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Selection and evaluation of third party logistics service provider (3PLSP) by using an interpretive ranking process (IRP)

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Abstract

Purpose – The concept of third-party logistics service provider (3PLSP) has been considered as an essential organizational philosophy to achieve profits. The purpose of this paper is to analyze and examine the contextual relationship among the critical success factors (CSF) of 3PLSPs practices in the cement manufacturing industry.

Design/methodology/approach – In this paper, the total 20 critical selection criteria with nine processes for the 3PLSPs, of an Indian cement manufacturing industry have been identified through an exhaustive literature review and opinions of the experts i.e. academics and industries. Interpretive ranking process (IRP) methodology has been presented to find out the rankings of the individual criteria and the mutual influence in the selection process.

Findings – The proposed model establishes the dominance of relationship among identified criteria, which plays a vital role in the 3PLSPs selection process which are experience in similar product, quality of management, information technology capacity, flexibility in operation and delivery, compatibility with the users.

Research limitations/implications – An empirical research approach has not been used to collect primary data to rank different criteria for effective 3PLSPs implementation in the Industry. In this paper, an example of Indian cement industry is presented to show the real world applicability of the proposed model.

Originality/value – This model would help a decision maker to decide the issues related to a selection of 3PLSPs. The third party service provider comprises the use of external companies who controls and delivers logistic activities. The paper discusses very practical issues in an analytical manner, using the case base method.

Keywords IRP, Multi-criteria decision making, Manufacturing industry, Critical success criteria, Third party logistic service provider

Paper type Research paper

1. Introduction

Logistics management (LM) is a detailed process of planning, implementing, and controlling the flow of various activities in the efficient, cost-effective way (storage of materials, products, and related information) within the supply chain to satisfy the needs and demands of customers (CLM, 2004). Logistics is the central part of the supply chain in which organizations can cut their costs, and the service quality to customers can be improved. It has a tremendous impact on the efficiency of the entire supply chain (Lieb and Randall, 1996; Yan *et al.*, 2003;

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Shen and Chou, 2010; Chiang *et al.*, 2011). Third Party Logistics (3PL) is an external organization that performs all or part of an organization's logistics functions (Coyle *et al.*, 2003; Delfmann *et al.*, 2002). It is a professional logistics group gaining profit by taking charge of part or full logistics in the supply chain of client's enterprise (Lambert and Cooper, 2000).

A third-party logistics service provider (3PLSP) offers a variety of services such as warehousing, transportation, product returnability, information system, management of inventory, cross-docking and packaging (Sink and Langley, 1997; Rabinovich *et al.*, 1999). A 3PLSPs can reduce client's inventory and stock out costs, through the government regulations and norms, obtain customs clearance to avoid delay (Selnes and Sallis, 2003). With the rapid increase in global trade, extreme competition, higher demands of customers, and fast expansion of supply chains and their network around the world, 3PLSPs play a crucial role in the dynamic and highly volatile environment (Murphy and Daley, 2001; Hsiao *et al.*, 2010).

To increase competitiveness and profitability of a supply chain, the internal activities and business processes and procedures should be collaborated and managed with multiple enterprises (Serve *et al.*, 2002). The globalization of markets has led to more complex supply chains demanding better contribution of managers in logistics operations. The lack of precise awareness of customs, tax regulations and infrastructure of destination countries has forced organizations to get hold of expertise of 3PLSPs. Most of the manufacturers have accepted that their core competencies are not in the logistics field, hence, gradually purchased logistics services and functions from 3PLSPs (Azadi and Saen, 2011; Bhatnagar *et al.*, 1999). The big companies are focusing on their core competencies in the supply chain and outsourcing the non-core business activities. The organizations can get a competitive advantage by establishing long-term relationships with 3PLSPs (Lambert *et al.*, 1999; Li *et al.*, 2011; Yeung, 2008; Coates and McDermott, 2002; Li and Warfield, 2011).

The demand of 3PLSPs has evolved to a higher level of complexity and precision (Maloni and Carter, 2006). The 3PLSPs improve operations efficiency of a supply chain (Berglund *et al.*, 1999) and play a crucial role in the logistic activities between the outsourcing company, the marketplace, and the customers (Liu and Wang, 2009). The outsourcing of logistics could bring a good amount of payoff and become an integral part of the organizational strategy (Sahay and Mohan, 2006). But, because of many incompatible, complex relationships, fear of loss of functional control and uncertainties, many organizations have failed about the service levels to be provided by the 3PLSPs.

In 3PL, three research areas have attracted the attention of the researchers and practitioners. First, the underlying reasons for outsourcing logistics functions; second, measuring the contribution of outsourcing the logistics services to the organization's capabilities; and lastly, the selection of 3PLSPs based on the various criteria (Boyson *et al.*, 1999). The principles followed by sub-criteria, i.e. a complex criteria hierarchy can make the problem more complex and realistic. Given the fact, the present work has been formulated.

This paper discusses the potential application of interpretive ranking process (IRP) method toward evaluation and selection of 3PLSPs. In this paper, an attempt is made to integrate the interpretive approach to decision-making with knowledge management. The aim of the current study is to examine and analyze the critical success factors (CSFs) used in refereeing the aids of 3PLSPs at the operational level, to develop a tool for measuring benefits of 3PLSPs for the cement industry. A knowledge management algorithm was reported in the present paper based on the concepts of 3PLSPs selection.

This document is prepared in the following sequence: An exhaustive literature review on 3PLSPs, identification of the selection criteria, and tools and techniques used for 3PLSP selection. Then a discussion on research methodology followed by the case study description. The next section summarizes the findings of the research work carried out; it also includes the discussion on influencing criteria followed by a conclusion, and managerial implications.

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2. Literature review

LM is the supply chain process that includes the planning, implementation and controlling, efficient, effective flow and storage of goods, services, and related information from the point of inception to the point of consumption to meet the customers' demands and expectations (Christopher, 1992). A 3PL provider is usually associated with the offering of a variety of services, other than just transportation or warehousing functions (Leahy *et al.*, 1995). The background of 3PLSP and tools and techniques used for 3PLSPs are the two divided categories of the present section.

2.1 Background of 3PLSP

Multiple, actual and apparent, criteria should be considered for the selection of 3PLSP as it is a complicated process and is a multi-criteria problem. Some processes are developed with precise customer needs while others are conjoint to entirely environments. Spencer *et al.* (1994) did the survey of 154 firms listed on the American public warehouse register and identified 23 criteria used by the listed companies to select their 3PLSP in the just-in-time situation. The primary criteria identified were on-time performance, excellent communication, service quality, service speed, and reliability. Fawcett and Smith (1995) identified five criteria for the evaluation of the 3PLSP performance, namely quality, flexibility, delivery, innovation, and cost of services. Morash *et al.* (1996) conducted a survey among sixty five US furniture industries and concluded that demand capabilities, determined logistics performance and supply capabilities are important criteria. Dapiran *et al.* (1996) and Millen *et al.* (1997) did an empirical study of eighty four users of 3PLs in Australia and found that cost was the most important factor for the selection of 3PLs followed by personal knowledge of the contractor, previous experience and references, services, coverage provided, experience in project management and new systems implementation, and competence. Stank and Maltz (1996) done a pilot review of criteria that affect the selection of 3PLSP in the domestic vs international logistics environment. They proposed six critical criteria were as: service capability, long-term cooperation, asset investment, learning potential, organizational characteristics, and uncertainty. Daugherty *et al.* (1996) said the logistics services offered by a 3PLSP should consist of following criteria such as, responsiveness to emergency assistance, ability in handling changes of atmosphere, flexibility in meeting external needs, emergency services, recommendations for potential problems, helping organizations cost reduction measures, responding to the uncertain needs of operational situations, predicting transportation problems, countermeasures when unable to offer services. Murphy and Daley (1997) did a survey of 375 members of the Council LM in the US and identified twelve criteria of international freight forwarders selection. The criteria namely, expertise and reliability were the top two criteria followed by the ability to provide relevant information, attention, reputation, which were among the top five criteria. Bhatnagar *et al.* (1999) concluded that service quality and cost are the most important criteria for the selection of 3PLSP, followed by reputation, the range of services, and relevant past experiences. Piplani *et al.* (2004) analyzed the interrelationship among the uses of IT at 3PLSPs in Singapore. It was found that many of the 3PLSPs were thinking to implement IT infrastructure in their regular operations, and some were already getting benefitted by the IT installation. It was concluded that lack of finance was the critical barrier for the total IT adoption. Ying and Dayong (2005) established the relationship between the supply chain members and 3PLSPs and concluded that 3PLSPS should re-engineer their logistics framework so that value of the customer can be increased. Sahay and Mohan (2006) explored 3PL services usage impact on the results of business. It was concluded that there is a significant positive relationship between the two. Kumar *et al.* (2006) developed a mathematical model for solving 3PL allocation problem using lexicographic goal programming under realistic constraints related to capacities of the markets, and this model was applied to a fish supply network. The results showed that there is a substantial improvement by reducing the number of 3PLSPs and reallocating them to

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the case fish markets. Choy *et al.* (2008) evaluated the performance of 3PLSPs and their partners using knowledge-based logistics performance measurement system. Hamdan and Rogers (2008) found the efficiency of the ware house of a 3PLSP by using data envelopment analysis (DEA). Li *et al.* (2008) resolved scheduling issues among 3PLSP transportation and parallel machine assembly by developing heuristic algorithms. Chen (2008) evaluated the performance of 3PLSPs using a conceptual client oriented and objective based model. Wang (2010) developed a just in time cost model and identified relationship among the manufacturer, an assembler, and a 3PLSP. An investigation on optimum production lot size, delivery lot size at the lowest expense was carried out. Lieb and Lieb (2010) examined the sustainable initiatives and their effects on 3PLSPs and their clients. Başligil *et al.* (2011) optimized a distribution network for 3PLSPS by using mixed integer programming and genetic algorithm (GA). Chen and Cai (2011) analyzed extended supply chain model with a budget constrained retailer, supplier, financing organization, and a 3PLSP. It was concluded that the developed model generated huge profits for the entire supply chain. Kayakutlu and Buyukozkan (2011) assessed the performance parameters for a 3PLSP and transportation operation and strategic planning were found to be the critical factors. Rajesh *et al.* (2012) explored 3PL sector and identified strategic aims for a 3PLSP by developing a balanced scoreboard outlook. Ülkü and Bookbinder (2012) analyzed the various pricing patterns for a 3PLSP and to increase the profit margin the quotations that made with respect to time of delivery and price were proposed. Yeung *et al.* (2012) developed a model establishing the relationship between three factors namely competitive advantage, outsourcing of logistics, and business performance. The structural equation modeling (SEM) was employed to test the model, and it was concluded that there is a positive relationship among the factors identified. Shah and Sharma (2012) discovered a reliable and valid scale for the measurement of benefits of cooperative 3PLSPs for Indian dairies. Ahn *et al.* (2013) determined the trend of market structures in Korea and Japan, and it was found that in Korea the market concentration ratio for the logistics industry showed the rapid turn to a competitive, low-concentration market structure, whereas the comparable market structure in Japan has already entered a competitive market. The results also highlighted that the rapid expansion in a subsidiary logistics market depends on a captive market that does not affect the 3PL market size and profitability. Diabat *et al.* (2013) established the interrelationship between the barriers to implementation of 3PL and two barriers namely lack of knowledge and application of IT, and fear of retrenchment by employees of the organization were found to be the most significant hindrances. Kaynak and Avci (2014) examined accountability dimensions (financial, logistics, contractual, marketing, environmental) in 3PLSPs and the impact of such issues on buyers trust was analyzed. The SEM was used for hypothesis testing, and it was found that logistics accountability, financial responsibility, and marketing accountability have positive effects on trust. Zhang *et al.* (2015) investigated 3PLSPs pricing problem and developed a nonlinear stochastic model for computing optimal freight rates for different delivery dates. Table I shows the summary of papers published in the area of 3PLSPs.

2.2 Tools and techniques for 3PLSPs

Based on literature review, the various tools/technologies used for the selection and performance evaluation of 3PLSP were classified into five categories: multi-criteria decision-making (MCDM) techniques, mathematical programming, artificial intelligence, statistical approaches, and integrated approach. The recent studies of Chai *et al.* (2013), Ho *et al.* (2010), Aguezzoul and Ladet (2006), Aguezzoul (2014) were referred for the categorization and explanation of the methods.

MCDM methodology is a systematic approach for the recommendation and selection of parameters from a set of identified criteria. The widely used MCDM methods in 3PLSP selection are: interpretive structural model (ISM), fuzzy sets theory (FST), technique for order preference by similarity to ideal solution (TOPSIS), multi-criteria optimization and compromise

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Sr. no.	Author(s)	Year	Country	Problem/application area
1	Spencer *et al.*	1994	USA	Selection of 3PLSP in just-in-time (JIT) situation
2	Fawcett and Smith	1995	USA	Evaluation of 3PLSP performance
3	Morash *et al.*	1996	USA	Strategic logistics capabilities for competitive advantage and firm success
4	Dapiran *et al.*	1996	Australia	3PL usage by large Australian firms
5	Millen *et al.*	1997	Australia	Usage of contract logistics services
6	Stank and Maltz	1996	USA	Selection of 3PLSP in the domestic vs international logistics environment
7	Daugherty *et al.*	1996	USA	Purchasers perception about 3PLSP
8	Murphy and Daley	1997	USA	Selection criteria for international freight forwarders
9	Bhatnagar *et al.*	1999	Singapore	Selection of 3PLSP
10	Piplani *et al.*	2004	Singapore	Perspectives on the use of information technology at 3PLSP in Singapore
11	Ying and Dayong	2005	China	Multi-agent Framework for 3PL in e-commerce
12	Sahay and Mohan	2006	India	Impact of usage of 3PL services on business results
13	Kumar *et al.*	2006	India	Allocation problem of 3PLSP for fish distribution
14	Choy *et al.*	2008	China	Improving supply chain flexibility of 3PLSP
15	Hamdan and Rogers	2008	USA	Analyzing the performance of 3PL logistics operations
16	Li *et al.*	2008	China	Coordinated scheduling of parallel machine manufacturing and 3PL transportation
17	Chen	2008	Taiwan	Customer focused objective based performance evaluation of logistics service providers
18	Wang	2010	Taiwan	The application of 3PL to implement the Just-In-Time system with minimum cost
19	Lieb and Lieb	2010	USA	Environmental sustainability in the 3PL industry
20	Başligil *et al.*	2011	Turkey	An optimization of distribution network for 3PL service providers
21	Chen and Cai	2011	China	Joint logistics and financial services by a 3PL firm
22	Kayakutlu and Buyukozkan	2011	Europe	Assessing performance factors for a 3PL in a value chain
23	Rajesh *et al.*	2012	India	Balanced scorecard framework for a 3PL service provider
24	Ülkü and Bookbinder	2012	USA	Optimal quoting of delivery time by a 3PL provider
25	Yeung *et al.*	2012	China	The impact of 3PL providers' capabilities on exporters' performance
26	Shah and Sharma	2012	India	3PLSP scale for co-operative dairies
27	Ahn *et al.*	2013	Korea and Japan	A comparative study of Korean and Japanese logistics industries market structures
28	Diabat *et al.*	2013	India	Interactions among barriers in third-party logistics implementation
29	Kaynak and Avci	2014	Turkey	Logistics service accountabilities and their effects on service buyer's trust
30	Zhang *et al.*	2015	Canada	A dynamic pricing strategy for a 3PL provider with different customers

Table I.
Summary of papers published in the area of 3PLSPs

solution (VIKOR), quality function deployment (QFD), analytic hierarchy process (AHP), analytic network process (ANP), elimination and choice expressing reality (ELECTRE), decision-making trial and evaluation laboratory (DEMATEL), and utility theory.

Artificial intelligence is used to integrate human expertise and qualitative criteria in the process of selection. The case-based reasoning/rule-based reasoning (CBR/RBR), inference method, artificial neural networks, data mining, and Delphi method are the methods used in the 3PLSP selection. In the literature integrated methodologies/approaches were also used in the different stages of 3PLSP selection process such as the identification of critical evaluation criteria, the elimination of unsuitable 3PL, and the final choice of the best 3PLSP.

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Most of the studies conducted on 3PLSPs are empirical and concentrate majorly on benefits and risks of outsourcing decision. Several researchers have carried out the investigation on the choice of a suitable 3PLSP in the logistics process using MCDM methods, mathematical programming models, and intelligent algorithm techniques.

Anderson *et al.* (2011) conducted an exploratory study of 309 Asia Pacific industries such as, Australia, New Zealand, China, India, Japan, South Korea, and Singapore in selecting their 3PLs and forecast the 3PLs performance, by the following seven criteria: customer interaction, reliable performance, supply chain innovation, price, customer service recovery, supply chain capacity, and professionalism, by using a multinomial logit statistical tool. Korpela and Tuominen (1996) used AHP to select the top 3PLSP in the processing industry. An intelligent technique such as CBR in the fuzzy environment was proposed by Yan *et al.* (2003). Lai (2004) applied a cluster analysis of 221 logistics providers in Hong Kong.

Thakkar *et al.* (2005) applied a hybrid methodology of ISM and ANP for an appropriate selection of 3PLSPs. Min and Joo (2006) have measured and benchmarked the operational performance of 3PLSP using DEA. So *et al.* (2006) applied the AHP procedure, to evaluate the service quality of four 3PLs in Korea. In another research, a fuzzy TOPSIS method was developed for the ranking and preference of the 3PLSP, with the central focus on financial stability as an essential requirement for supply chain partners (Bottani and Rizzi, 2006). Kumar *et al.* (2006) formulated a multi-objective problem (MOP) model for 3PL allocation problem in India. The objectives were to minimize the cost of service, late deliveries, and markets not being served by 3PL.

Jharkharia and Shankar (2007) developed and applied an ANP based model for the selection of an appropriate 3PL provider. Göl and Çatay (2007) used AHP procedure to help in the decision-making process for selecting the suitable global 3PLSP in a Turkish automotive firm. Işıklar *et al.* (2007) proposed an intelligent decision support framework which integrated CBR/RBR and MOP techniques in a fuzzy environment for effective 3PL evaluation and selection. Yan *et al.* (2003) proposed CBR/RBR model for 3PL selection. Almeida (2007) proposed a multi-criteria decision making model for 3PL selection in Brazil based on a utility functions and ELECTRE method. Tsai *et al.* (2007) proposed a binary logit model for investigating the 3PL behavior of high-tech industry. The design allowed to select twenty-four 3PLs, to be organized into two groups: express and forwarder. The confirmatory factor analysis was used to examine the interrelationships among generic variables. Zhou *et al.* (2008) also applied DEA to measure the competitiveness and operational efficiency of ten leading 3PL providers in China. Four input criteria were considered, namely operating expenses, net fixed assets, current liabilities, and salaries and wages, while operating income was the only output of the model.

Büyüközkan *et al.* (2008) proposed a hybrid model of fuzzy AHP-TOPSIS to select the most appropriate strategic support associate in the logistics supply chain. Hamdan and Rogers (2008) applied a DEA-based approach to evaluate the efficiency of a group of nineteen 3PL warehouses logistics operators in the USA. Liu and Wang (2009) used an integrated fuzzy method: the Delphi method to recognize appropriate evaluation criteria, a judgment method to exclude inappropriate 3PL, and a Linear Programming (LP) model for the ultimate selection of 3PLSPs. In Belgium, Schittekat and Sörensen (2009) proposed an MOP model using a Tabu search algorithm for the allocation, routing problem to select 3PL and their equivalent transport platforms with the objective of minimizing total cost of the carriage network. Liou and Chuang (2010) used an integrated multi-criteria approach for 3PLSP for airline services of Taiwan, with a mixture of three models: DEMATEL to form the interrelationship between criteria, ANP to decide the criteria weights, and VIKOR to order (rank) the 3PLSP. Recently, Li *et al.* (2012) proposed an integrated fuzzy sets approach and LPP model to evaluate 3PLs performance for an air conditioner manufacturer in China. The four criteria were used, namely: management success, business strength, service quality, and business growth criteria.

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Falsini *et al.* (2012) proposed a method that combined AHP, DEA, and LP to back the multi-criteria evaluation and selection of 3PLSP. The validation of the model was concentrated in three sectors in Italy, specifically: industry and defense, consumer goods and perishable products. Ho *et al.* (2012) formed a united QFD and fuzzy-AHP for selection of 3PLSP. The model was utilized in the case of a supplier of Chinese hard disk parts. Perçin and Min (2013) developed a decision-aid tool linking QFD, fuzzy-linear regression and MOP for Turkish automobile part manufacturers to pick the suitable 3PLSP. Hsu *et al.* (2013) proposed an integrated approach: DEMATEL and ANP by considering the same criteria used by Liou and Chuang (2010) applied to the Taiwanese airline. Lehmusvaara *et al.* (1999) used an integrated approach to evaluate the performance of truck carriers by combining AHP and mixed integer linear programming (MIP) approach.

Many authors have pointed out regarding the utility of intuitive decision-making. An interview-based study of experienced professionals in the US context, reported by Burke and Miller (1999), brings out the service of intuitive decision stating the types of workplace situations in which intuition is used. Patton (2003) marked the function of intuition in decision-making in unusual situations in which decision leaders have to take action without all information. A holistic perception of decision-making fusing its complexity and messiness is proposed by Hampson (1995) in the structure of a model. This model involves interpretive systems of more and less leading members, objects and maneuvering, structures and systems, power relationships, and the external atmosphere. Creighton (2001) has brought out the limitations of the rational choice theory of decision-making in the context, including dynamic and rapid change, open systems, and significant uncertainties and discontinuities. It was further added, in such critical decision-making conditions, interpretive models of decision-making are attained to be more useful. However, even though the interpretive models direct the issues of understanding and meaning, they still slip to mark the knowledge creation process satisfactorily.

Kannan *et al.* (2009) developed a model for selection of reverse logistics (RL) service provider for the battery manufacturing industries in India using ISM and fuzzy TOPSIS approach and it was found that a parameter namely technical/engineering capability of the service provider is the most important. Govindan *et al.* (2012) prepared a hierarchical structural model of selection criteria using ISM tool for the choice of 3PLSP for a tire industry and found that criteria namely information technology applications, organizational performance, and RL functions were the most significant. Prakash *et al.* (2015) identified and ranked the obstacles in the implementation of RL using fuzzy AHP methodology for an Indian electronics industry. It was found that out of twenty-eight barriers three barriers namely lack of coordination with 3PL providers, customer perception about RL, and lack of a system to monitor returns were the most significant, which organizational managers should overcome. The sensitivity analysis was also conducted to monitor changes in the ranking of the hindrances by changing weights of criteria and a parameter namely the lack of coordination/collaboration was found to score the highest rank in five experiments. AHP is the most widely used MCDM approach for the green supplier selection (Govindan *et al.*, 2015). Prakash and Barua (2016a) used fuzzy AHP for evaluation and ranking of criteria for the selection of a third party reverse logistics service provider (3PRLSP) for Indian electronics industries. After investigation a parameter namely "reverse logistics operations" was found to be the most significant among the seven criteria. Further, VIKOR was employed for the final selection of the service provider and among the seven reverse logistics partners (RLP), sixth logistics partner (RLP6) was selected. To verify the robustness of the proposed methodology sensitivity analysis was also performed and RLP6 was found to have the maximum priority at all the conditions. Prakash and Barua (2016b) used fuzzy AHP for evaluation and ranking of selection parameters for the selection of RLP for the Indian electronics industries. After analysis, a factor namely capacity criteria secured the first rank among the seven major criteria, and the use of fuzzy TOPSIS approach revealed that

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RLP6 is the best among seven service providers and the results of sensitivity analysis showed that RLP1 is the potential partner for considered industry.

Senthil *et al.* (2014) used integrated MCDM approach (AHP and fuzzy TOPSIS) for the selection of 3PRLSP. AHP was used to assign the weights to the selection criteria and fuzzy TOPSIS was employed for the final ranking, finally sensitivity analysis was also performed. Garg (2016) used fuzzy AHP for the evaluation of seven criteria, and it was concluded that a parameter namely integration and the network is the most significant, and use fuzzy TOPSIS approach revealed that strategic alliance partner three (SP3) is the best one among the seven identified partners for Indian airline industry. The outcome of sensitivity analysis indicated that SP3 had the highest ranking and should be given full consideration. Ravi (2012) employed AHP and TOPSIS for the selection of 3PRLSP for the computer hardware manufacturing industry.

2.3 Papers published using IRP methodology

This section of the paper discusses about the recent papers published on IRP methodology. Prakash and Barua (2015) used fuzzy AHP and IRP for evaluation, prioritization, and comparison of barriers to RL adoption in the Indian electronics industries. The results of fuzzy AHP and IRP revealed that policy barriers were the most major obstacles for the implementation of RL. Mangla *et al.* (2014) developed a decision model based on fuzzy AHP and IRP for analyzing the risks linked with green supply chain practices implementation for Indian poly plastic manufacturing company, and the results indicated that the operational risk was the most critical among the four risks. Luthra *et al.* (2015) analyzed the CSF for green supply chain management implementation for achieving sustainability in Indian automobile industries and a CSF namely competitiveness was found to be the most significant. Haleem *et al.* (2012) analyzed the CSFs for the world-class manufacturing practices implementation. A ISM methodology was used for establishing interrelationship between the identified CSFs, and IRP was used to rank the CSFs. It was concluded that a CSF namely excellent top management was the most important which had the highest driving power. An IRP approach highlighted that a CSF namely reduction in energy consumption and waste minimization was the most significant.

In the past, a lot of research work has been carried out in the area of 3PLSP selection. Many researchers employed a single MCDM method or integrated approach in developing the model. It may be noted that no work has been reported so far in the area of 3PLSP selection using IRP methodology, which is a relatively new ranking approach and this research work is the pioneering one to address the classification of 3PLSP selection criteria using IRP methodology. Table II shows the summary of major tools/techniques used for 3PLSPs selection

3. Research methodology

The objective of this paper is to develop a new conceptual framework using IRP, a MCDM approach, for understanding the rankings of the selection criteria for the selection of a 3PLSP for Indian cement manufacturing industries. This research is first of its kind, using the IRP methodology for identifying the dominance interrelationship among the identified criteria and to rank them based on their relative importance, influencing the selection of 3PLSP problem. Hence, the findings of this research would guide the logistics managers to re-consider their framework toward the selection criteria and decision-making process. An introduction to IRP methodology and steps involved in the approach are discussed in the following sections of the paper.

3.1 IRP

It uses the conscious selection and intuitive method of decision-making. The IRP takes the strengths of the rational selection process and blends it with the strengths of the intuitive process at the elemental level.

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Sr.No	Approach	Industry/sector	Author(s)	Year	Country
1	AHP	Shipping	Asuquo *et al.*	2014	UK
2	AHP	Frozen food	Peng	2012	China
3	Two-phase AHP and TOPSIS	Automotive	Perçin	2009	Turkey
4	Fuzzy sets theory, MOP, CBR, RBR	Logistics outsourcing	Işıklar	2007	Turkey
5	Fuzzy sets theory	Air conditioner manufacturing	Li *et al.*	2012	China
6	AHP	IT distribution	Cirpin and Kabadayi	2015	Turkey
7	ISM	FMCG, automobile and heavy industries	Qureshi *et al.*	2008	India
8	Integrated Fuzzy	Electronics	Liu and Wang	2009	Taiwan
9	Fuzzy TOPSIS	Dairy products	Bottani and Rizzi	2006	Italy
10	Fuzzy AHP and Fuzzy TOPSIS	Logistics	Büyüközkan *et al.*	2008	Turkey
11	QFD and fuzzy AHP	Hard disk supplier	Ho *et al.*	2012	China
12	QFD, fuzzy linear regression and MOP	Automotive part manufacturing	Perçin and Min	2013	Turkey
13	AHP	Service quality evaluation of 3PLSP	So *et al.*	2006	Korea
14	AHP	Automotive	Göl and Çatay	2007	Turkey
15	AHP, DEA, and linear programming (LP)	Defense, perishable products and consumer goods.	Falsini *et al.*	2012	Italy
16	ISM and ANP	Food	Thakkar *et al.*	2005	India
17	DEMATEL, ANP and VIKOR	Airline	Liou and Chuang	2010	Taiwan
18	Utility theory and ELECTRE	3PLSP selection	Almeida	2007	Brazil
19	ANP	3PLSP selection	Jharkharia and Shankar	2007	India
20	AHP	Processing industry	Korpela and Tuominen	1996	Finland
21	ISM and fuzzy TOPSIS	Battery manufacturing	Kannan *et al.*	2009	India
22	ISM	Tire manufacturing	Govindan *et al.*	2012	India
23	Fuzzy AHP	Electronics	Prakash *et al.*	2015	India
24	Fuzzy AHP and VIKOR	Electronics	Prakash and Barua	2016a	India
25	Fuzzy AHP and Fuzzy TOPSIS	Electronics	Prakash and Barua	2016b	India
26	AHP and fuzzy TOPSIS	Plastic recycling plant	Senthil *et al.*	2014	India
27	Fuzzy AHP and IRP	Electronics	Prakash and Barua	2015	India
28	Fuzzy AHP and Fuzzy TOPSIS	Airline	Garg	2016	India
29	Fuzzy AHP and IRP	Poly plastic manufacturing	Mangla *et al.*	2014	India
30	AHP and TOPSIS	Computer hardware	Ravi	2012	India

Table II.
Summary of major tools/techniques used for 3PLSPs selection

It is constructed on strengths of the paired comparison approach, to lessen the cognitive overload (Warfield, 1974; Saaty, 1977). It overcomes the detriments of the paired comparison process such as AHP (Saaty, 1977). In AHP, an expert gives the judgment about the significance of one element over the other with its intensity, but the interpretation of the same may be biased, affecting the final results of the model and in comparison with ISM methodology, IRP is a novel tool ranking method which ranks the parameters concerning their performance outcomes, whereas ISM approach takes only the parameters into consideration. IRP demands more information/data and delivers realistic, and qualitatively betters results than ISM (Haleem *et al.*, 2012). Most of the MCDM models are based on the weighting of the parameters whose magnitude has a significant role to play in the hierarchy of the design. High technical skill, knowledge, and tremendous expertise is required for

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assigning weights to the parameters. The justification for the assigned weights is sometimes difficult to be validated.

In IRP, an expert gives inputs concerning the interpretive logic for dominance of one factor over the other for each paired comparison. Also, IRP does not require the information about the degree or level of a dominant position, which is arduous to be interpreted and is challenging for the validation. Moreover, IRP checks an internal validity with the help of vector logic of the dominance in the form of a dominance system graph. The strengths of the IRP methodology are listed as follows: it is easy to distinguish the influence of interactions rather than the variables in an abstract sense. The understanding of interactions would aid comparison; it is relatively easy to judge the dominance of one interaction with the other rather than the amount of a dominant position; it is based on the strength of paired comparison as it does not generate any cognitive overload; it is not significantly dependent on the weight of the factor or variable, which is a disputable matter in multi-criteria decision-making process; it can be applied to rank any assemblage of variables regarding the interacting variables; various interest groups can be included for evaluation schemes to counter the prejudice in the evaluation; the comprehensive software resources are not required for the development of a model; the knowledge generated during the ranking process can be saved systematically as a foundation for future decision making.

The shortcomings of the approach are: this technique is based on judgmental and interpretive methods and may be extremely idiosyncratic; it typically considers all the criteria are equal, neglecting their relativistic importance; it is complex to be validated concerning objective validation tests; it is challenging to interpret a matrix of size beyond 10×10 as the number of paired comparisons would exponentially increase, and thus, only modest-sized problems can be efficiently executed with this method (Sushil, 2009).

3.2 The basic steps of IRP

(1) Identification of two sets of variables – one to be ranked, second the parameters on which the ranking has to be carried out, e.g. actors and processes, actions and performance, alternatives and criteria, etc.

(2) Identification of contextual relationship among the two sets of variables.

(3) Development of a cross-interaction matrix between the two sets of variables.

(4) Conversion of the binary matrix into an interpretive matrix by interpreting the relationships.

(5) Translation of the interpretive matrix into an interpretive logic of pair wise comparisons and dominating interactions matrix by explaining the dominance of one relationship over the other.

(6) Develop ranking and interpret the ranks regarding the dominance of the number of interactions.

(7) Validation of ranks obtained.

(8) Displaying ranking diagrammatically in the form of an "Interpretive Ranking Model" (Sushil, 2005).

4. Case study

ABC Limited is India's leading manufacturer of cement and ready-mixed concrete with a countrywide network of factories and sales offices. Established in 1986, ABC is acknowledged as a forerunner and leader in cement and concrete technology. Among the first companies in India to include environmental protection as a corporate commitment,

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ABC regularly wins awards for best practices in environment management at its plants and mines, and for demonstrating good corporate citizenship. The quality of its products and customer services make ABC Ltd. the most preferred brand in the Indian cement industry.

ABC Ltd. has boarded on an initiative to improve the efficiency of its supply chain, which include 1,000 trucks that carry cement from its plants to sales outlets across the country. Logistics forms the most critical and substantial component of the input cost of cement, accounting for nearly 35 percent of the total cement sales. While ABC uses rail transportation substantially being fast and cost efficient, it also relies heavily on road transport to supply cement from its plant to almost all cities and remote towns in India. Due to market competition as well as improve the supply chain efficiency and transportation cost, ABC Ltd. is committed to improving the 3PLSPs practices.

The purpose of this paper is to examine and analyze the CSFs used in refereeing the aids of 3PLSPs at the operational level, to develop a tool for measuring benefits of 3PLSPs for the cement industry. The proposed model establishes the dominance of relationship among identified criteria, which plays a vital role in the 3PLSPs selection process. The relevant selection criteria defined in this study are shown in the Table III. We now apply the IRP methodology to the cement industry sector under study.

The various steps which lead to the formulation of IRP model are discussed below (Sushil, 2009).

4.1 Proposed selection criteria of 3PLSPs

The brief description of the twenty selection criteria for the choice of 3PLSPs, identified through an exhaustive literature review and opinion of experts from academics and the Indian cement manufacturing industries is shown in Table III and the parameters or processes on which the selection has to be made are listed in Table IV.

4.2 Identification of factors or variables

The first step is to recognize two sets of variables, i.e. one set of variables that are to be ranked and the other set of variables on the evidence of which ranking has to be carried out. For example, one set would consist of the alternatives to be ranked and the other set would comprise of the criteria that are to be taken into consideration for ranking the alternatives. Table IV presents parameters or processes for the selection of 3PLSP.

4.3 Contextual relationship

Once the variables are recognized, the next step is to identify the contextual relationship among them.

4.4 Cross-interaction of factors or variables

The relation among the two sets of variables can be expressed in a cross-interaction matrix as presented in Table V. The cross-interaction binary matrix: "1" indicates a connection between the pair of factors or variables and "0" showing no association (Hill and Warfield, 1972). In some cases all the pairs of interactions may exist, that makes the cross-interaction matrix as a unit matrix.

4.5 Interpretation of interactions among the variables

The cross-interaction–binary matrix can be transformed into a cross-interaction –interpretive matrix (Sushil, 2005) by interpreting the interactions. "1," indicates all the possibility of interactions between the pair(s) of variables to be construed concerning the contextual association as shown in Table VI.

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Table III.
Proposed criteria for the selection of 3PLSPs

Criteria	Brief description	Author(s) and Year
Compatibility with the users (A1)	The compatibility with the company's culture, vision and values provide ease of working, flexibility. Also, it improves long-term relationship and productivity of an organization	Bowersox and Daugherty (1990), Boyson *et al.* (1999), Jharkharia and Shankar (2007), Qureshi *et al.* (2008)
Cost of service (A2)	In the present competitive environment, organizations demand more for less by asking for value added services, while cost may not always be the most important selection criteria. It includes the total logistics outsourcing cost, and its related terms include low cost of distribution, price, cost reduction, operational cost, order processing cost, warehouse cost, and saving on cost	Bhatnagar *et al.* (1999), Bottani and Rizzi (2006), Colson and Dorigo (2004), Dapiran *et al.* (1996), Fawcett and Smith (1995), Govindan *et al.* (2012), Jharkharia and Shankar (2007), Maltz (1994), McGinnis *et al.* (1995), Menon *et al.* (1998), Millen *et al.* (1997), Morash *et al.* (1996), Mortensen and Lemoine (2008), Qureshi *et al.* (2008), Spencer *et al.* (1994), Tate (1996)
Quality of service (A3)	It includes ISO standards and confirmation of environment issues, commitment to continuous improvement, quality control, disaster and risk management, etc.	Bhatnagar *et al.* (1999), Bottani and Rizzi (2006), Colson and Dorigo (2004), Fawcett and Smith (1995), Govindan *et al.* (2012), Jharkharia and Shankar (2007), Logan (2000), Maltz (1994), McGinnis *et al.* (1995), Menon *et al.* (1998), Moberg and Speh (2004), Mortensen and Lemoine (2008), Qureshi *et al.* (2008), Sheen and Tai (2006), Spencer *et al.* (1994), Yeung (2006)
Reputation of vendor (A4)	It highlights the quality, level of service, customer satisfaction, and reliability of an organization. A good reputation of 3PLSP boosts the long-term business	Bhatnagar *et al.* (1999), Boyson *et al.* (1999), Göl and Çatay (2007), Jharkharia and Shankar (2007), Knemeyer and Murphy (2004; 2005), Lieb and Randall (1996), Liu and Wang (2009), Murphy and Daley (1997), Perçin and Min (2013), Qureshi *et al.* (2008), Spencer *et al.* (1994)
Performance measurement (A5)	It is the measurement of performance of the vendor based on, on-time delivery, delay in internal approvals, quality processes, selection of distribution network, after sales service, selection of transportation process, resource utilization, etc.	Expert's opinion
Willingness to use logistics manpower (A6)	It shows the capability of the vendor in case of an emergency or overload. The willingness to use logistics manpower improves the on-time delivery of goods or services	Expert's opinion
Flexibility in billing (A7)	It helps in maintaining the long-term relationship with the client. Internal business approvals affect the flexibility in billing	Expert's opinion
Long term relationship (A8)	It refers to developing trust, sharing incentives, rewards, risks. Also, to have a good level of cooperation and rapport among the customer and 3PLSPs. It helps to improve reliability, dependence, alliance, Compatibility, etc.	Bhatnagar *et al.* (1999), Bottani and Rizzi (2006), Boyson *et al.* (1999), Dapiran *et al.* (1996), Knemeyer and Murphy (2004, 2005), Jharkharia and Shankar (2007), Logan (2000), Millen *et al.* (1997), Moberg and Speh (2004), Mortensen and Lemoine (2008), Murphy and Daley (1997), Qureshi *et al.* (2008), Sheen and Tai (2006), Spencer *et al.* (1994), Stank and Maltz (1996), Tate (1996), Thakkar *et al.* (2005)

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Criteria	Brief description	Author(s) and Year
Quality of management (A9)	A high quality of management is represented by timely decisions taken by the managers to maintain the long-term relationship with the clients	Qureshi *et al.* (2008)
Information sharing and mutual trust (A10)	It includes the information sharing capability within the organization, which helps to facilitate the execution of logistics operations with greater efficiency. It includes attributes such as information security, tracking, etc.	Aghazadeh (2003), Bottani and Rizzi (2006), Boyson *et al.* (1999), Chow *et al.* (2005), Colson and Dorigo (2004), Efendigil *et al.* (2008), Göl and Çatay (2007), Govindan *et al.* (2012), Hamdan and Rogers (2008), Hsu *et al.* (2013), Işıklar *et al.* (2007), Jharkharia and Shankar (2007), Knemeyer and Murphy (2004, 2005), Lai *et al.* (2002), Lehmusvaara *et al.* (1999), Liu and Wang (2009), Moberg and Speh (2004), Qureshi *et al.* (2008), Sheen and Tai (2006), Spencer *et al.* (1994), Stank and Maltz (1996), Thakkar *et al.* (2005), Zhou *et al.* (2008)
Operational performance (A11)	It improves potential problem-solving capability, fault diagnosing capability, responsiveness, system security, long-term business relationship, and confidentiality of the sensitive data	Bowersox and Daugherty (1990), Qureshi *et al.* (2008), Spencer *et al.* (1994), Van Hoek (2001)
Information technology capacity (A12)	IT capability of a company gets improved by adopting software's, such as enterprise resource planning (ERP), vehicle routing packages, vehicle loading optimization, electronic data interchange (EDI), etc.	Qureshi *et al.* (2008), Rahman (2004), Vaidyanathan (2005)
Fixed assets (A13)	Fixed assets of a 3PLSP include the availability of appropriate physical machinery or types of equipment, in acceptable size and quality, which helps in delivering duties or services to the satisfaction level of the customers	Hum (2000), Qureshi *et al.* (2008)
Experience on similar product (A14)	It helps in on-time delivery, in getting internal business approvals, in developing quality control of processes, in designing a proper distribution network, in improving after sales service, in improving transportation methods, in the delivery of optimum quantity and in proper utilization of internal resources	Liu and Wang (2009)
Delivery performance (A15)	It depends upon the timely delivery of the services or goods, quality of delivery, and reliability. High delivery performance increases reputation and market share and vice versa	Bottani and Rizzi (2006), Fawcett and Smith (1995), Govindan *et al.* (2012), Jharkharia and Shankar (2007), Liu and Wang (2009), McGinnis *et al.* (1995), Menon *et al.* (1998), Morash *et al.* (1996), Mortensen and Lemoine (2008), Perçin and Min (2013), Qureshi *et al.* (2008), Spencer *et al.* (1994), Stock *et al.* (1998), Yeung (2006)
Employee satisfaction level (A16)	Every employee is an integral component of a company. A satisfied employee improves the performance of the overall supply chain	Expert's opinion

(*continued*)

Table III.

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Table III.

Criteria	Brief description	Author(s) and Year
Financial performance (A17)	A sound financial position signifies the continuation of the quality of services and regular upgrading of the machinery	Bottani and Rizzi (2006), Boyson *et al.* (1999), Bowersox and Daugherty (1990), Bradley (1993), Göl and Çatay (2007), Harrington (1994), Jharkharia and Shankar (2007), Liu and Wang (2009), McGinnis *et al.* (1995), Menon *et al.* (1998), Murphy and Daley (1997), Qureshi *et al.* (2008), Sink and Langley (1997), Thakkar *et al.* (2005), Zhou *et al.* (2008)
Market share (A18)	The current market share of the 3PLSP may influence the selection decision of the client. Internal business approvals may increase the market share	Expert's opinion
Geographical spread and range of services provided (A19)	It includes the market coverage, international potential, shipment destinations, geographical specializations and the range of services provided by the 3PLSP	Bottani and Rizzi (2006), Boyson *et al.* (1999), Colson and Dorigo (2004), Dapiran *et al.* (1996), Degraeve *et al.* (2004), Göl and Çatay (2007), Jharkharia and Shankar (2007), Kumar *et al.* (2006), Liu and Wang (2009), Millen *et al.* (1997), Moberg and Speh (2004), Morash *et al.* (1996), Mortensen and Lemoine (2008), Murphy and Daley (1997), Qureshi *et al.* (2008), Spencer *et al.* (1994), Thakkar *et al.* (2005), Tsai *et al.* (2007)
Flexibility in operation (A20)	It is the capability of an organization to adapt fluctuating customer demands. It includes responsiveness to service requirements, capacity to grow the customers' business, etc.	Bottani and Rizzi (2006), Daugherty *et al.* (1996), Fawcett and Smith (1995), Göl and Çatay (2007), Jharkharia and Shankar (2007), Lehmusvaara *et al.* (1999), McGinnis *et al.* (1995), Menon *et al.* (1998), Moberg and Speh (2004), Morash *et al.* (1996), Spencer *et al.* (1994), Stank and Maltz (1996), Tate (1996), Yeung (2006)

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S.no.	Parameters or processes	Brief description
1	On-time delivery (P1)	It leads to customer satisfaction. The delivery performance of 3PLSP is observed in reliability and speed dimension. Information sharing, geographical spread, & use of IT improves on-time delivery, which in turn improves reputation and market share of the organization
2	Government approvals (P2)	The necessary approvals should be taken from the government from time to time, and the activities or services offered by the 3PLSP should be as per the regulatory norms. The management of the organization is responsible for taking timely approvals from the governing bodies
3	Internal business, approvals, and processes (P3)	The permission taking procedures within the organization should be streamlined; delay in the same may affect the cost and quality of services, reputation, long term relationship, delivery and operational performance, flexibility in billing, customer relationship, information sharing process, IT implementation, and employee satisfaction. The overall efficiency of the organization relies heavily on the internal approvals and processes
4	Quality control process (P4)	The implementation of world class quality programs such as Kaizen and TQM, leads to overall performance enhancement and safety management. The proper control of quality guarantees reliability, reduction of service or commodity cost, satisfaction, and loyalty of the customer. There should be continuous improvement in quality assurance processes
5	Distribution process from distributor to customer (P5)	The selection of proper distribution process from the dealer to the client plays a significant role in improving delivery and operational performance, reduction of distribution costs, order processing cost, warehousing cost, and service cost. A good information sharing network and geographical spread improve delivery processes performance
6	After sales service (P6)	An excellent aftersales is need of the time. It helps to improve customer reputation and market share. Flexibility in offering services, responsiveness boosts long-term customer relationship and reputation. A provision of contacting the service provider in case of emergency will be an added advantage. Information sharing and use of IT infrastructure play a vital role in efficient after sales service
7	Transportation processes(P7)	The transport process is an integral dimension of the distribution process. The selection of a proper shipping process helps in the reduction of distribution cost, improves reputation, delivery and operation performance. The geographical spread simplifies the transportation process
8	Optimal quantity delivery (P8)	The optimization capabilities helps in saving distribution, transportation cost. The proper information sharing, use of IT infrastructure, and experience on the similar product helps in optimal quantity delivery
9	Internal and external resource utilization (P9)	The qualified talent and infrastructure of the organization should be used efficiently to increase the market share, service quality, delivery performance, customer relationship, responsiveness, and reputation. The proper information management and experience on similar products helps in the efficient utilization of resources, which reduces the cost, and increases the overall performance of the organization

Table IV.
Parameters or processes for the selection of 3PLSP

4.6 Pairwise comparison of factors or variables

The interpretive matrix is used as a base to pair and compare the ranking factors or variables w.r.t. the reference variable(s). The interpretive inference of dominating interaction among the choice criteria on several parameters or processes is recorded in the data or knowledge base, as shown in Table AI. In a paired comparison, the ranking variables interactions with respect to the respective reference variable(s) are compared. All the dominating interactions are compiled in the dominating interactions matrix as shown in Table VII.

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	P1	P2	P3	P4	P5	P6	P7	P8	P9
A1	1	1	1	1	0	1	1	1	1
A2	1	0	1	1	1	1	1	1	1
A3	1	0	1	1	1	1	1	1	1
A4	1	0	1	1	0	1	0	1	1
A5	1	0	1	1	1	1	1	1	1
A6	1	0	0	0	0	0	0	0	0
A7	0	0	1	0	0	0	0	0	0
A8	1	0	1	1	1	1	1	1	1
A9	1	1	1	1	1	1	1	1	1
A10	1	0	1	1	1	1	1	1	1
A11	1	0	1	1	1	1	1	0	1
A12	1	0	1	1	1	1	1	1	1
A13	0	0	0	0	0	0	0	0	1
A14	1	0	1	1	1	1	1	1	1
A15	1	0	1	1	1	0	1	0	0
A16	1	0	1	1	0	1	0	0	1
A17	0	0	1	1	0	0	0	0	0
A18	0	0	1	0	0	0	0	0	0
A19	1	0	1	1	1	1	1	0	0
A20	1	0	1	1	1	1	1	1	1

Table V.
Binary matrix

4.7 Matrix of dominance

The number of dominating interactions is composed in the form of a dominance matrix, which gives the number of instances in which one ranking variable dominates or being dominated by other ranking variable. The total of rows of the matrix provides the total number of events in which the particular ranking variable(s) or factor(s) dominates all other factors or variables, and the sum of a column designates the total number of incidents in which a ranking variable is being controlled by all other ranking variables. The difference between number dominating variables in column "D" and a corresponding number of variables being dominated in row "B" supplies the net dominance for a ranking variable. The positive net dominance indicates that the concerned variable has more numbers dominating than being dominated while the net negative dominance would signify that the relevant variable is being dominated by number of cases than dominating other variables. The variable or factor having net positive dominance in maximum number of instances is ranked I, followed by the lower number of dominance relations. The variables or factors with more negative net dominance will be ranked lower since these are being controlled more by other factors or variables. The dominance matrix is shown in Table VIII.

4.8 Validation

For the purpose of confidence building the ranks of the variables obtained from the dominance matrix are validated.

4.9 Interpretive ranking model

The ranks obtained are portrayed in the form of an "Interpretive Ranking Model" as shown in Figure 1.

4.10 Recommendation for action

Based on the levels obtained from the IRP Model, the choice of the selected alternative(s) should be made. The interpretation of this decision will generate the suggestions for action.

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	P1	P2	P3	P4	P5	P6	P7	P8	P9
A1	Compatibility improves on-time delivery	Government approvals may affect compatibility with users	Internal business approvals may improve compatibility	Quality controlling of processes improves compatibility with users		Compatibility improves after sales services	Compatibility with users improves transportation process	Compatibility with users improves optimum quantity delivery	Compatibility increases resource utilization
A2	Cost of service depends upon on-time delivery		Internal business approvals affect the cost of service	A good quality process reduces the service cost	A good distribution network reduces service cost	Cost of service depends upon the ability to offer good after sales service	Selection of proper transportation reduces service cost	Delivery of optimum quantity reduces cost	Efficient resource utilization reduces cost
A3	On-time delivery improves quality of service		Delay in Internal approvals may delay quality of service		Proper distribution network improves quality of service	Ability to offer after sales service improves quality of service	Selection of proper transportation process improves quality of service	Delivery of optimum quantity improves quality of service	Efficient resource utilization improves quality of service
A4	On-time delivery improves reputation		Reputation depends on the internal business approvals	Quality processes improve reputation of vendor		A good after sales service improves reputation of vendor		Delivery of optimum quantity improves reputation	Efficient resource utilization improves reputation
A5	On-time delivery improves performance		Delay in Internal approvals may affect performance	Quality processes improve performance	Proper distribution network improves performance	A good after sales service improves performance	Selection of proper transportation process improves performance	Delivery of optimum quantity improves performance	Efficient resource utilization improves performance
A6	Use of logistics man power improves on- time delivery								

(continued)

Table VI.
Interpretive matrix

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Table VI.

	P1	P2	P3	P4	P5	P6	P7	P8	P9
A7			Internal business approvals affect the flexibility in billing						
A8	Long term relationship depends upon timely delivery		Internal business approvals may affect long term relationship	Quality processes improve long term relationship	Proper distribution network improves long term relationship	A good after sales service improves long term relationship	Selection of proper transportation process improves long term relationship	Delivery of optimum quantity improves long term relationship	Efficient resource utilization improves long term relationship
A9	Quality of management yields to timely delivery	Management takes government approvals for improving the performance	Internal business approvals may affect quality of management	Quality of management controls quality of the processes	Proper distribution network depends on good quality of management	A good after sales service depends on good quality of management	A good quality of management selects proper transportation process	A good quality of management helps in delivery of optimum quantity	A good quality of management helps in proper utilization of resources
A10	Information sharing and mutual trust helps in on-time delivery		Internal business approvals may affect information sharing and trust	Information sharing and mutual trust improves the quality of processes	Information sharing and mutual trust improves the distribution network	After sales services gets improved by Information sharing and mutual trust	Transportation will get improved by information sharing and trust	optimum quantity will be delivered by information sharing	Information sharing and mutual trust helps in efficient resource utilization
A11	On-time delivery improves operational performance		Internal business approvals may affect operational performance	Quality processes improve operational performance	Proper distribution network improves operational performance	Proper after sales services improves operational performance	Proper transportation improves operational performance		Proper utilization of resources improves operational performance

(continued)

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	P1	P2	P3	P4	P5	P6	P7	P8	P9
A12	Information technology helps in on-time delivery		Internal business approvals may affect IT implementation	IT improves quality control of processes	IT helps in designing a proper distribution network	IT helps in giving good after sales service	IT eases the transportation processes	IT helps in the delivery of optimum quantity	IT helps in the proper utilization of resources
A13									Fixed assets along with efficient utilization of resources will improve reputation
A14	Experience in similar product helps in on-time delivery		Experience in similar product helps in getting internal business approvals	Experience in similar product helps in improving quality control of processes	Experience helps in designing a proper distribution network	Experience in similar product helps in improving after sales service	Experience in similar product helps in improving transportation processes	Experience in similar product helps in the delivery of optimum quantity	Experience in similar product helps in proper utilization of resources
A15	On-time delivery improves delivery performance		Internal business approvals may improve delivery performance	Quality control of processes may improves delivery performance	Designing a proper distribution network improves delivery performance		Proper transportation improves delivery performance		
A16	Satisfied employee will deliver on-time		Internal business approvals may affect employee satisfaction	Satisfied employee will control the quality		Satisfied employee will give good after sales service			Employee satisfaction helps in proper utilization of resources
A17			Internal business approvals may affect financial performance	Good financial performance improves the quality control of processes					

(*continued*)

Table VI.

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	P1	P2	P3	P4	P5	P6	P7	P8	P9
A18			Internal business approvals may increase the market share						
A19	Geographical spread improves on-time delivery		Internal business approvals may affect geographical spreading	Geographical spread depends on the quality control of the processes	Geographical spreading may simplify the distribution network	Geographical spreading improves after sales service	Geographical spreading may simplify the transportation processes		
A20	Flexibility improves on-time delivery		Internal business approvals may affect flexibility in operation	Flexibility in operation along with quality control processes improves performance and reputation	Flexibility in operation along with distribution processes improves performance and reputation	Flexibility in operation improves after sales service	Flexibility in operation along with transportation processes improves performance and reputation	Flexibility in operation increases the possibility of optimum quantity delivery	Flexibility in operation will utilize resources efficiently and improve the reputation and performance

Table VI.

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Table VII. Dominations interactions matrix

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
A1			P3, P4, P9	P1, P4, P6	P1, P4, P6	P2, P6, P8, P9	P3	P1, P6, P8	P3, P4, P6	
A2	P1, P6, P8		P4, P6, P9	P1, P6, P8	P6, P8, P9	P3, P9	P3	P1, P4, P6, P8, P9	P3, P6, P8, P9	P3
A3	P1, P6, P8	P3		P1, P6, P8	P1, P6, P8	P3, P9	P3	P1, P6, P8	P3.P6, P8	P3
A4						P3	P3	P1, P6, P8	P3, P9	
A5		P3, P5, P7				P9	P3	P1, P6, P8	P1, P3, P4, P6, P8, P9	P3
A6							P1			
A7										
A8						P6, P8	P1, P4, P6, P8			
A9		P1, P4	P4, P5, P9	P1, P4, P5, P6, P7, P8		P1, P3, P5, P6, P7, P8, P9	P1, P3, P4, P5, P6, P7, P8, P9			P1, P3, P4, P5, P6, P8, P9
A10						P1, P4, P5, P6, P7, P8, P9	P1, P4, P5, P6, P7, P8, P9			
A11						P1, P3, P4, P5, P6, P7	P1, P3, P4, P5, P6, P7, P9			
A12	P3	P3, P5, P6, P7, P8, P9	P3, P4, P9	P1, P4, P5, P6, P7, P8, P9		P1, P4, P5, P6, P7, P8, P9	P1, P4, P5, P6, P7, P8, P9	P1, P3, P4, P5, P6, P7, P8, P9		
A13										
A14		P3, P4, P5, P6, P7, P8, P9	P1, P4, P5, P6, P7, P8			P1, P4, P5, P6, P7, P8	P1, P4, P5, P6, P7, P8, P9	P1, P4, P5, P6, P7, P8		
A15						P1, P3, P5, P7	P1, P3, P4, P5, P7			
A16		P1, P9	P1, P4, P6, P9	P1, P4, P6		P3	P3	P1, P4, P6		
A17			P4	P4		P3	P3			
A18						P3	P3			
A19				P1, P4, P5, P6, P7		P3	P3			
A20			P4, P6, P9	P1, P3, P4, P5, P6, P7, P8, P9				P1, P3, P4, P5, P6, P7, P8, P9		

	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20
A1	P3, P4, P6, P8	P9	P9		P1, P2, P3, P7, P8, P9	P3, P9	P9		P7	P3, P9
A2	P1, P6, P8				P1, P8	P3	P9			P3, P5, P7

(*continued*)

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Table VII.

A3	P1, P6, P8, P9			P1, P5, P7, P8	P3, P9	P9			P3
A4					P3, P9	P9			
A5	P1, P8	P8, P9		P1, P8	P3, P9, P10				P3
A6									
A7			P3, P8						
A8			P1, P3, P4, P5, P6, P7, P8				P4, P6, P7		
A9	P1, P2, P3, P4, P5, P6, P7, P8, P9	P1, P4, P5, P6, P7, P8, P9	P1, P2, P3, P4, P5, P6, P7, P8, P9	P1, P3, P5, P7	P3	P3, P4, P5, P6, P7, P9	P1, P3, P4, P6	P1, P2, P3, P6, P9	P1, P3, P6, P8, P9
A10	P1, P4, P5, P6, P7, P8		P1, P4, P5, P6, P7, P8, P9	P1, P5, P7	P3	P3, P5, P6, P7, P9	P1, P3, P6	P3	
A11			P1, P4, P5, P6, P7, P9				P1, P3, P4, P5, P6, P7		
A12	P1, P3, P4, P5, P6, P7, P8		P1, P3, P4, P5, P6, P7, P8	P1, P3, P5, P7, P8	P3	P3, P5, P6, P7, P8, P9	P3	P3	P3
A13									
A14	P1, P4, P5, P6, P7, P8		P1, P4, P5, P6, P7, P8, P9	P1, P5, P7, P8	P3	P1, P3, P4, P5, P6, P7, P8, P9	P1, P3, P6	P1, P3, P4, P6, P9	P3
A15			P1, P4, P5, P7				P1, P3, P5, P7		
A16	P1, P4, P6, P9		P3	P1		P1, P6, P9			P1, P3, P6, P9
A17			P3						
A18			P3						
A19			P3				P1, P4, P5, P6, P7		
A20	P1, P3, P4, P5, P6, P7, P8, P9		P3	P1, P3, P5, P7, P8, P9		P3, P9	P1, P3, P4, P5, P6, P7, P8, P9	P1, P3, P4, P5, P6, P7	

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	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	D	D-B	Rank
A1			3	3	3	4	1	3	3		4	1	1		6	2	1		1	2	38	31	V
A2	3		3	3	3	2	11	5	4	1	3				2	1	1			3	45	24	VII
A3	3	1		3	3	2	1	3	3	1	4				4	2	1			1	32	6	X
A4						1	1	3	2							2	1				10	–27	XIV
A5		3				1	1	3	6	1	2	2			2	3				1	25	16	VIII
A6							1														1	–52	XVIII
A7													2								2	–63	XX
A8						2	4						7					3			16	–26	XIII
A9		2	3	6		7	8			7	9	7	9		4	1	6	4	5	5	83	65	II
A10						7	7				6		7		3	1	5	3	1		40	30	VI
A11						6	7						6					6			25	–28	XV
A12	1	6	3	7		7	7	8			7		7		5	1	6	1	1	1	68	58	III
A13				1																	1	–54	XIX
A14		7	6			6	7	6			6		7		4	1	8	3	5	1	67	67	I
A15						4	5						4					4			17	–20	XII
A16		2	4	3		1	1	3			4		1		1		3			4	27	13	IX
A17			1	1		1	1						1								5	–29	XVI
A18						1	1						1								3	–34	XVII
A19				5		1	1						1					5			13	–6	XI
A20			3	8				8			8		1		6		2	8	6		50	32	IV
B	7	21	26	40	9	53	65	42	18	10	53	10	55		37	14	34	37	19	18	568		

Table VIII.
The dominance matrix

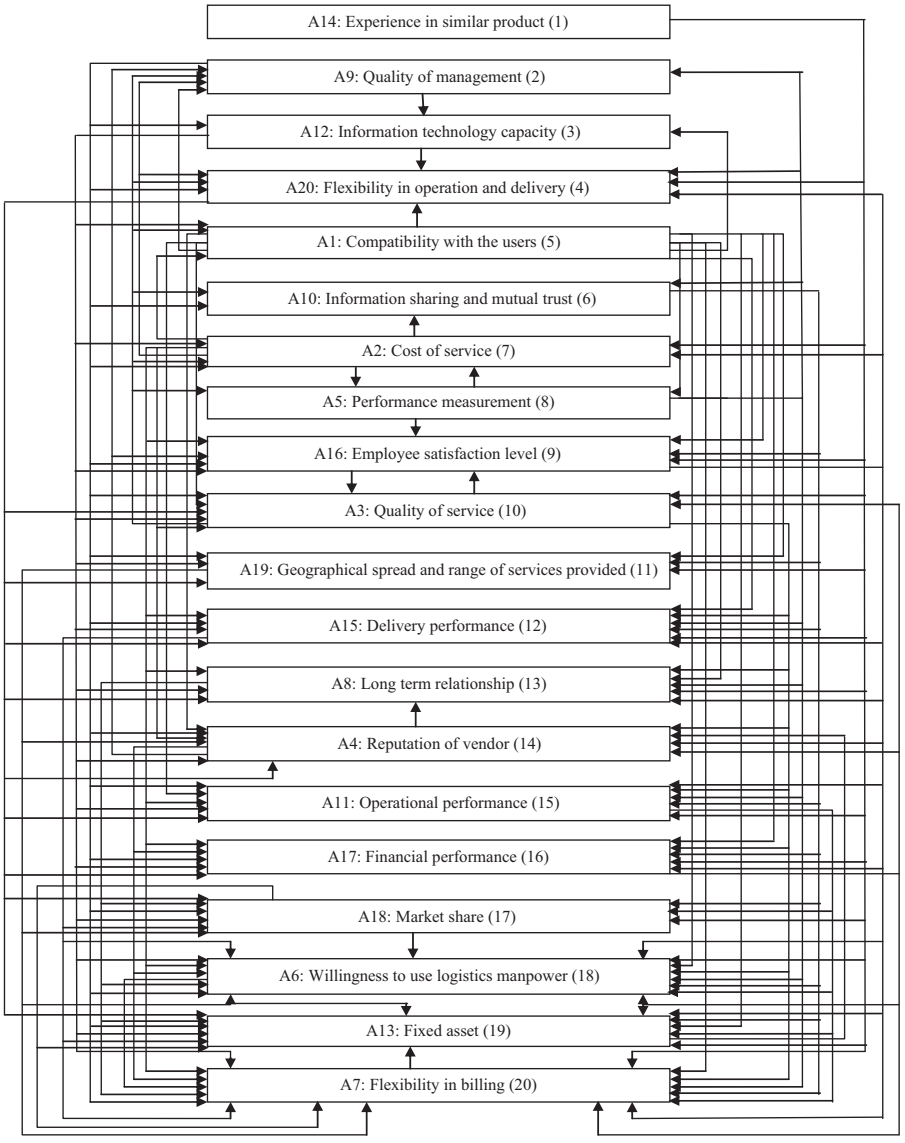

Figure 1.
Interpretive ranking model of factors w.r.t. processes

5. Results and discussions

The IRP model of twenty criteria shown in the Figure 1 indicating their ranks was developed by taking ranking values from the dominance matrix (Table VIII). The most important (top five) and least significant (bottom five) variables are discussed here as under- a factor namely experience in the similar product (A14) is found to have the highest rank in the hierarchy, it dominated 13 criteria (A2, A3, A6, A7, A8, A11, A13, A15, A16, A17, A18, A19, and A20) and got dominated by none. The net dominance value is 67, and this is the maximum value. The quality of management (A9) secured the second position in the hierarchy. It dominated 15 criteria (A2, A3, A4, A6, A7, A10, A11, A12, A13, A15, A16, A17,

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A18, A19, A20) with a D-value of 83 and got dominated by five criteria (A1, A2, A3, A4, A5) with a B-value of 18. The net dominance value is (D-B) 65. A factor namely information technology capacity (A12) is at the third position as it dominated 15 criteria (A1, A2, A3, A4, A6, A7, A8, A11, A13, A15, A16, A17, A18, A19, A20) with a D- value of 68 and got dominated by three factors (A1, A5, A9) with a B-value of 10 and with a net dominance value of 58. A factor namely flexibility in operation and delivery (A20) is placed at fourth position as it dominated nine criteria (A3, A4, A8, A11, A13, A15, A17, A18, and A19) with a D- value of 50 and got dominated by eight criteria (A1, A2, A3, A5, A9, A12, A14, A16) with a B- value of 18 and with a net dominance value of 32. It may be noted that there is a big difference in the magnitude of dominance value among the factor at rank 3 and rank 4. A factor namely compatibility with the users (A1) is at the fifth position with D- a value of 38 and B- a value of 7. It dominated 15 factors (A3, A4, A5, A6, A7, A8, A9, A11, A12, A13, A15, A16, A17, A19, and A20), it got dominated by three factors (A2, A3, and A12) with a net dominance value of 31. These five factors are critical and should be considered for the 3PLSP selection.

Among low ranking factors, the financial performance (A17) is placed at the 16th position, and its net dominance value is negative with a magnitude of 29. It dominated five factors (A3, A4, A6, A7, and A13) with a D- value of 5 and got dominated by ten criteria (A1, A2, A3, A4, A9, A10, A12, A14, A16, and A20) with a B-value of 34. As the factor A17 got dominated by more factors and it dominated fewer factors, the dominance is negative. A factor at sixteenth position is market share (A18) that dominated only three elements (A6, A7, and A13) with a D- value of 3 and got dominated by nine criteria (A8, A9, A10, A11, A12, A14, A15, A19, A20) with a B-value of 37. It has pure dominance of −34. A factor namely willingness to use logistics manpower is at the 18th position with net dominance value −52. It dominated only one factor (A7) with a D-value 1 and got dominated by 16 factors (A1, A2, A3, A4, A5, A8, A9, A10, A11, A12, A14, A15, A16, A17, A18, A19) with a B-value of 53. A factor, namely fixed asset (A19) is at the 19th level in the hierarchy of ranks with a clear dominance of −54. It got dominated by 14 factors (A1, A7, A8, A9, A10, A11, A12, A13, A14, A15, A16, A17, A18, A19, and A20) with a B-value of 55 and dominated one factor (A4) with very less D-value of magnitude 1. It has the net dominance of −54. The least important factor in the selection of 3PLSP is flexibility in billing (A7). It dominated only one factor (A13) with a D- value of 2 and got dominated by 17 factors (A1, A2, A3, A4, A5, A6, A8, A9, A10, A11, A12, A14, A15, A16, A17, A18, A19) with a maximum B- value of 65. The above-discussed low ranking variables or factors should be given very less weight for the selection of 3PLSP in the cement industries.

6. Conclusion

In the present research work, an IRP model is developed considering the 20 important criteria obtained through an exhaustive literature review and expert's opinion. A cross-interaction matrix, which comprises of the binary matrix and interpretive matrix are developed. Then, the interpretive logic knowledge base is prepared to follow by dominating interaction matrix. After this, a dominance matrix is formed which gives the final rankings of the all the criteria. Interpretive Ranking Model is formulated based on the dominance matrix. The structure of the model is shown in Figure 1. From the formulated IRP model it may be noted that, the top ten criteria in the descending order of rankings are experienced in similar products, quality of management, information technology capacity, flexibility in operation and delivery, compatibility with the users, information sharing and mutual trust, cost of service, performance measurement, employee satisfaction level, quality of service. The intermediate ranking positions from the 11th position to 15th position in the descending order of rankings are geographically spread and range of services provided, delivery performance, long-term relationship, the reputation of vendor, operational performance.

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The last five criteria having low rankings in the descending order are financial performance, market share, a willingness to use logistics manpower, fixed asset, and flexibility in billing.

Peng (2012) concluded that transportation cost, the storage technology, and operation speed are relevant criteria from the selection perspective and Işıklar found that information technology, performance, cost, and quality are important. Kannan *et al.* (2009) stated that willingness and attitude is the significant selection criterion, which is similar to the compatibility with the user parameter of this research work. Garg (2016) found that IT systems rank is fourth among seven factors, which makes it an important factor. Also, Govindan *et al.* (2012) and Prakash and Barua (2016b) concluded that information technology and applications is one of the most significant parameter for the selection of 3PLSP. Qureshi *et al.* (2008) found that two selection criteria namely management quality and IT capability were the most important criteria driving all other factors. So *et al.* (2006) concluded that responsiveness (willingness to help and ability to offer prompt services to the clients) of the service provider plays a very vital role in the selection process, this parameter is very much relevant to the factor of this research work namely flexibility in operation and delivery, which holds fourth rank in the hierarchical IRP model. Liu and Wang (2009) found that logistics information system, customer service, ability to handle particular business needs, responsiveness were among the top five selection parameters for the 3PLSP. Cirpin and Kabadayi (2015) highlighted that a factor namely flexibility is the most important in deciding the 3PLSPs selection which is one of the top five ranked criteria of the present work. All these results of other researchers are very much in parallel with the findings of the present research.

Liu and Wang (2009) found that experience in the similar industry, service quality, price, and reputation are not relevant criteria as compared to criteria, namely, logistics information system, customer service, on-time shipments and deliveries, capability to handle specific business requirements, responsiveness of the 3PLSP and Asuquo *et al.* (2014) stated that reputation is the most important factor for the selection of 3PLSP. These results are contradicting to some extent with the results obtained in the present work. The difference in the results obtained is because the approach or technique used for evaluating the selection criteria is different and opinions of the experts in the case companies differ as each outsourcing organization has its unique requirements and evaluation parameters for the selection of 3PLSP. Due to this, the weights of the criteria vary significantly from organization to organization and the relevant results are valid only for the case company and cannot be made generic for other agencies.

In current years, the intricacy of 3PLSPs selection has attracted many researchers and practitioners to investigate the relevant criteria for the selection of 3PLSP, and to choose the best one by using an MCDM approach. The proposed study modeled the selection criteria of the 3PLSPs problem for an Indian cement manufacturing industry using MCDM framework, by applying IRP methodology, which helps in providing a vital perspective concerning the ranking of the criteria to form a guideline for the researchers and practitioners.

7. Future scope and limitations of the study

The present research work is carried out for the selection of 3PLSP taking Indian cement manufacturing industries only into consideration, in future the same case studies may be extended to a variety of industries for the choice of 3PLSPs effectively. An integrated IRP methodology, i.e. along with the IRP approach: total interpretive structural modeling; ANP; SEM; ISM; technique for order of preference by similarity to ideal solution (TOPSIS); utility theory; concept advanced ISM (CAISM); AHP; decision-making trial and evaluation laboratory (DEMATEL); FST; QFD; elimination and choice expressing reality (ELECTRE); multi-criteria optimization and compromise solution (VIKOR), etc. may be used which gives better results as compared to IRP methodology alone. In this study only 20 important

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criteria are considered, there may be other criteria which are not included in this model, but may affect 3PLSPs selection. Further, considering more criteria will give better results, but, the model becomes complicated and time-consuming.

The present study has a few limitations, the contextual relationships between the criteria of the model is established by considering the judgments of the expert panel from the cement manufacturing industries, which may be biased, affecting the accuracy of the final results. Multiple evaluators should be preferred rather than a single reviewer to avoid the bias and to reduce the partiality in the decision-making process. The model developed may differ from company to company, hence, analyzing the accuracy and comparison is a tough task as there is no general context among the industries.

In the future, the authors would like to develop an IRP model for decision making under fuzzy environment and validate this model using a SEM methodology also commonly known as linear structural relationship approach.

8. Managerial implications

In the past, due to the increased competition caused by globalization and rapid technological advances, many practitioners and researchers have focused on the benefits of outsourcing i.e. having 3PLSPs, which helps to improve the competitive advantage and the organizations can concentrate on the core competency. These days, most of the organizations firmly believe that, working in association with a good 3PLSPs increase the reputation of the organization and improves the long-term relationship. This, in turn, increases the service level, quality, flexibility, delivery and operational performance of the 3PLSP, ultimately, reducing the prices of the commodities or services, resulting in customer satisfaction and increased market share for the organization. Hence, the selection of a good or responsive 3PLSP creates a very positive impact on economy of the organization by increasing revenue, profit, and makes companies commercially competent, which improves the overall efficiency of the supply chain and is a need of time for every organization to progress and survive in a competitive environment. Therefore, 3PLSPs selection problem is one of the most significant issues of a supply chain management. The selected 3PLSPs should satisfy the needs of the company, and choice of the same is not a simple task for the logistics managers. Relevant director's dedication and involvement from the same company helps to utilize their experience and expertise in a critical selection process. Mathematical models assist in providing valuable information that the managers use in the decision-making process.

This research work presented a review of the issues which affect the selection of 3PLSPs and proposed a decision-making model. It directs the 3PLSPs selection problem toward a scientific and rational decision-making process, which can benefit other organizations apart from the cement manufacturing industries, by making minor modifications to the model. This model helps the logistics managers to understand the direct, indirect and dominance relationship among the identified criteria and guides them in finding their influence on the 3PLSPs selection process. The IRP model developed in the present work provides insight into the LM of manufacturing industries about the criteria to be taken into consideration in the selection of 3PLSPs.

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Appendix

Paired comparison	Interacting with process	Interpretive logic
A1 dominating A3	P3	Internal approvals and compatibility with users directly affect the quality of service
	P4	Compatibility with users and quality control processes directly affect the quality of service
	P9	Proper study of compatibility with users and proper resource utilization can highly improve quality of service
A1 dominating A4	P1	Compatibility with users and on time delivery directly affect the reputation of vendor
	P4	Compatibility with users and quality control processes affect the reputation of vendor
	P6	Compatibility with users and after sales service directly affect the reputation of vendor
A1 dominating A5	P1	Compatibility with users and on time delivery directly affect the performance measurement
	P4	Compatibility with users and quality control processes affect the performance measurement
	P6	Compatibility with users and after sales service directly affect the performance measurement
A1 dominating A6	P2	Compatibility with users and government approvals directly affect the willingness to use logistic manpower
	P6	Compatibility with users and after sales service directly affect the willingness to use logistic manpower
	P8	Compatibility with users and optimum quantity delivery directly affect the willingness to use logistic manpower
	P9	Compatibility with users and resource utilization directly affect the willingness to use logistic manpower
A1 dominating A7	P3	Compatibility with users and internal business approvals and processes directly affect flexibility in billing
A1 dominating A8	P1	Long term relationship is directly dependent on compatibility with users and on time delivery
	P6	Compatibility with users and after sales and service directly affect the long term relationship
	P8	Compatibility with users and optimum quantity delivery directly affect the long term relationship
A1 dominating A9	P3	Compatibility with users and internal business approvals and processes are directly related to quality of management
	P4	Compatibility with users and quality control processes are directly related to quality of management
	P6	Compatibility with users and after sales and services are directly related to quality of management
A1 dominating A11	P3	Compatibility with users and internal business approvals and processes are directly related to operational performance
	P4	Compatibility with users and quality control processes are directly related to operational performance
	P6	Compatibility with users and after sales service are directly related to operational performance
	P8	Compatibility with users and optimum quality delivery are directly related to operational performance
A1 dominating A12	P9	Compatibility with users and resource utilization are directly related to operational performance
A1 dominating A13	P9	Compatibility with users and resource utilization directly affect fixed asset
A1 dominating A15	P1	Compatibility with users and on time delivery directly affect the delivery performance
	P2	Compatibility with users and government approvals directly affect the delivery performance
	P3	Compatibility with users and internal business approvals and processes directly affect the delivery performance
	P7	Compatibility with users and transportation process directly affect the delivery performance
	P8	Compatibility with users and optimum quantity delivery directly affect the delivery performance
	P9	Compatibility with users and resource utilization affect the delivery performance

(*continued*)

Table AI. Interpretive logic knowledge base ranking of criteria w.r.t. processes

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Table AI.

Paired comparison	Interacting with process	Interpretive logic
A1 dominating A16	P3	Compatibility with users and internal business approvals directly affect the employee satisfaction level
	P9	Compatibility with users and resource utilization affect the employee satisfaction level
A1 dominating A17	P9	Compatibility with users and resource utilization affect the financial performance
A1 dominating A19	P7	Compatibility with users and transportation process directly affect the geographical spread and range of service provider
A1 dominating A20	P3	Compatibility with users and internal business approvals and processes directly affect the flexibility in operation and delivery
	P9	Compatibility with users and resource utilization affect the flexibility in operation and delivery
A2 dominating A1	P1	Costs of service and on time delivery directly affect the compatibility with users
	P6	Cost of service and after sales service directly affect the compatibility with users
	P8	Cost of service and optimum quantity delivery directly affect the compatibility with users
A2 dominating A3	P4	Cost of service and quality control processes directly affect the quality of service
	P6	Cost of service and after sales service directly affect the quality of service
	P9	Cost of service and resource utilization directly affect the quality of service
A2 dominating A4	P1	Cost of service, and on time delivery directly affect reputation of vendor
	P6	Cost of service and after sales service directly affect the reputation of vendor
	P8	Cost of service and optimum quantity delivery directly affect the reputation of vendor
A2 dominating A5	P6	Cost of service and after sales service directly affect the performance measurement
	P8	Cost of service and optimum quantity delivery directly affect the performance measurement
	P9	Cost of service and resource utilization directly affect the performance measurement
A2 dominating A6	P3	Cost of service and internal business approvals and processes directly affect the willingness to use logistic man power
	P9	Cost of service and resource utilization directly affect the willingness to use logistic man power
A2 dominating A7	P3	Cost of service and internal business approvals and processes directly affect the flexibility in billing
A2 dominating A8	P1	Cost of service and on time delivery directly affect long term relationship
	P4	Cost of service and quality control processes directly affect the long term relationship
	P6	Cost of service and after sales service directly affect the long term relationship
	P8	Cost of service and optimum quantity delivery directly affect the long term relationship
	P9	Cost of service and resource utilization directly affect the long term relationship
A2 dominating A9	P3	Cost of service and internal business approvals and processes directly affect the quality of management
	P6	Cost of service and after sales service directly affect the quality of management
	P8	Cost of service and optimum quantity delivery directly affect the quality of management
	P9	Cost of service and resource utilization directly affect the quality of management

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Paired comparison	Interacting with process	Interpretive logic
A2 dominating A10	P3	Cost of service and internal business approvals and processes directly affect the information sharing and mutual trust
A2 dominating A11	P1	Cost of service and on time delivery directly affect operational performance
	P6	Cost of service and after sales service directly affect the operational performance
	P8	Cost of service and optimum quantity delivery directly affect the operational performance
A2 dominating A15	P1	Cost of service and on time delivery directly affect the delivery performance
	P8	Cost of service and optimum quantity delivery directly affect the delivery performance
A2 dominating A16	P3	Cost of service and internal business approvals and processes directly affect the employee satisfaction level
A2 dominating A17	P9	Cost of service and resource utilization directly affect the financial performance
A2 dominating A20	P3	Cost of service and internal business approvals and processes directly affect the flexibility in operations and delivery
	P5	Cost of service and distribution process from distributor to customer help in flexibility in operations and delivery
	P7	Cost of service and transportation process from distributor to customer help in flexibility in operations and delivery
A3 dominating A1	P1	Quality of service and on time delivery directly affect the compatibility with users
	P6	Quality of service and after sales service directly affect the compatibility with users
	P8	Quality of service and optimum quantity delivery directly affect the compatibility with users
A3 dominating A2	P3	Quality of service and internal business approvals and processes directly affect the compatibility with users
A3 dominating A4	P1	Quality of service and on time delivery directly affect the reputation of vendor
	P6	Quality of service and after sales service directly affect the reputation of vendor
	P8	Quality of service and optimum quantity delivery directly affect the reputation of vendor
A3 dominating A5	P1	Quality of service and on time delivery directly affect the performance measurement
	P6	Quality of service and after sales service directly affect the performance measurement
	P8	Quality of service and optimum quantity delivery directly affect the performance measurement
A3 dominating A6	P3	Quality of service and internal business approvals and processes directly affect the willingness to use logistic man power
	P9	Quality of service and resource utilization directly affect the willingness to use logistic man power
A3 dominating A7	P3	Quality of service and internal business approvals and processes directly affect the flexibility in billing
A3 dominating A8	P1	Quality of service and on time delivery directly affect the long term relationship
	P6	Quality of service and after sales service directly affect the long term relationship
	P8	Quality of service and optimum quantity delivery directly affect the long term relationship

(*continued*)

Table AI.

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Paired comparison	Interacting with process	Interpretive logic
A3 dominating A9	P3	Quality of service and internal business approvals and processes directly affect the quality of management
	P6	Quality of service and after sales service directly affect the quality of management
	P8	Quality of service and optimum quantity delivery directly affect the quality of management
A3 dominating A10	P3	Quality of service and internal business approvals and processes directly affect the information sharing and mutual trust
A3 dominating A11	P1	Quality of service and on time delivery directly affect the operational performance
	P6	Quality of service and after sales service directly affect the operational performance
	P8	Quality of service and optimum quantity delivery directly affect the operational performance
	P9	Quality of service and resource utilization directly affect the operational performance
A3 dominating A15	P1	Quality of service and on time delivery directly affect the delivery performance
	P5	Quality of service and distribution process directly affect the delivery performance
	P7	Quality of service and transportation process directly affect the delivery performance
	P8	Quality of service and optimum quantity delivery directly affect the delivery performance
A3 dominating A16	P3	Quality of service and internal business approvals and processes directly affect the employee satisfaction level
	P9	Quality of service and resource utilization directly affect the employee satisfaction level
A3 dominating A17	P9	Quality of service and resource utilization directly affect the financial performance
A3 dominating A20	P3	Quality of service and internal business approvals and processes directly affect the flexibility in operation and delivery
A4 dominating A6	P3	Reputation of vendor and internal business approvals and processes directly affect the willingness to use L logistics manpower
A4 dominating A7	P3	Reputation of vendor and internal business approvals and processes directly affect the flexibility in billing
A4 dominating A8	P1	Reputation of vendor and on time delivery directly affect the long term relationship
	P6	Reputation of vendor and after sales service directly affect the long term relationship
	P8	Reputation of vendor and optimum quantity delivery directly affect the long term relationship
A4 dominating A9	P3	Reputation of vendor and internal business approvals and processes directly affect the quality of management
	P9	Reputation of vendor and resource utilization directly affect the quality of management
A4 dominating A16	P3	Reputation of vendor and internal business approvals and processes directly affect the employee satisfaction
	P9	Reputation of vendor and resource utilization directly affect the employee satisfaction
A4 dominating A17	P9	Reputation of vendor and resource utilization directly affect the financial performance
A5 dominating A2	P3	Performance measurement and internal business approvals and processes directly affect the cost of service
	P5	Performance measurement and distribution processes directly affect the cost of service
	P7	Performance measurement and transportation processes directly affect the cost of service
A5 dominating A6	P9	Performance measurement and resource utilization directly affect the willingness to use logistic manpower
A5 dominating A7	P3	Performance measurement and internal business approvals and processes directly affect the flexibility in billing

(continued)

Table AI.

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Paired comparison	Interacting with process	Interpretive logic
A5 dominating A8	P1	Performance measurement and on time delivery directly affect the long term relationship
	P6	Performance measurement and after sales service directly affect the long term relationship
	P8	Performance measurement and optimal quantity delivery directly affect the long term relationship
A5 dominating A9	P1	Performance measurement and on time delivery directly affect the quality of management
	P3	Performance measurement and internal business approvals and processes directly affect the quality of management
	P4	Performance measurement and quality control process directly affect the quality of management
	P6	Performance measurement and after sales service directly affect the quality of management
	P8	Performance measurement and optimal quantity delivery directly affect the quality of management
	P9	Performance measurement and resource utilization directly affect the quality of management
A5 dominating A10	P3	Performance measurement and internal business approvals and processes directly affect the information sharing and trust
A5 dominating A11	P1	Performance measurement and on time delivery directly affect the operational performance
	P8	Performance measurement and optimal quantity delivery directly affect the operational performance
A5 dominating A12	P8	Performance measurement and optimal quantity delivery directly affect the information technology capacity
	P9	Performance measurement and resource utilization directly affect the information technology capacity
A5 dominating A15	P1	Performance measurement and on time delivery directly affect the delivery performance
	P8	Performance measurement and optimal quantity delivery directly affect the delivery performance
A5 dominating A16	P3	Performance measurement and internal business approvals and processes directly affect the delivery performance
	P9	Performance measurement and optimal quantity delivery directly affect the delivery performance
	P10	Performance measurement and external resource utilization directly affect the delivery performance
A5 dominating A20	P3	Performance measurement and internal business approvals and processes directly affect the flexibility in operation and delivery
A6 dominating A7	P1	Willingness to use logistics man power will help in on time delivery, which is more important than A7
A7 dominating A13	P3	A13 is not having any direct role
	P8	A1 is not having any direct role
A8 dominating A6	P6	Proper after sales service helps in maintaining long term relationship and is more important than A6
	P8	Optimal quantity delivery will help to maintain long term relationship and is more important than A6
A8 dominating A7	P1	Long term relations can be maintained by on time delivery is more important than A7
	P4	Long term relations can be maintained by quality control processes is more important than A7
	P6	Long term relations can be maintained by good after sales service and is more important than A7
	P8	Long term relationships can be maintained by delivering optimal quantity and is important than A7

(*continued*)

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Paired comparison	Interacting with process	Interpretive logic
A8 dominating A13	P1	Long term relations can be maintained by on time delivery is more important than A13
	P3	Long term relations can be maintained by internal business approvals and is more important than A13
	P4	Long term relations can be maintained by quality control processes and is more important than A13
	P5	Proper distribution process improves long term relations and is more important than A13
	P6	Good after sales service helps in maintaining long term relations and is more important than A13
	P7	Good transportation processes helps in maintaining long term relations and is more important than A13
	P8	Optimal quantity delivery helps in maintaining long term relations and is more important than A13
A8 dominating A18	P4	Long term relations can be maintained by quality control processes and is more important than A18
	P6	Good after sales service helps in maintaining long term relations and is more important than A18
	P7	Good transportation processes helps in maintaining long term relations and is more important than A18
A9 dominating A2	P1	Quality of management for on time delivery is more important than A2
	P4	Quality of management for implementing quality control processes is more important than A2
A9 dominating A3	P4	Quality of service can be improved by implementing quality control processes
	P5	Quality of service can be improved by designing a proper distribution process
	P9	A good quality of management utilizes resources efficiently to give quality of service
A9 dominating A4	P1	A good quality of management may increase reputation of the vendor by devising ways for on time delivery
	P4	A good quality of management will implant quality control processes for increasing A4
	P5	A good quality of management by proper distribution process increases A4
	P6	A good quality of management by giving proper after sales service increases A4
	P7	A good quality of management selects proper transportation process which increases A4
	P8	A good quality of management by delivering optimal quantity improves A4
A9 dominating A6	P1	Quality of management for on time delivery is more important than A6
	P3	Internal business approvals for quality are more important than A6
	P5	Quality of management for proper distribution process is more important than A6
	P6	Quality of management for proper after sales service is more important than A6
	P7	Quality of management for selecting proper transportation process is more important than A6
	P8	Quality of management for optimal quantity delivery is more important than A6
	P9	Quality of management for efficient utilization of resources is more important than A6
A9 dominating A7	P1	Quality of management for on time delivery is more important than A7
	P3	Internal business approvals for quality are more important than A7
	P4	Quality of management for implanting quality control processes are more important than A7
	P5	Quality of management for proper distribution process is more important than A7
	P6	Quality of management for proper after sales service is more important than A7

(continued)

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Table AI.

Paired comparison	Interacting with process	Interpretive logic
	P7	Quality of management for selecting proper transportation process is more important than A7
	P8	Quality of management for optimal quantity delivery is more important than A7
	P9	Quality of management for efficient utilization of resources is more important than A7
A9 dominating A10	P1	A good quality of management may ask employees to share information for on time delivery
	P3	A good quality of management may take internal approvals for sharing information
	P4	A good quality of management may improve quality control processes by sharing information
	P5	By sharing information proper distribution network can be selected
	P6	A good quality of management may improve after sales service by sharing information
	P8	A good quality of management may deliver optimal quantity by sharing information
	P9	A good quality of management uses information sharing principle for efficient utilization of resources
A9 dominating A11	P1	A good quality of management improves operational performance by on time delivery
	P2	A good quality of management takes government approvals for improving operational performance
	P3	A good quality of management takes internal approvals for improving operational performance
	P4	A good quality of management may implement quality control processes for improving operational performance
	P5	A good quality of management may select proper distribution network for improving operational performance
	P6	A good quality of management may improve operational performance by giving good after sales service
	P7	A good quality of management may select proper transportation process for improving operational performance
	P8	A good quality of management may improve operational performance by optimal quantity delivery
	P9	A good quality of management may improve operational performance by utilizing resources efficiently
A9 dominating A12	P1	A good quality of management improves on time delivery by using IT
	P4	A good quality of management may implement IT controlled quality control processes
	P5	A good quality of management may select proper distribution network by using IT
	P6	A good quality of management may give good after sales service by using IT
	P7	A good quality of management may select proper transportation process by using IT
	P8	A good quality of management may deliver optimal quantity by using IT
	P9	A good quality of management may utilize resources efficiently using IT
A9 dominating A13	P1	A13 is not having any direct role
	P2	A13 is not having any direct role
	P3	A13 is not having any direct role
	P4	A13 is not having any direct role
	P5	A13 is not having any direct role
	P6	A13 is not having any direct role

(*continued*)

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Table AI.

Paired comparison	Interacting with process	Interpretive logic
	P7	A13 is not having any direct role
	P8	A13 is not having any direct role
	P9	A13 is not having any direct role
A9 dominating A15	P1	A good quality of management improves delivery performance by on time delivery
	P3	A good quality of management takes internal approvals for improving delivery performance
	P5	A good quality of management may select proper distribution network for improving delivery performance
	P7	A good quality of management may select proper transportation process for improving delivery performance
A9 dominating A16	P3	A good quality of management may take internal approvals for employee satisfaction
A9 dominating A17	P3	A good quality of management takes internal approvals for improving financial performance
	P4	A good quality of management may implement quality control processes for improving financial performance
	P5	A good quality of management may select proper distribution network for improving financial performance
	P6	A good quality of management may improve financial performance by giving good after sales service
	P7	A good quality of management may select proper transportation process for improving financial performance
	P9	A good quality of management may improve financial performance by utilizing resources efficiently
A9 dominating A18	P1	A good quality of management increases market share by on time delivery
	P3	A good quality of management takes internal approvals for increasing market share
	P4	A good quality of management may implement quality control processes for increasing market share
	P6	A good quality of management may increase market share by giving good after sales service
A9 dominating A19	P1	A good quality of management may spread the firm for on time delivery
	P2	A good quality of management takes government approvals for geographical spread
	P3	A good quality of management takes internal approvals for geographical spread
	P6	A good quality of management may improve after sales service by spreading geographically
	P9	A good quality of management may utilize resources efficiently by spreading geographically
A9 dominating A20	P1	A good quality of management improves on time delivery by being flexible in operations
	P3	A good quality of management takes internal approvals for being flexible in operations
	P6	A good quality of management may give good after sales service by being flexible in operations
	P8	A good quality of management may deliver optimal quantity by being flexible in operations
	P9	A good quality of management may utilize resources efficiently for being flexible in operations
A10 dominating A6	P1	Information sharing improves on time delivery and is more important than A6
	P4	Information sharing improves the quality control processes and is more important than A6
	P5	Information sharing improves distribution process and is more important A6
	P6	Information sharing improves after sales service and is more important A6

(*continued*)

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Paired comparison	Interacting with process	Interpretive logic
	P7	Information sharing improves transportation processes and is more important A6
	P8	Information sharing helps in optimal quantity delivery and is more important A6
	P9	Information sharing improves resource utilization and is more important A6
A10 dominating A7	P1	A7 is not having any direct role
	P4	A7 is not having any direct role
	P5	A7 is not having any direct role
	P6	A7 is not having any direct role
	P7	A7 is not having any direct role
	P8	A7 is not having any direct role
	P9	A7 is not having any direct role
A10 dominating A11	P1	Information sharing improves on time delivery which improves A11
	P4	Information sharing improves the quality control processes which improves A11
	P5	Information sharing improves distribution process which improves A11
	P6	Information sharing improves after sales service which improves A11
	P7	Information sharing improves transportation processes which improves A11
	P8	Information sharing helps in optimal quantity delivery which improves A11
A10 dominating A13	P1	A7 is not having any direct role
	P4	A7 is not having any direct role
	P5	A7 is not having any direct role
	P6	A7 is not having any direct role
	P7	A7 is not having any direct role
	P8	A7 is not having any direct role
	P9	A7 is not having any direct role
A10 dominating A15	P1	Information sharing improves on time delivery which improves A15
	P5	Information sharing improves distribution process which improves A15
	P7	Information sharing improves transportation processes which improves A15
A10 dominating A16	P3	Information sharing helps in internal business approvals, which may increase satisfaction level of employees
A10 dominating A17	P3	Information sharing helps in internal business approvals, which may increase A17
	P5	Information sharing improves distribution process which improves A17
	P6	Information sharing improves after sales service which improves A17
	P7	Information sharing improves transportation processes which improves A17
	P9	Information sharing helps in efficient utilization of resources which increase A17

(*continued*)

Table AI.

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Table AI.

Paired comparison	Interacting with process	Interpretive logic
A10 dominating A18	P1	Information sharing improves on time delivery which improves A18
	P3	Information sharing helps in internal business approvals, which may increase A18
	P6	Information sharing improves after sales service which improves A18
A10 dominating A19	P3	Information sharing helps in internal business approvals, which may increase A19
A11 dominating A6	P1	On time delivery improves operational performance and is more important than A6
	P3	Internal business approvals improve operational performance and is more important than A7
	P4	Quality control processes improve operational performance and is more important than A6
	P5	Distribution processes improve operational performance and is more important than A6
	P6	After sales services improve operational performance and is more important than A6
	P7	Transportation processes improve operational performance and is more important than A6
A11 dominating A7	P1	On time delivery improves operational performance and is more important than A7
	P3	Internal business approvals improve operational performance and is more important than A7
	P4	Quality control processes improve operational performance and is more important than A7
	P5	Distribution processes improve operational performance and is more important than A7
	P6	After sales services improve operational performance and is more important than A7
	P7	Transportation processes improve operational performance and is more important than A6
	P9	Operational performance can be improved by utilizing resources efficiently, which is more important than A7
A11 dominating A13	P1	A13 is not having any direct role
	P4	A13 is not having any direct role
	P5	A13 is not having any direct role
	P6	A13 is not having any direct role
	P7	A13 is not having any direct role
	P9	Operational performance can be improved by utilizing resources efficiently, which is more important than A7
A11 dominating A18	P1	On time delivery improves operational performance and in turn increases A18
	P3	Internal business approvals improve operational performance and in turn increases A18
	P4	Quality control processes improve operational performance and in turn increases A18
	P5	Distribution processes improve operational performance and in turn increases A18
	P6	After sales services improve operational performance and in turn increases A18
	P7	Transportation processes improve operational performance in turn increases A18
A12 dominating A1	P3	Internal approvals and with the help IT compatibility with the users can be improved

(*continued*)

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Table AI.

Paired comparison	Interacting with process	Interpretive logic
A12 dominating A2	P3	Internal approvals for the implementation of IT reduces A2
	P5	Use of IT for distribution process reduces A2
	P6	Use of IT for after sales service reduces A2
	P7	Use of IT for transportation process reduces A2
	P8	Use of IT for optimal quantity of delivery reduces A2
	P9	Use of IT for efficient utilization of resources reduces A2
A12 dominating A3	P3	Internal approvals for the implementation of IT Improves A3
	P4	Use of IT for the quality control process improves A3
	P9	Use of IT for efficient utilization of resources improves A3
A12 dominating A4	P1	Use of IT helps in on time delivery which increases A4
	P4	IT enabled quality control processes improve A4
	P5	Use of IT for distribution process improves A4
	P6	Use of IT for after sales service improves A4
	P7	Use of IT for transportation process improves A4
	P8	Use of IT for optimal quantity of delivery improves A4
	P9	Use of IT for efficient utilization of resources improves A4
A12 dominating A6	P1	A6 is not having any direct role
	P4	A6 is not having any direct role
	P5	A6 is not having any direct role
	P6	A6 is not having any direct role
	P7	A6 is not having any direct role
	P8	A6 is not having any direct role
	P9	A6 is not having any direct role
A12 dominating A7	P1	A7 is not having any direct role
	P4	A7 is not having any direct role
	P5	A7 is not having any direct role
	P6	A7 is not having any direct role
	P7	A7 is not having any direct role
	P8	A7 is not having any direct role
	P9	A7 is not having any direct role

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Table AI.

Paired comparison	Interacting with process	Interpretive logic
A12 dominating A8	P1	Use of IT helps in on time delivery which improves A8
	P3	Use of IT for internal approvals improve A8
	P4	IT enabled quality control processes improve A8
	P5	Use of IT for distribution process improves A8
	P6	Use of IT for after sales service improves A8
	P7	Use of IT for transportation process improves A8
	P8	Use of IT for optimal quantity of delivery improves A8
	P9	Use of IT for efficient utilization of resources improves A8
A12 dominating A11	P1	Use of IT helps in on time delivery which improves A11
	P3	Use of IT for internal approvals improve A11
	P4	IT enabled quality control processes improve A11
	P5	Use of IT for distribution process improves A11
	P6	Use of IT for after sales service improves A11
	P7	Use of IT for transportation process improves A11
	P8	Use of IT for optimal quantity of delivery improves A11
A12 dominating A13	P1	A13 is not having any direct role
	P3	A13 is not having any direct role
	P4	A13 is not having any direct role
	P5	A13 is not having any direct role
	P6	A13 is not having any direct role
	P7	A13 is not having any direct role
	P8	A13 is not having any direct role
	P9	A13 is not having any direct role
A12 dominating A15	P1	Use of IT helps in on time delivery which improves A15
	P3	Use of IT for internal approvals improve A15
	P5	Use of IT for distribution process improves A15
	P7	Use of IT for transportation process improves A15
	P8	Use of IT for optimal quantity of delivery improves A15
A12 dominating A16	P3	Use of IT for internal approvals may increase A16
A12 dominating A17	P3	Use of IT for internal approvals improve A17
	P5	Use of IT for distribution process improves A17
	P6	Use of IT for after sales service improves A17

(*continued*)

Paired comparison	Interacting with process	Interpretive logic
	P7	Use of IT for transportation process improves A17
	P8	Use of IT for optimal quantity of delivery improves A17
	P9	Use of IT for efficient utilization of resources improves A17
A12 dominating A18	P3	Use of IT for internal approvals improve A18
A12 dominating A19	P3	Use of IT for internal approvals improve A19
A12 dominating A20	P3	Use of IT for internal approvals improve A20
A13 dominating A4	P9	A4 is not having any direct role
A14 dominating A2	P3	Experience in similar product reduces A2
	P4	Experience in similar products and implementation of quality control processes reduces A2
	P5	Experience in similar products and proper distribution of processes reduces A2
	P6	Experience in similar products and proper after sales service reduces A2
	P7	Experience in similar products and proper transportation process reduces A2
	P8	Experience in similar products and delivery of optimal quantity, reduces A2
	P9	Experience in similar products and efficient utilization of resources, reduces A2
A14 dominating A3	P1	Experience in similar products and on time delivery improves A3
	P4	Experience in similar products and implementation of quality control processes improves A3
	P5	Experience in similar products and proper distribution of processes improves A3
	P6	Experience in similar products and proper after sales service improves A3
	P7	Experience in similar products and proper transportation process improves A3
	P8	Experience in similar products and delivery of optimal quantity, improves A3
A14 dominating A6	P1	Experience in similar products and on time delivery is more important than A6
	P4	Experience in similar products and implementation of quality control processes is more important than A6
	P5	Experience in similar products and proper distribution of processes is more important than A6
	P6	Experience in similar products and proper after sales service is more important than A6
	P7	Experience in similar products and proper transportation process is more important than A6
	P8	Experience in similar products and delivery of optimal quantity, is more important than A6
A14 dominating A7	P1	A7 is not having any direct role
	P4	A7 is not having any direct role
	P5	A7 is not having any direct role
	P6	A7 is not having any direct role
	P7	A7 is not having any direct role
	P8	A7 is not having any direct role
	P9	A7 is not having any direct role

(*continued*)

Table AI.

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Table AI.

Paired comparison	Interacting with process	Interpretive logic
A14 dominating A8	P1	Experience in similar products and on time delivery helps in building long term relationship
	P4	Experience in similar products and implementation of quality control processes helps in building long term relationship
	P5	Experience in similar products and proper distribution of processes helps in building long term relationship
	P6	Experience in similar products and proper after sales service helps in building long term relationship
	P7	Experience in similar products and proper transportation process helps in building long term relationship
	P8	Experience in similar products and delivery of optimal quantity, helps in building long term relationship
A14 dominating A11	P1	Experience in similar products and on time delivery improves operational performance
	P4	Experience in similar products and implementation of quality control processes improves operational performance
	P5	Experience in similar products and proper distribution of processes improves operational performance
	P6	Experience in similar products and proper after sales service improves operational performance
	P7	Experience in similar products and proper transportation process improves operational performance
	P8	Experience in similar products and delivery of optimal quantity, improves operational performance
A14 dominating A13	P1	A13 is not having any direct role
	P4	A13is not having any direct role
	P5	A13 is not having any direct role
	P6	A13 is not having any direct role
	P7	A13 is not having any direct role
	P8	A13 is not having any direct role
	P9	A13 is not having any direct role
A14 dominating A15	P1	Experience in similar products and on time delivery improves delivery performance
	P5	Experience in similar products and proper distribution of processes improves delivery performance
	P7	Experience in similar products and proper transportation process improves delivery performance
	P8	Experience in similar products and delivery of optimal quantity, improves delivery performance
A14 dominating A16	P3	Experience in similar products and with internal business approvals employee satisfaction level may be achieved
A14 dominating A17	P1	Experience in similar products and on time delivery improves financial performance
	P3	Experience in similar products and with internal approvals financial performance can be improved
	P4	Experience in similar products and with good control processes financial performance can be improved
	P5	Experience in similar products and proper distribution of processes improves financial performance
	P6	Experience in similar products and proper after sales service improves financial performance
	P7	Experience in similar products and proper transportation process improves financial performance
	P8	Experience in similar products and delivery of optimal quantity, improves financial performance
	P9	Experience in similar products and efficient utilization of resources increases financial performance

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Table AI.

Paired comparison	Interacting with process	Interpretive logic
A14 dominating A18	P1	Experience in similar products and on time delivery increases market share
	P3	Experience in similar products and internal approvals increases market share
	P6	Experience in similar products and proper after sales service increases market share
A14 dominating A19	P1	Experience in similar products and on time delivery will help in geographical spreading
	P3	Experience in similar products and with internal approvals wide range of services may be offered
	P4	Experience in similar products and good quality control processes increases A19
	P6	Experience in similar products and proper after sales service increases A19
	P9	Experience in similar products and proper utilization of resources increases A19
A14 dominating A20	P3	Experience in similar products and with internal approvals makes the operations flexible
A15 dominating A6	P1	On time delivery improves delivery performance and is more important than A6
	P3	Internal business approvals improve delivery performance and is more important than A7
	P5	Distribution processes improve delivery performance and is more important than A6
	P7	Transportation processes improve delivery performance and is more important than A6
A15 dominating A7	P1	A7 is not having any direct role
	P3	A7 is not having any direct role
	P4	A7 is not having any direct role
	P5	A7 is not having any direct role
	P7	A7 is not having any direct role
A15 dominating A13	P1	A13 is not having any direct role
	P4	A13 is not having any direct role
	P5	A13 is not having any direct role
	P7	A13 is not having any direct role
A15 dominating A18	P1	On time delivery improves delivery performance and in turn increases A18
	P3	Internal business approvals improve delivery performance and in turn increases A18
	P5	Distribution processes improve delivery performance and in turn increases A18
	P7	Transportation processes improve delivery performance in turn increases A18
A16 dominating A2	P1	Satisfied employee delivers on time reducing cost of service
	P9	Satisfied employee will utilize resources efficiently reducing cost of service
A16 dominating A3	P1	Satisfied employee delivers on time improving quality of service
	P4	Satisfied employee will control the quality, hence quality of services will get improved
	P6	Satisfied employee will give good after sales service improving A3
	P9	Satisfied employee will utilize resources efficiently in order to give quality of service

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Table AI.

Paired comparison	Interacting with process	Interpretive logic
A16 dominating A4	P1	Satisfied employee delivers on time improving reputation of vendor
	P4	Satisfied employee will control the quality, hence improving reputation of vendor
	P6	Satisfied employee will give good after sales service improving A4
A16 dominating A6	P3	A6 is not having any direct role
A16 dominating A7	P3	A7 is not having any direct role
A16 dominating A8	P1	Satisfied employee delivers on time which will help in long term relation ship
	P4	Satisfied employee will control the quality, which will help in long term relation ship
	P6	Satisfied employee will give good after sales service which will help in long term relation ship
A16 dominating A11	P1	Satisfied employee delivers on time which will improve operational performance
	P4	Satisfied employee will control the quality, which will improve operational performance
	P6	Satisfied employee will give good after sales service which will improve operational performance
	P9	Satisfied employee will utilize resources efficiently which will improve operational performance
A16 dominating A13	P3	A13 is not having any direct role
A16 dominating A15	P1	Satisfied employee delivers on time which will improve delivery performance
A16 dominating A17	P1	Satisfied employee delivers on time which will improve financial performance
	P6	Satisfied employee will give good after sales service which will improve financial performance
	P9	Satisfied employee will utilize resources efficiently which will improve financial performance
A16 dominating A20	P1	Satisfied employee delivers on time for giving flexibility in operations and delivery
	P3	Employee satisfaction with internal approvals will affect A20
	P6	Satisfied employee will give good after sales service for giving flexibility in operations and delivery
	P9	Satisfied employee will utilize resources efficiently for giving flexibility in operations and delivery
A17 dominating A3	P4	Good financial performance will implement quality control processes which will increase quality of service
A17 dominating A4	P4	Good financial performance will implement quality control processes which will improve reputation
A17 dominating A6	P3	A6 is not having any direct role
A17 dominating A7	P3	A7 is not having any direct role
A17 dominating A13	P3	A13 is not having any direct role
A18 dominating A6	P3	A6 is not having any direct role
A18 dominating A7	P3	A7 is not having any direct role
A18 dominating A13	P3	A13 is not having any direct role

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Table AI.

Paired comparison	Interacting with process	Interpretive logic
A19 dominating A4	P1	On time delivery and geographical spread improves A4
	P4	Geographical spread and quality control processes improve A4
	P5	Geographical spread and proper distribution process improves A4
	P6	Geographical spread and proper after sales service improves A4
	P7	Geographical spread and proper transportation processes improves A4
A19 dominating A6	P3	A6 is not having any direct role
A19 dominating A7	P3	A7 is not having any direct role
A19 dominating A13	P3	A13 is not having any direct role
A19 dominating A18	P1	On time delivery and geographical spread increases A18
	P4	Geographical spread and quality control processes increase A18
	P5	Geographical spread and proper distribution process increase A18
	P6	Geographical spread and proper after sales service increase A18
	P7	Geographical spread and proper transportation processes increase A18
A20 dominating A3	P4	Flexibility in operation along with quality control processes improves A3
	P6	Flexibility in operation along with proper after sales service improves A3
	P9	Flexibility in operation will utilize resources efficiently and increase the quality of service
A20 dominating A4	P1	Flexibility in operation along with on time delivery improves A4
	P3	Flexibility in operation along with internal approvals improves A4
	P4	Flexibility in operation along with quality control processes improves A4
	P5	Flexibility in operation along with proper distribution process improves A4
	P6	Flexibility in operation along with proper after sales service improves A4
	P7	Flexibility in operation along with proper transportation process improves A4
	P8	Flexibility in operation along with optimum quantity delivery improves A4
	P9	Flexibility in operation will utilize resources efficiently and improve the reputation of vendor
A20 dominating A8	P1	Flexibility in operation along with on time delivery improves A8
	P3	Flexibility in operation along with internal approvals improves A8
	P4	Flexibility in operation along with quality control processes improves A8
	P5	Flexibility in operation along with proper distribution process improves A8
	P6	Flexibility in operation along with proper after sales service improves A8
	P7	Flexibility in operation along with proper transportation process improves A8
	P8	Flexibility in operation along with optimum quantity delivery improves A8
	P9	Flexibility in operation will utilize resources efficiently and improve A8

(*continued*)

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Table AI.

Paired comparison	Interacting with process	Interpretive logic
A20 dominating A11	P1	Flexibility in operation along with on time delivery improves A11
	P3	Flexibility in operation along with internal approvals improves A11
	P4	Flexibility in operation along with quality control processes improves A11
	P5	Flexibility in operation along with proper distribution process improves A11
	P6	Flexibility in operation along with proper after sales service improves A11
	P7	Flexibility in operation along with proper transportation process improves A11
	P8	Flexibility in operation along with optimum quantity delivery improves A11
	P9	Flexibility in operation will utilize resources efficiently and improve A11
A20 dominating A13	P3	A13 is not having any direct role
A20 dominating A15	P1	Flexibility in operation along with on time delivery improves A15
	P3	Flexibility in operation along with internal approvals improves A15
	P5	Flexibility in operation along with proper distribution process improves A15
	P7	Flexibility in operation along with proper transportation process improves A15
	P8	Flexibility in operation along with optimum quantity delivery improves A11
	P9	Flexibility in operation will utilize resources efficiently and improve A15
A20 dominating A17	P3	A17 is not having any direct role
	P9	Flexibility in operation will utilize resources efficiently and improve A17
A20 dominating A18	P1	Flexibility in operation along with on time delivery increases A18
	P3	Flexibility in operation along with internal approvals increases A18
	P4	Flexibility in operation along with quality control processes increases A18
	P5	Flexibility in operation along with proper distribution process increases A18
	P6	Flexibility in operation along with proper after sales service increases A18
	P7	Flexibility in operation along with proper transportation process increases A18
	P8	Flexibility in operation along with optimum quantity delivery increases A18
	P9	Flexibility in operation will utilize resources efficiently and improve A18
A20 dominating A19	P1	Flexibility in operation along with on time delivery helps to achieve A19
	P3	Flexibility in operation along with internal approvals helps to achieve A19
	P4	Flexibility in operation along with quality control processes helps to achieve A19
	P5	Flexibility in operation along with proper distribution process helps to achieve A19
	P6	Flexibility in operation along with proper after sales service helps to achieve A19
	P7	Flexibility in operation along with proper transportation process helps to achieve A19

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