in terms of quality of roads, 76th in terms of quality of port infrastructure, 71st in terms of quality of air transport infrastructure and 27th in terms of quality of railroad infrastructure. Lack of quality infrastructure does affect the logistics operations in a country. The size of the Indian logistics industry is about US $104.10 billion in 2014, witnessing a growth of about 4.9 percent over the previous year and thus plays a key role in the country's economic development. Transportation accounts for about 60 percent of the market revenues of logistics service providers (Frost and Sullivan, 2014). Apart from the infrastructural developments planned by the government of India , the individual firms and the logistics service providers also have to play important roles in improving the supply chain efficiencies particularly in a developing economy like India with limited logistical capabilities (Wiengarten et al., 2014). The logistics service providers assume a central role, connecting the firms to their suppliers and to the market but face multiple challenges and risks which are rarely analysed. While lack of infrastructure has been pointed out as a major cause of supply chain inefficiencies in India (Bagchi, 2001; Srivastava, 2006) there is limited research on how logistics service providers and their customers can effectively manage logistics risks to improve supply chain efficiencies. The importance of logistics and lack of research on logistics related risks motivated us to undertake this research.

Our research team approached a cement company which is located in the southern part of India, (from now it is referred as CementCo) which is a leading manufacturer of cement along with other by products such as dry mix and concrete. CementCo has 11 facilities in India which includes two packing terminals and one research centre. CementCo exports to multiple countries around the world apart from selling within India. Thus, CementCo's logistics set up is complex and has multiple risks involved. CementCo is facing challenges in its logistics which is currently managed by two third party logistics service providers (3PL). The 3PLs manage both domestic and international logistics for CementCo and also manage warehouses for distributing the products. The 3PLs believed that they face multiple risks which hinder their abilities to provide adequate services to its clients and especially CementCo. The objectives of the logistics department at CementCo is to ensure on-time delivery of its products to the distributors in both domestic and international markets at the lowest cost. Hence, CementCo agreed to participate in the study along with its logistics service providers to understand and analyze the risks involved.

In the initial stage of data collection, our research team organized a focussed group discussion lasting an hour with logistics managers of CementCo and managers from the two 3PLs to understand the logistics activities, the challenges faced and to validate the risks identified from the literature. The group agreed to include 41 of the identified individual risks identified and decided to add three more risks, which they considered to be relevant for them and the services they provide to CementCo. The three risks which were added were fuel price volatility, limited customer base and inability of transportation infrastructure to handle significant changes in demand. It was decided that the two managers each from the two 3PLs who manage CementCo's logistics and three of the most experienced logistics managers from CementCo will be providing the necessary inputs to be used in this research and the risks which impact the 3PLs' performance as well as the logistics objectives of CementCo will be considered. The results of the analysis were also to be shared with Vice President of supply chain of CementCo (who was not involved in providing inputs) and one senior executive eah from the 3PLs for validation and further insights.

4.1 Determining interrelationships between risks

In this phase, the essential risk and influence of the risks over one another was identified with the assistance of the experts using DEMATEL. As mentioned earlier the steps involved in the DEMATEL were applied to the above context as follows:

Step 1: Direct relationship matrix "A"

In this step the risks identified from the literature and validated by the experts were rated by the experts in a two hour workshop moderated by the researchers. The ratings indicate the influence of one risk on another, (for an instance, what is the extent of influence of planning risk and process design (R1) on quality risk (R2) on a scale of 0 to 4). From these ratings the direct relationship matrix among the identified risks was obtained and tabulated as Table 3. Similarly, all the following steps were conducted as outlined in the previous section.

Step 2: Normalized matrix "S"

The initial direct relationship is normalized through the eqns. (2) and (3) and the normalized matrix (Table 4) was tabulated.

Step 3: Total influence matrix "M"

From the normalized matrix, the total influence matrix was calculated with the assistance of the eqn. 4 and the total influence matrix "M" is shown in Table 5.

Step 4: Sum of rows "r_i" and columns "s_i"

The total influences received and given by the each sub-category of risks were calculated through the eqns. 5 and 6 and shown in Table 6. The total influence matrix over sub-categories was calculated (with the same procedures as mentioned earlier) and its corresponding total influences received and given among the main dimensions were shown in Table 7 and 8 respectively.

Step 5: Casual and effect diagraph

Based on the total influences received and given by the dimensions and sub-categories the influence map was created which explains the central role and relation of each sub-category in relation to others. The influential map of dimensions and sub-categories are shown in Fig 2 to 5.

5.0 Results and Discussion

This study separates the influence among risk dimensions and within the individual risk sub-categories. Fig 3 reveals that among the three main dimensions of risks, internal logistics risk

(D1) has high influence over remaining other dimensions. Customer related logistics risk **(D3)** and financial risk **(D2)** holds the second and third position in the influential map respectively. It is interesting to note that the internal risks of the 3PLs influence both the financial and the customer related risks while the customer related risks also result in financial risks. The result of this analsysis shows that the impact of the internal risks on financial risks also get compounded by certain practices by CementCo i.e sudden change in delivery plans, lack of information shared by CementCo with the 3PLs regarding demand, occasional delays in payment, arms-lenth relationship and lack of trust etc.

Table 3: Initial direct relationship matrix "A"

	R1	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**	**R11**	**R12**	**R13**	**R14**	**R15**	**R16**	**R17**	**R18**	**R19**	**R20**	**R21**	**R22**
R1	0	0	4	2	0	1	4	4	2	3	0	0	3	3	4	0	2	0	3	0	0	4
R2	0	0	0	3	2	1	4	4	2	3	1	3	4	4	3	2	2	0	3	4	0	3
R3	1	0	0	3	3	2	1	0	0	3	0	1	2	0	3	4	0	0	4	3	2	0
R4	2	2	2	0	4	1	4	3	1	2	0	0	2	0	0	3	2	0	0	2	0	0
R5	0	3	2	1	0	2	2	0	2	3	0	2	3	0	4	2	2	0	3	4	4	2
R6	4	4	3	4	3	0	3	4	0	3	0	4	4	3	4	3	2	2	0	0	1	4
R7	1	1	4	1	3	2	0	4	0	3	1	3	2	4	3	3	1	0	2	3	1	0
R8	1	1	0	2	0	1	1	0	0	4	0	4	4	4	4	3	1	0	0	1	3	4
R9	2	3	0	4	3	0	0	0	0	2	0	2	3	0	2	4	3	2	1	3	0	3
R10	2	2	2	3	2	2	2	1	3	0	0	4	2	3	4	4	3	0	2	3	2	4
R11	0	4	0	0	0	0	4	0	0	0	0	0	3	0	3	4	1	2	2	0	3	4
R12	0	2	4	0	3	1	2	1	3	1	0	0	3	3	2	4	3	2	3	0	4	2
R13	2	1	3	3	2	1	3	1	2	3	2	2	0	1	1	3	0	0	0	0	0	0
R14	2	1	0	0	0	2	1	1	0	2	0	2	4	0	4	3	4	0	1	2	3	4
R15	1	2	2	0	1	1	1	1	3	1	2	3	4	1	0	3	4	0	2	0	1	3
R16	0	3	1	2	3	2	2	2	1	1	1	1	2	2	2	0	3	4	3	2	3	0
R17	3	3	0	3	3	3	4	4	2	2	4	2	0	1	1	2	0	3	2	0	3	2
R18	0	0	0	0	0	3	0	0	3	0	3	3	0	0	0	3	2	0	2	3	0	0
R19	2	2	1	0	2	0	0	0	4	3	3	2	0	4	3	2	3	3	0	3	2	0
R20	0	1	2	3	1	0	4	4	2	2	0	0	0	3	0	3	0	2	2	0	3	0
R21	0	0	3	0	1	4	2	2	0	3	2	1	0	2	4	2	2	0	3	2	0	2
R22	1	2	0	0	3	1	1	1	2	1	1	3	0	1	2	0	3	0	0	0	3	0

Table 4: Normalized direct influence matrix "S"

	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	R21	R22
R1	0.00	0.00	0.07	0.04	0.00	0.02	0.07	0.07	0.04	0.05	0.00	0.00	0.05	0.05	0.07	0.00	0.04	0.00	0.05	0.00	0.00	0.07
R2	0.00	0.00	0.00	0.05	0.04	0.02	0.07	0.07	0.04	0.05	0.02	0.05	0.07	0.07	0.05	0.04	0.04	0.00	0.05	0.07	0.00	0.05
R3	0.02	0.00	0.00	0.05	0.05	0.04	0.02	0.00	0.00	0.05	0.00	0.02	0.04	0.00	0.05	0.07	0.00	0.00	0.07	0.05	0.04	0.00
R4	0.04	0.04	0.04	0.00	0.07	0.02	0.07	0.05	0.02	0.04	0.00	0.00	0.04	0.00	0.00	0.05	0.04	0.00	0.00	0.04	0.00	0.00
R5	0.00	0.05	0.04	0.02	0.00	0.04	0.04	0.00	0.04	0.05	0.00	0.04	0.05	0.00	0.07	0.04	0.04	0.00	0.05	0.07	0.07	0.04
R6	0.07	0.07	0.05	0.07	0.05	0.00	0.05	0.07	0.00	0.05	0.00	0.07	0.07	0.05	0.07	0.05	0.04	0.04	0.00	0.00	0.02	0.07
R7	0.02	0.02	0.07	0.02	0.05	0.04	0.00	0.07	0.00	0.05	0.02	0.05	0.04	0.07	0.05	0.05	0.02	0.00	0.04	0.05	0.02	0.00
R8	0.02	0.02	0.00	0.04	0.00	0.02	0.02	0.00	0.00	0.07	0.00	0.07	0.07	0.07	0.07	0.05	0.02	0.00	0.00	0.02	0.05	0.07
R9	0.04	0.05	0.00	0.07	0.05	0.00	0.00	0.00	0.00	0.04	0.00	0.04	0.05	0.00	0.04	0.07	0.05	0.04	0.02	0.05	0.00	0.05
R10	0.04	0.04	0.04	0.05	0.04	0.04	0.04	0.02	0.05	0.00	0.00	0.07	0.04	0.05	0.07	0.07	0.05	0.00	0.04	0.05	0.04	0.07
R11	0.00	0.07	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.05	0.07	0.02	0.04	0.04	0.00	0.05	0.07
R12	0.00	0.04	0.07	0.00	0.05	0.02	0.04	0.02	0.05	0.02	0.00	0.00	0.05	0.05	0.04	0.07	0.05	0.04	0.05	0.00	0.07	0.04
R13	0.04	0.02	0.05	0.05	0.04	0.02	0.05	0.02	0.04	0.05	0.04	0.04	0.00	0.02	0.02	0.05	0.00	0.00	0.00	0.00	0.00	0.00
R14	0.04	0.02	0.00	0.00	0.00	0.04	0.02	0.02	0.00	0.04	0.00	0.04	0.07	0.00	0.07	0.05	0.07	0.00	0.02	0.04	0.05	0.07
R15	0.02	0.04	0.04	0.00	0.02	0.02	0.02	0.02	0.05	0.02	0.04	0.05	0.07	0.02	0.00	0.05	0.07	0.00	0.04	0.00	0.02	0.05
R16	0.00	0.05	0.02	0.04	0.05	0.04	0.04	0.04	0.02	0.02	0.02	0.02	0.04	0.04	0.04	0.00	0.05	0.07	0.05	0.04	0.05	0.00
R17	0.05	0.05	0.00	0.05	0.05	0.05	0.07	0.07	0.04	0.04	0.07	0.04	0.00	0.02	0.02	0.04	0.00	0.05	0.04	0.00	0.05	0.04
R18	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.05	0.00	0.05	0.05	0.00	0.00	0.00	0.05	0.04	0.00	0.04	0.05	0.00	0.00
R19	0.04	0.04	0.02	0.00	0.04	0.00	0.00	0.00	0.07	0.05	0.05	0.04	0.00	0.07	0.05	0.04	0.05	0.05	0.00	0.05	0.04	0.00
R20	0.00	0.02	0.04	0.05	0.02	0.00	0.07	0.07	0.04	0.04	0.00	0.00	0.00	0.05	0.00	0.05	0.00	0.04	0.04	0.00	0.05	0.00
R21	0.00	0.00	0.05	0.00	0.02	0.07	0.04	0.04	0.00	0.05	0.04	0.02	0.00	0.04	0.07	0.04	0.04	0.00	0.05	0.04	0.00	0.04
R22	0.02	0.04	0.00	0.00	0.05	0.02	0.02	0.02	0.04	0.02	0.02	0.05	0.00	0.02	0.04	0.00	0.05	0.00	0.00	0.00	0.05	0.00

Table 5: Total influence matrix "M"

	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	R21	R22
R1	0.05	0.06	0.12	0.09	0.07	0.07	0.14	0.13	0.09	0.13	0.03	0.08	0.13	0.12	0.16	0.09	0.11	0.03	0.11	0.06	0.06	0.13
R2	0.05	0.08	0.07	0.12	0.12	0.08	0.16	0.14	0.10	0.14	0.06	0.14	0.16	0.15	0.16	0.15	0.12	0.04	0.12	0.14	0.08	0.13
R3	0.05	0.05	0.05	0.10	0.11	0.08	0.08	0.05	0.05	0.12	0.03	0.08	0.09	0.06	0.12	0.15	0.06	0.03	0.12	0.10	0.09	0.05
R4	0.07	0.08	0.08	0.05	0.12	0.06	0.13	0.11	0.06	0.10	0.03	0.06	0.10	0.06	0.07	0.13	0.09	0.03	0.05	0.09	0.05	0.05
R5	0.04	0.12	0.10	0.08	0.08	0.09	0.11	0.07	0.10	0.13	0.04	0.11	0.13	0.07	0.16	0.13	0.11	0.04	0.12	0.13	0.14	0.10
R6	0.12	0.15	0.13	0.15	0.15	0.07	0.16	0.16	0.08	0.16	0.05	0.17	0.18	0.15	0.19	0.18	0.14	0.08	0.09	0.08	0.11	0.16
R7	0.06	0.08	0.13	0.08	0.12	0.09	0.08	0.13	0.06	0.14	0.05	0.13	0.12	0.14	0.15	0.16	0.10	0.04	0.11	0.12	0.09	0.07
R8	0.06	0.08	0.06	0.09	0.07	0.07	0.09	0.06	0.06	0.14	0.03	0.14	0.14	0.13	0.15	0.14	0.09	0.03	0.06	0.07	0.12	0.13
R9	0.07	0.11	0.05	0.12	0.12	0.05	0.07	0.06	0.06	0.10	0.03	0.10	0.12	0.06	0.11	0.15	0.12	0.07	0.08	0.11	0.06	0.11
R10	0.09	0.12	0.11	0.12	0.13	0.10	0.13	0.10	0.12	0.10	0.04	0.16	0.13	0.14	0.18	0.19	0.15	0.05	0.12	0.12	0.12	0.15
R11	0.03	0.11	0.04	0.04	0.05	0.04	0.12	0.05	0.04	0.06	0.03	0.06	0.10	0.05	0.12	0.13	0.07	0.06	0.08	0.05	0.10	0.11
R12	0.05	0.10	0.13	0.06	0.13	0.08	0.11	0.08	0.11	0.10	0.04	0.08	0.13	0.12	0.13	0.17	0.13	0.07	0.12	0.07	0.14	0.10
R13	0.07	0.07	0.10	0.10	0.09	0.06	0.11	0.07	0.08	0.11	0.06	0.09	0.06	0.07	0.09	0.13	0.06	0.03	0.05	0.05	0.05	0.05
R14	0.07	0.08	0.06	0.05	0.07	0.08	0.09	0.08	0.05	0.10	0.04	0.10	0.13	0.06	0.15	0.13	0.14	0.03	0.08	0.08	0.11	0.13
R15	0.06	0.10	0.09	0.06	0.08	0.06	0.09	0.07	0.10	0.09	0.07	0.12	0.14	0.08	0.08	0.14	0.14	0.04	0.09	0.05	0.08	0.11
R16	0.04	0.11	0.07	0.09	0.12	0.09	0.11	0.10	0.07	0.10	0.06	0.09	0.11	0.10	0.12	0.10	0.13	0.10	0.12	0.10	0.12	0.07
R17	0.10	0.13	0.07	0.12	0.13	0.11	0.16	0.14	0.10	0.13	0.11	0.12	0.09	0.10	0.13	0.15	0.09	0.09	0.11	0.07	0.13	0.12
R18	0.02	0.04	0.03	0.04	0.04	0.08	0.04	0.04	0.08	0.04	0.07	0.09	0.04	0.04	0.05	0.11	0.08	0.03	0.07	0.08	0.04	0.04
R19	0.07	0.10	0.07	0.06	0.10	0.05	0.07	0.06	0.12	0.12	0.09	0.10	0.07	0.13	0.14	0.13	0.13	0.09	0.07	0.11	0.10	0.07
R20	0.03	0.07	0.08	0.10	0.07	0.05	0.12	0.12	0.07	0.10	0.03	0.06	0.06	0.11	0.07	0.13	0.06	0.06	0.09	0.05	0.10	0.05
R21	0.04	0.06	0.10	0.05	0.08	0.12	0.10	0.09	0.05	0.12	0.07	0.09	0.07	0.10	0.15	0.12	0.10	0.03	0.11	0.09	0.07	0.10
R22	0.04	0.08	0.04	0.04	0.10	0.05	0.07	0.06	0.07	0.07	0.04	0.10	0.05	0.06	0.10	0.06	0.10	0.02	0.05	0.04	0.10	0.05

Table 6: Sum of influences given and received on criteria

Logistic Risk	r_i	s_i	$r_i + s_i$	$r_i - s_i$
R1	2.031224	1.281372	3.312595	0.749852
R2	2.51584	1.971168	4.487007	0.544672
R3	1.722051	1.777415	3.499467	-0.05536
R4	1.654017	1.791443	3.44546	-0.13743
R5	2.194854	2.130453	4.325307	0.064401
R6	2.882251	1.618223	4.500473	1.264028
R7	2.248147	2.321939	4.570086	-0.07379
R8	2.002096	1.960577	3.962673	0.04152
R9	1.926557	1.722554	3.649111	0.204003
R10	2.631646	2.369318	5.000964	0.262327
R11	1.549902	1.092122	2.642024	0.45778
R12	2.255654	2.255593	4.511246	6.07E-05
R13	1.618241	2.359945	3.978186	-0.7417
R14	1.920332	2.100314	4.020645	-0.17998
R15	1.911658	2.76041	4.672068	-0.84875
R16	2.107866	2.953798	5.061663	-0.84593
R17	2.489408	2.314438	4.803845	0.17497
R18	1.197551	1.085018	2.282568	0.112533
R19	2.043834	2.008305	4.052139	0.035529
R20	1.675739	1.842799	3.518539	-0.16706
R21	1.905184	2.06387	3.969054	-0.15869
R22	1.394895	2.097874	3.492769	-0.70298

Table 7: Total influence matrix for dimensions "M_D"

	D1	**D2**	**D3**
D1	0.09	0.12	0.10
D2	0.08	0.09	0.10
D3	0.08	0.10	0.09

Table 8: Sum of influences given and received on Dimensions

Dimensions	r_i	s_i	r_i+s_i	r_i-s_i
D1	0.31	0.25	0.56	0.06
D2	0.27	0.31	0.58	-0.04
D3	0.26	0.28	0.54	-0.01

To generate more insights**,** we tried to identify risks belonging to the cause and effect group within each broad category of risks i.e internal, financial and customer related.

5.1 Cause and effect analysis

Based on figure 4, the causal risks amongst internal risks can be sorted as R6>R1> R2> R11> R10> R9> R5> R8> R12. Thus, R6 (flexibility related risk) is at the top of the causal group indicating that it is the primary causal risk among the internal risks faced by the 3PLs. R1 (process design and planning risk) is the second causal risk among the internal risk categories. This risk occurs due to the fact that supporting processes may not be availabale in place to ensure the quality control, some times the logistics processes may have unreliable cycle times and 3PLs may have insufficient capabilities to incorporate latest technological developemnts. The third position among the causal group of risks for internal risks is R2 (quality risk) and this may happen due to some shipping errors, damage and spoilage in transit. The fourth position is occupied by R11 (lack of expertise) and this is may be due to lack of capability to handle special product needs with specific logistics requirements by customers, labor instability or lack of appropriate labor skills at warehouses, due to high turnover and loss of key personnel and not having knowledge of specific industry's requirements and regulations. The fifth position is R10 (disruption). This happens due to strikes /delays in transportation due to congestion, accidents. It may also due to customs delays/confiscations and Strikes /delays in transportation due to natural disasters. The remaining risks (R9, R5, R8 and R12) are placed in the cause group, but has little influence towards the effect group.

The risks in the effect group are denoted as influenced risk. The effort group is sorted as follows: R3>R7>R4>R13. Thus, R3 (lead time) is the risk which gets influenced most followed by R7 (socio-political risk) and R4 (breakdown and hazard risks). Most of the risks manifest in increase in transportation lead times (Manuj and Mentzer, 2008; Selviaridis et al., 2008; Tummala and Schoenherr, 2011). Sociopolitical risks such as labour strikes, lack of labour availability (Pujawan and Geraldin, 2008) are also causes of concern for the 3PLs.

Based on figure 5, there is no causal risk within the financial risks. Both the risks (R13 and R14) belong to the effect group but those risks may influence risks in other dimensions.

Based on figure 6, the causal risks amongst customer related risks can be sorted as follows: R17>R18>R19. Among the three risks under this group, R17 (Lack of trust and opportunism risk) is the primary causal risk. This occurs due to the strained relations with customers and opportunistic behavior from the client such as prioritizing other logistics service providers. The second causal risk is R18 (Dependency risk) and it happens due to the lack of alternative clients, limited customer base and litigation risks from clients. The last risk R19 (Intellectual property rights risk) occurs due to the loss of control and risk of losing proprietary information to the client.

The effort group for customer related risks is sorted as follows: R21>R20>R22>R16. From our result, R21 (Cultural/language risk) and R20 (information sharing risk) is nearer to the cause group and is less influenced by the causal group. Nowadays, most of the companies trained their employees to adopt themselves to the cultural and language change.

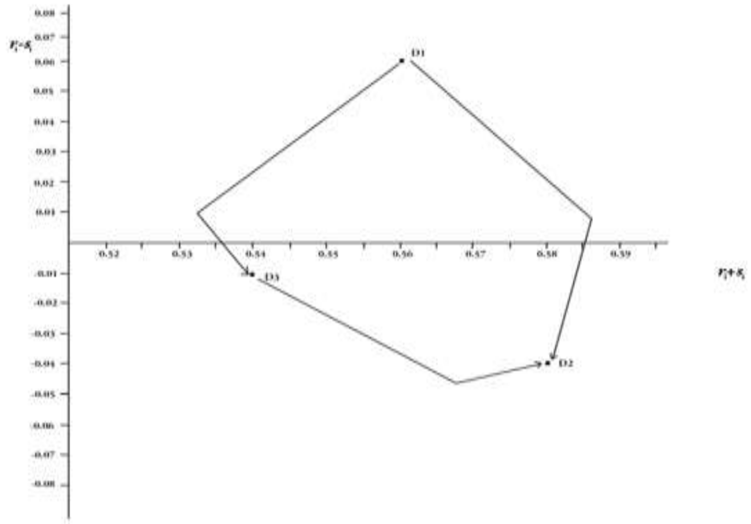


Fig 3: Casual diagram with degree of central role and degree of relation of dimensions

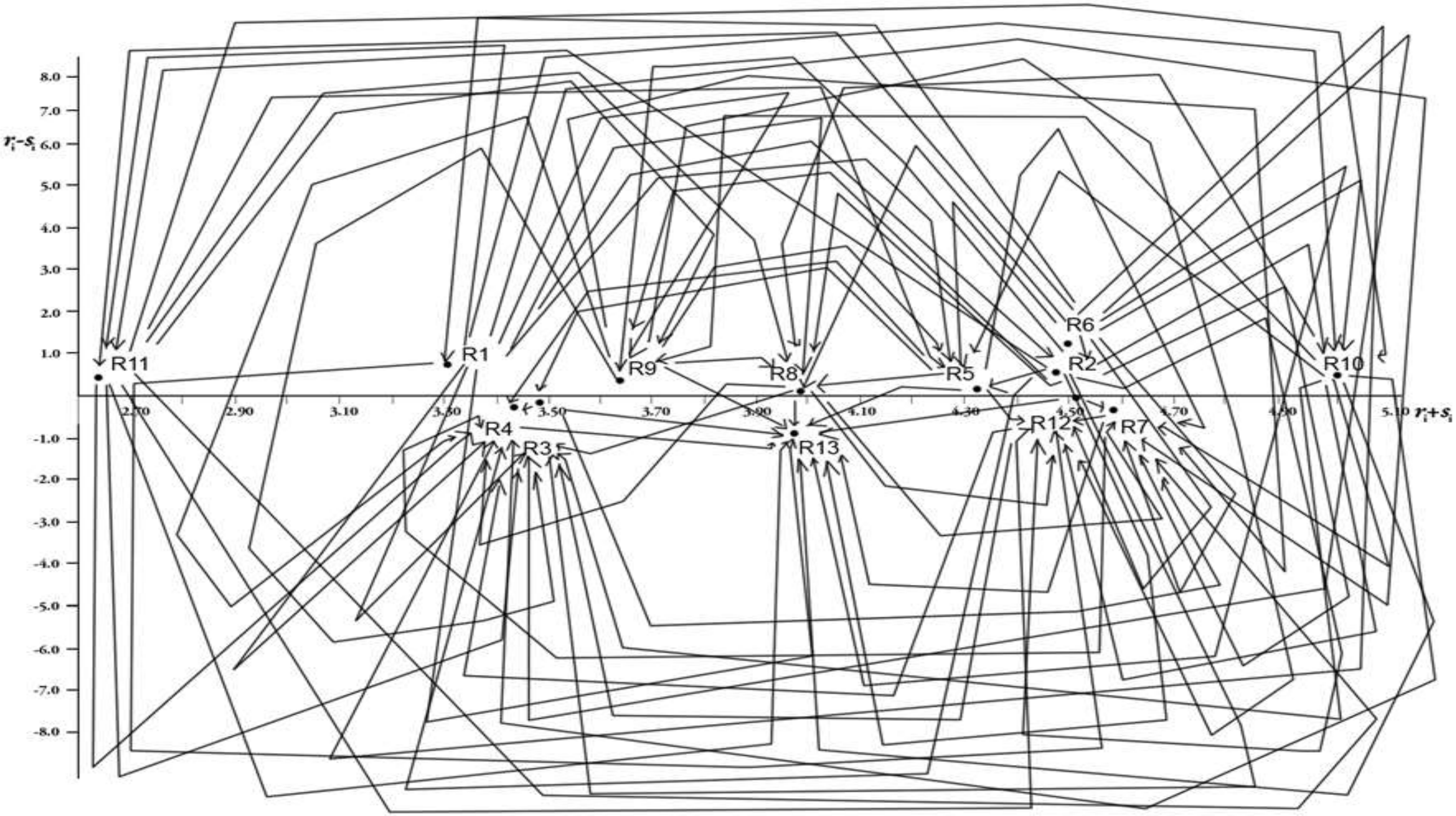


Fig 4: Casual diagram with degree of central role and degree of relation of internal logistic risks

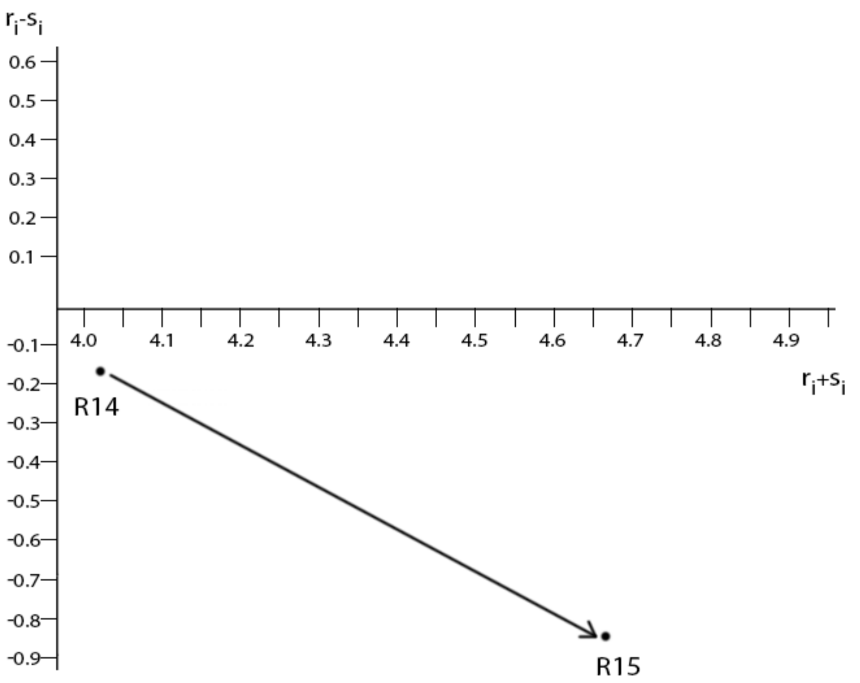


Fig 5: Casual diagram with degree of central role and degree of relation of financial risks

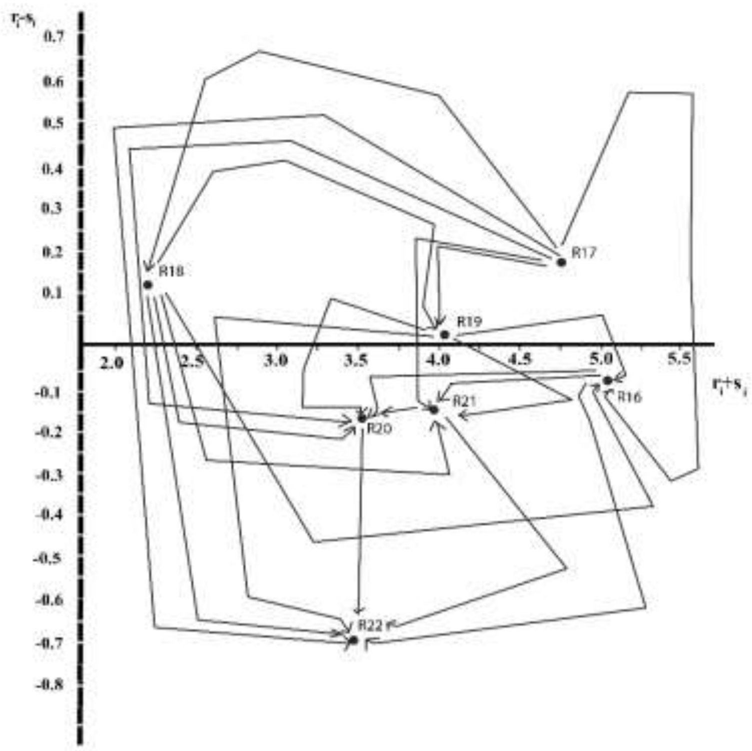


Fig 6: Casual diagram with degree of central role and degree of relation of customer related risks

5.2 Validation of results

The results of the DEMATEL analysis are shared first with the experts and later with a validation group (not includingthe expert team involved in the study) consisting of one senior executive each from the two 3PLs and Vice President –Supply Chain of CementCo for their insights and comments. We also validated the results based on the literature from the field of risk management and logistics management. Validation using both industrial insights and academic state-of-the art ensures that the results are robust. The validation team agreed with the findings and the Vice President –Supply Chain of CementCo also commented that it was insightful for him to know that some of CementCo's practices are also creating risks for the 3PLs and in turn affecting the logistics performance of the company.

During the meeting with the validation experts, they indicated that in-order to mitigate the risks there is need to increase flexibility particularly the ability to change volumes and possibly of rerouting of shipments (Chopra and Sodhi, 2004). Logistics, rerouting and delivery flexibility are also identified as key dimensions of flexibility in global supply chains (Kumar et al., 2008).

Experts also believed that quality risks i.e shipping errors or damage in transit are also common sources of risks and can be addressed with top priority, which is also one of the stated preferences by logistics manager as a freight service attribute (Danielis et al., 2005). Lack of capability to handle specific logistics requirements (Selviaridis et al., 2008; Jharkharia and Shankar,2007) and labor instability or lack of appropriate labor skills in handling products are also key sources of logistics risks (Deleris and Erhun, 2011).

The validation experts said that it is interesting to find the socio-political risks such as labour strikes, lack of labour availability in the effect group which essentially means that other risks in the cause group needs to be addressed to minimize its impact. They noted that it is difficult to get labour for their loading-unloading operations who are usually employed from nearby villages and towns and their availability becomes difficult during harvest seasons or in the time of any disruption in nearby areas. Sometimes getting them to follow safety procedures is difficult and time consuming. But, increasing efforts are needed to train them and ensure their availability and also ensuring better work conditions for them. The occurence of natural disasters, epidemics at locations of logistics facilities and geopolitical events such as terrorism, war, political instability at locations of logistics facilities are rare events. The validation experts believed that they need not explicitly plan for such disasters but it will be good to have some back-up options to minimize the effect of those.

Opportunistic behavior by supply chain partners has also been reported in the literature (Khan and Burnes, 2007) and is usually a critical source of risk. Dependency risk is also a credible risk where the suppliers may feel that they are too dependent on their customers and they also remain under the threat of litigation from clients (Cuchiella and Gastaldi, 2006). Validation experts mentioned that they are always wary of the opportunistic behavior by the other. CementCo's VP-Supply Chain said that sometimes during periods of high demand, they have been left stranded as the 3PLs have decided to allocate less capacity to them. Similarly, the 3PL executives also felt that they are never sure whether they will get the contracts for the subsequent quarter. 3PL executives also said that in a way they are locked with bigger customers like CementCo. They cannot work like an individual transporter who has five trucks or less. Commitment from both sides will surely help reduce the uncertainty.

The validation team also mentioned that because of the large number of risks it is very difficult to see the most important interrelationship between the risks and that we should focus on some important risk categories. They also believed that it is important to analyse how risks in one category impact risks in the other category and not just within its own category. They said they though at an aggregate level, internal risks influence financial risks bith directly and through customer risks, they need to know which internal risks influence which customer risks and financial risks, which customer risks influence internal and financial risks and which financial risks influence internal risks. Such detailed insights will be useful for planning mitigation actions.

5.2.1 Prioritization of risks and further validation

To respond to the above suggestions, we first calculated the threshold limit for identifying the most important interrelationships. This threshold limit is denoted by θ. The threshold is calculated by taking the mean and standard deviation of the values from the M, and added one standard deviation to the mean (Xia et al., 2015). From M (Table 4), we can get the mean of M (0.09066) and the standard deviation (0.0355), thus, $\theta = 0.1262$. All the relationships meeting or exceeding the threshold value are underlined in the overall M matrix (table 9). We then plot these strongest dyadic relationships (Figure 7). Two-way significant relationships are represented by solid lines, whereas one-way relationships are represented by dashed lines.

The results generate interesting insights. Among the internal risks, R2 (quality risk), R5(IT and information sharing risk), R6 (flexibility related risks), R10 (disruption) and R12 (lack of coverage) each has influence on three customer risk categories. Among these, R2, R6 and R10 also influence the financial risks. Thus, some internal risks faced by 3PLs are resulting in customer related risks particularly planning and forecasting risk. Infact, planning and forecasting risk due to changes in planning by customer is the one risk which gets influenced by the largest number (eleven) of other risks. Thus, essentially, many other risks are the causes of planning and forecasting changes by customers. It is also interesting to note that R7 (socio-political risk) and R10 (disruption risk) have bidirectional relationships with both influencing each other. It is easy to explain that labor strikes, labor availability issues at 3PL facilities, changes in trade and environmental regulations lead to logistics disruptions in terms of delays in transportation, customs clearance, congestion etc while those disruptions further cause socio-political risks. Similarly, R15 (risk due to debtors and lack of access to capital) and R17 (lack of trust and opportunism) also have bi-directional relationships. Sometimes lack of capital at the 3PL creates capacity problems which results in loss of trust by customer and withholding of payments which further excarbate the situation.

Experts noted that quality risk in terms of shipping errors, information sharing risk which is most frequently manifested as failure to update status to customer, lack of flexibility by the 3PL in handling additional volumes or rerouting some shipments and lack of coverage in some geographical regions apart from disruptions like strikes etc create lot of uncertainty in CementCo's planning process. These apparent challenges from both the 3PLs and the customer CementCo creates lack of trust and results in a negative cycle of poor delivery performance of 3PLs and in turn CementCo to its markets. Sometimes this lack of trust may be traced back to lack of capacity or lack of flexibility at the 3PL which can in turn be attributed to lack of working capital either from delays in payment by customer or from the lending agency i.e bank or the financial services provider. This thorough analysis of risks both within and across risk categories clearly pointed to the current arms length relationship between the service provider and the customer and called for more collaborative relationship and integration for the beneft of both.

Among the financial risks, R14 (risk due to exchange rates, taxes and fuel prices) influence three customer risks- R16 (planning and forecasting), R17 (lack of trust and opportunism) and R22 (payment) while R15 (risk due to debtors and lack of access to capital) influence R16 (planning and forecasting) and R17 (lack of trust and opportunism). On being shared this finding, the experts said that taxes and fuel price increases manytimes lead to strikes and disruptions in the transport sector and that affects the planning process of the customer and they have to make last minute changes to delivery plans. It may also result in occasional payment delays by the customer and frequent requests to customers to release payments to 3PLs may sometimes result in lack of trust and opportunistic behaviour by the customer. The validation group who was not fully aware of seriousness of these chain of events caused by fuel price increases or tax rates which are not under the control of 3PLs and CementCo and found the results insightful and highlighting these apparently sensitive issue made CementCo realize the seriousness of the issue and Vice-President of Supply Chain commited that such payment delays due to fuel price increases should not happen.

Among the customer risks, R17 (lack of trust and opportunism) has influence on four internal risks faced by the 3PLs i.e R2 (quality risk), R5 (IT and information sharing risk), R7 (socio-political risk) and R8 (sustainability risks). The 3PL managers did admit that arms-length relationship between CementCo and the 3PLs have an indirect effect on quality risks in terms of shipping errors, lack of information sharing, occasional labour disputes particularly for loaders of 3PLs working at CementCo sites and may even result in health hazard issues of those workers resulting in sustainability risk. The validation group realized that lack of trust between ground level employees of both CementCo and the 3PLs are indeed creating some problems and sometimes even retaliatory action like non-sharing of information on time and quality problems.

The above validation exercise about the causal and effect groups within each category and between categories of risks along with support from literature demonstrates the robustness of the exercise being carried out.

Table 9: Total influence matrix with threshold

	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	R21	R22
R1	0.0452	0.0600	0.1227	0.0903	0.0692	0.0668	0.1345	0.1263	0.0873	0.1276	0.0343	0.0760	0.1259	0.1170	0.1554	0.0933	0.1073	0.0292	0.1089	0.0562	0.0642	0.1335
R2	0.0516	0.0771	0.0698	0.1196	0.1178	0.0770	0.1563	0.1439	0.1018	0.1434	0.0580	0.1404	0.1598	0.1525	0.1555	0.1498	0.1245	0.0416	0.1233	0.1376	0.0839	0.1306
R3	0.0513	0.0540	0.0521	0.0988	0.1097	0.0765	0.0791	0.0524	0.0494	0.1146	0.0291	0.0749	0.0944	0.0578	0.1231	0.1457	0.0628	0.0316	0.1224	0.1024	0.0894	0.0505
R4	0.0663	0.0838	0.0823	0.0513	0.1236	0.0593	0.1291	0.1052	0.0588	0.0992	0.0251	0.0590	0.0963	0.0572	0.0729	0.1255	0.0886	0.0264	0.0532	0.0852	0.0540	0.0517
R5	0.0436	0.1173	0.0971	0.0801	0.0754	0.0887	0.1126	0.0686	0.0953	0.1320	0.0392	0.1108	0.1270	0.0743	0.1589	0.1344	0.1122	0.0380	0.1204	0.1312	0.1366	0.1012
R6	0.1244	0.1517	0.1331	0.1463	0.1470	0.0734	0.1545	0.1562	0.0776	0.1575	0.0464	0.1705	0.1773	0.1450	0.1906	0.1790	0.1378	0.0753	0.0891	0.0802	0.1082	0.1614
R7	0.0615	0.0844	0.1309	0.0798	0.1230	0.0903	0.0788	0.1333	0.0590	0.1350	0.0515	0.1295	0.1199	0.1428	0.1496	0.1557	0.0974	0.0372	0.1053	0.1149	0.0944	0.0741
R8	0.0575	0.0771	0.0587	0.0860	0.0676	0.0692	0.0884	0.0601	0.0549	0.1384	0.0335	0.1393	0.1413	0.1333	0.1526	0.1407	0.0936	0.0308	0.0602	0.0682	0.1165	0.1343
R9	0.0706	0.1108	0.0525	0.1229	0.1177	0.0478	0.0738	0.0615	0.0564	0.1023	0.0339	0.0985	0.1174	0.0605	0.1087	0.1517	0.1197	0.0681	0.0769	0.1063	0.0611	0.1075
R10	0.0867	0.1152	0.1074	0.1234	0.1248	0.0991	0.1277	0.0987	0.1220	0.0955	0.0440	0.1576	0.1296	0.1356	0.1768	0.1848	0.1478	0.0460	0.1154	0.1233	0.1197	0.1505
R11	0.0276	0.1139	0.0418	0.0391	0.0525	0.0408	0.1215	0.0485	0.0425	0.0555	0.0322	0.0568	0.1036	0.0528	0.1149	0.1340	0.0735	0.0603	0.0827	0.0452	0.0977	0.1124
R12	0.0448	0.1018	0.1272	0.0625	0.1268	0.0776	0.1092	0.0809	0.1104	0.1007	0.0422	0.0792	0.1298	0.1209	0.1310	0.1693	0.1325	0.0737	0.1236	0.0687	0.1403	0.1027
R13	0.0658	0.0674	0.0986	0.0979	0.0906	0.0571	0.1096	0.0657	0.0748	0.1102	0.0566	0.0886	0.0632	0.0686	0.0877	0.1268	0.0576	0.0262	0.0527	0.0492	0.0513	0.0520
R14	0.0740	0.0758	0.0555	0.0533	0.0647	0.0839	0.0877	0.0789	0.0534	0.1035	0.0367	0.1027	0.1345	0.0640	0.1480	0.1339	0.1376	0.0331	0.0752	0.0806	0.1130	0.1304
R15	0.0562	0.0951	0.0846	0.0551	0.0837	0.0643	0.0857	0.0730	0.1029	0.0863	0.0693	0.1172	0.1359	0.0774	0.0803	0.1367	0.1358	0.0359	0.0932	0.0518	0.0795	0.1118
R16	0.0417	0.1142	0.0732	0.0911	0.1183	0.0891	0.1087	0.0981	0.0743	0.0949	0.0569	0.0921	0.1085	0.1025	0.1218	0.0967	0.1251	0.1040	0.1163	0.0975	0.1168	0.0661
R17	0.0987	0.1279	0.0688	0.1165	0.1307	0.1134	0.1569	0.1442	0.0976	0.1251	0.1090	0.1225	0.0939	0.1005	0.1270	0.1459	0.0894	0.0914	0.1102	0.0721	0.1291	0.1187
R18	0.0240	0.0425	0.0315	0.0354	0.0414	0.0781	0.0444	0.0368	0.0833	0.0407	0.0721	0.0898	0.0426	0.0391	0.0482	0.1075	0.0768	0.0296	0.0715	0.0828	0.0411	0.0383
R19	0.0727	0.0972	0.0686	0.0560	0.0970	0.0518	0.0727	0.0595	0.1245	0.1207	0.0871	0.1028	0.0745	0.1303	0.1361	0.1286	0.1273	0.0886	0.0669	0.1104	0.1002	0.0705
R20	0.0324	0.0646	0.0788	0.0961	0.0719	0.0448	0.1230	0.1179	0.0743	0.0977	0.0268	0.0596	0.0610	0.1078	0.0735	0.1288	0.0603	0.0609	0.0855	0.0544	0.1041	0.0516
R21	0.0407	0.0610	0.1030	0.0523	0.0802	0.1153	0.0998	0.0909	0.0504	0.1200	0.0667	0.0869	0.0708	0.0980	0.1517	0.1218	0.1037	0.0340	0.1096	0.0856	0.0648	0.0980
R22	0.0442	0.0784	0.0395	0.0377	0.0970	0.0541	0.0677	0.0599	0.0716	0.0686	0.0416	0.1008	0.0530	0.0623	0.0962	0.0634	0.1030	0.0231	0.0459	0.0392	0.0978	0.0501

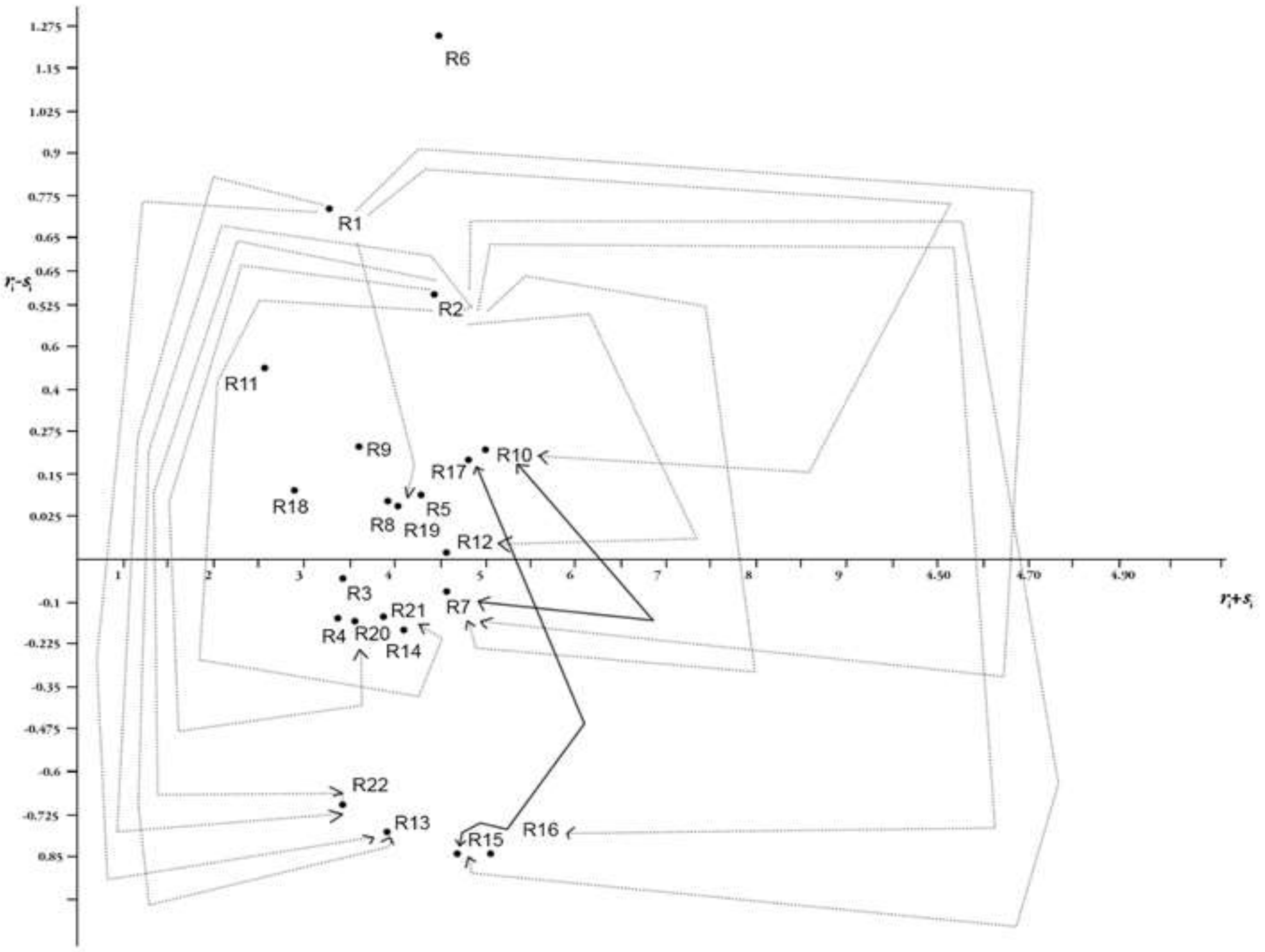


Figure 7: The prominence-causal DEMATEL graph

6. Managerial Implications

Our thorough analysis of risks both within and across risk categories clearly pointed to the current arms length relationship between the service provider and the customer and calls for more collaborative relationship and integration for the beneft of both. In such a commoditized business, lack of availability of the product directly results in lost sales. It also pointed out that external changes like fuel price hike, taxation related changes, disruptions in the form of strikes etc should not influence behaviour of the employees in the partner organizations as these are usually outside anybody's control. The analysis shows that developing strategic relationships with the logistics service providers is extremely important for CementCo's business as logistics costs contribute to significant percentage of its total costs and is also crucial to ensure that the products reach the customers on time. A key ingredient to build such a collaborative relationship is trust which can lead directly to cooperation, or indirectly through the development of commitment (Power, 2005). Our finding of better relationship building with 3PLs is also supported by Jayaram and Tan (2010) who found that relationship building with 3PLs have strong impact on firm performance and note that firms constrained in their resources can achieve superior performance by focusing on creating an environemnt that enhances trust and commitment with their 3PLs. Similarly, Leuschner et al. (2014) note that Trust augmented with safeguarding mechanisms avoid opportunistic behavior of the other party in the relationship and trust can result in customer loyalty and business growth.

Building long term relationships with suppliers in general and with and the 3PLs in this context can reduce risks (Zsidisin, 2003) but such long-term alliances can also potentially enhance risk if the customer becomes over-dependent on one supplier (Lonsdale, 1999). In the context of the given problem, since CementCo has decided that both the 3PLs are needed by them to address different geographies and they do not necessarily compete with each other, the validation team of the senior executives agreed that it is logical for them to enter into long term relationships.

Results also show that the 3PLs also need to improve internal processes related to quality management, improve flexibility of its operations and also try to improve geographical coverage of its services. This will not only improve its business relationship with CementCo but also with its other customers. This finding concurs well with the literature. Panayides and So (2005) note that that improvement in material and information flow by logistics service providers requires managers to address organisational as well as operational aspects and managers should be confident of building such relationships. Such relationship orientation will

not only develop organisational competencies but will also directly impact the logistics service provider's effectiveness and in turn the performance of the overall supply chain.
The participating organizations were indeed very satisfied with the exercise and realized the power of the methodology to bring out issues which were affecting their performances.

7. Conclusion

This research has made key contributions to both logistics risk management and to the application potential of DEMATEL by proposing an augmented version of it. It addresses the less researched area of logistics risks faced by 3PLs and identified the cause and effect groups of risks not only within the broad categories of risks i.e internal, financial and customer related but also within those categories. Thus, it contributes to the literature on logistics risk management by considering a comprehensive set of risks faced by 3PLs, modelling their interrelationships and by demonstrating the value of a collaborative approach to risk management between 3PLs and their customers. Use of threshold values helped in identifying the critical set of risks and helped generate powerful insights on the cause-effect linkage between the risks.

The novel analysis of inter-category influence on risks using DEMATEL has not been attempted in prior literature to the best of our knowledge. It enhances the suitability of DEMATEL to generate practical insights on how risks of one category influence risks in other categories and thus can guide the decision maker to prioritize risks for mitigation. Thus, we contribute to the body of literature on MCDM by proposing a version of DEMATEL with additional analysis.

Our results demonstrated the importance of collaboration between the customer and logistics service provider. Supply chain integration and performance literature have rarely considered the role of logistics service providers with a notable exception being Jayaram and Tan (2010) while 3PL literature has not considered supply chain integration (Fabbe-Costes et al., 2008). This study also points out that companies using 3PLs fail to recognize their strategic role and hence continue to maintain arms-lenth relationship resulting in lack of trust. Thus, this research points out a gap in the supply chain integration literature in terms of consideration of logistics service providers and calls for future research in that direction. Our results are in line with the findings of Wiengarten et al. (2014) who note that manufacturing plants situated in countries with relatively low levels of logistical capabilities gain higher performance benefits from external integration compared to plants situated in countries with high levels of logistical capabilities. Thus, in a country like India with limited logistical capabilities, integration between logistical service providers and manufacturing companies using their services assume high significance. Tian et al. (2010) also found in a study conducted in China that 3PLs with strong customer orientation generated significant value for their customers while Tsai et al. (2012) confirmed that relationship risk resulting from poor communication also creates asset and competence risks which negatively impacts the firm outsourcing its logistics activities.

Thus, the key recommendations of our study for 3PLs will be to improve customer orientation (So, 2005; Tian et al., 2010), to have well developed processes for quality management, to improve flexibility of its operations (Barad and Sapir, 2003; Naim e al., 2006; Hartmann and Grahl, 2011) and to improve geographical coverage of its services to suit customer needs. Similarly, firms using the services of 3PLs should consider the 3PLs as strategic partners (Sinkovics and Roath, 2004), focus on building trust and long term relationship (Qureshi et al., 2007; Jayaram and Tan, 2010; Tsai et al., 2012; Leuschner et al., 2014) and share information with the 3PLs (Qureshi et al., 2007). The above approaches are expected to reduce risks for the logistics service providers and their customers and improve overall supply chain performance.

Our research also has some limitations It addresses logistics risks faced by two 3PLs in the context of its relations with one of its customers CementCo in India and hence lacks generalizability. Nevertheless, the study is conducted in the context of a developing economy and logistics service providers in other developing countries may face similar risks and challenges. Hence the identified risks and the methodology may provide foundation for conducting similar studies in other developing economies. Moreover, the findings in terms of need of increased collaboration and integration between logistics service providers and their customers will also be relevant in other developing economies with limited logistics infrastructure (Wiengarten et al., 2014).

Conducting the analysis as outlined in this paper with generic risks would have generated some insights and improved generalizability but would have lacked the specific take-aways which this research could suggest to the participating companies. Also given the nature of the task and the large number of risks involved, we instructed the experts to reach a consensus when providing the inputs which sometimes led to longer discussions and an overall lengthy process.

One scope of future research will be to capture inputs from individual experts in terms of fuzzy or grey numbers as it may be difficult for experts to provide crisp inputs and to use fuzzy or grey DEMATEL or other fuzzy or grey MCDM methods. Potential also exists to develop coordination mechanisms between logistics service providers considering the probabilities of occurrences of the risks and their impact on supply chain performance measures.

In addition, this research also opens opportunities for future research opportunities to identify supply chain integration mechanisms between triads of suppliers, customers and logistics service providers and to evaluate the impact of those mechanisms on reducing risks and on improving performance. This may also require development of suitable constructs and scales for integration between suppliers, customers and logistics service providers. Finally, this research also calls for future research on development of comprehensive risk management processes developed in collaboration between logistics service providers and their customers and between buyers and suppliers in general.

Acknowledgements

Kannan Govindan's research is partially supported by Forsknings-og Innovationsstyrelsen for project 4070-00139B.

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