Research Article

Selection of Third Party Logistics Service Provider Using a Multi-Criteria Decision Making Approach for Indian Cement Manufacturing Industries

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Abstract

Today, third party logistics service providers (3PLSP) are into nearly all the businesses right from providing raw material to finish goods. 3PLSP's are also getting convoluted in customer oriented operations. At the right cost and consideration of all affecting criteria anything can be outsourced. Every organization needs to find a smart balance of what to produce in-house and what to procure/hire from outside service providers. Over the past few decades, academicians/researchers and practitioners around the world have been motivated and guided by work related to the factors that have led to the success of 3PLSP. The purpose of this paper is to prepare a model for the selection of 3PL vendor for the Indian cement manufacturing industry using an analytical hierarchy process (AHP) which is a tool of multi-criteria decision making (MCDM) methodology. This approach enables the managers of the organization to understand the contextual relationships of the selection criteria which improves the reliability of the decision. The proper selection of the 3PLSP makes the organization competitive and increases the profitability. Through an exhaustive literature review and opinion of experts (5 from the industry and 4 from the academics), twenty major selection criteria were identified and the top five parameters in the descending order of ranking are compatibility with the users, cost of service, quality of service, reputation of vendor, and performance measurement.

Keywords: 3PL; analytic hierarchy process (AHP); Vendor selection; Cement manufacturing Industry

1. Introduction

A third party logistics service provider (3PLSP or TPLSP) is an organization that provides service to its customers for part or all of their SCM functions. The 3PLSP's are typically specialized in integrated operations, warehousing and transportation services that are scaled and customized to

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customers' needs & demands based on market conditions and service delivery requirements for their products and materials. These services often include value-added services related to the production or procurement of goods, i.e. services that integrate parts of the supply chain. The 3PL system is a process which targets a particular function in the management, like warehousing, transportation, raw material provider, etc. India is identified as the second largest outsourcing destination after China and is on the path to becoming the most substantial in this environment, Indian service providers endeavor to stay in the market. The 3PLSP's have evolved by the emerging trends of outsourcing the entire set of "non-core competencies". The rise of competition has created quality, but at the same time poses a question before the outsourcing companies of ranking aptly and choosing the right 3PLSP. The selection of the same has been carried out by various methods before like Intuitive Process or Rational Choice Processes.

2. Literature Review

In recent years, 3PLSP's have played a paramount role in a supply chain of organizations. A brief literature review is given in this section of the paper. Tate (1996) identified seven factors (compatibility, a thorough understanding of a partner's business needs, open communications, commitment, fairness, flexibility, and trust) that improved long- term relationship between 3PL and their customers. Logan (2000) used agency theory to help in bonding 3PL/customers relationships. It is postulated that cost reduction and service improvement criteria are expected by clients to avoid conflicts with their 3PLSP's. Fawcett and Smith (1995) identified five criteria to evaluate the 3PLSP performance, namely, quality, delivery, flexibility, cost and innovation in services. Morash *et al*. (1996) suggested for a US furniture industry that logistics performance is determined by demand capabilities, that include pre-sale and post-sale customer services, delivery speed, delivery reliability, and responsiveness to target market and supply capabilities, which comprise wide spread distribution coverage, selective distribution coverage, and low total cost distribution. Stank and Maltz (1996) presented a preliminary review on factors that influence the decision to purchase 3PLSP in the domestic versus international logistics environment. The six keys factors identified are asset investment, learning capability, long-term cooperation, organizational characteristics, service capacity, and uncertainty/volatility. Dapiran *et al*. (1996) and Millen *et al*. (1997) stated that cost is the primary selection criteria for 3PLSP & other relevant criteria are services, personal knowledge of the contractor, coverage provided, previous experience and references, experience in project management and new systems' implementation, and perceived competence. Cirpin and Kabadayi (2015) used analytic hierarchy process (AHP) in the selection of 3PLSP selection for an IT distributor company, and it was concluded that the most important criteria in the company's 3PLSP selection process are operational flexibility, reliability, and information sharing & trust. Zhang *et al*. (2015) proposed a dynamic pricing strategy (DPS) and developed a stochastic nonlinear programming (SNLP) model that computes the optimal freight rates for different delivery dates incorporating the 3PLSP's current holding cost and available transportation capacity for each route. The modification of the standard multinomial logit (MNL) function to predict customer choices was carried out. Through a simulation experiment, it was found that the proposed MNL function can be a good replacement for the joint MNL function.

3. Research Methodology

The aim of this paper is to develop a conceptual framework for identifying the relevant criteria and ranking the same for the selection of 3PLSP in the context of the Indian

cement industries using analytical hierarchy process (AHP). The experts from academia and industry were invited for brainstorming and interview sessions. The details of the experts regarding designation and experience is shown in Table 1.

Table 1. Details of the experts from academia and industry.

Expert No.	Designation/Profile	Work experience	Category
1	Professor, Industrial Engineering Department	>18	Academics
2	Professor, Supply Chain and Operations Management	16	Academics
3	Associate professor, Industrial Engineering and Operation Research	14	Academics
4	Professor, Organization Management	15	Academics
5	Procurement Manager company "XYZ Cement"	20	Industry
6	Transportation & Logistics Manager company "PQR cement"	18	Industry
7	Senior Procurement Consultant "IJY Supply Chain Solutions"	19	Industry
8	Supply Chain Manager company " CTV cement"	14	Industry
9	Purchasing Manager company "PQR cement"	16	Industry

Not much research work has been done in this the 3PLSP area in the cement industry sector, hence, findings of the current research will form guidelines for the criteria on which the 3PLSP should be selected. The analytic hierarchy process methodology, its advantages, limitations, and steps involved in the approach are discussed in the following section of the paper.

3.1 Analytical Hierarchy Process (AHP)

The AHP decomposes the decision process as a hierarchical structure and also deals with quantifiable and intangible criteria by using the pair-wise comparison matrices. It is a widely used technique for incorporating qualitative and quantitative criteria in decision making. It has been widely applied in various areas including education, engineering, sports, government, manufacturing and social management (Ho, 2008).

It has the following advantages (Bahurmoz, 2003; Bahurmoz, 2006; Carlsson and Walden, 1995; David and Saaty, 2007; Libertore *et al*., 1992) –

1. It can consider many options/parameters/factors at one time and allows to make comparisons, unlike relative merit method or dimensional analysis, which can tackle only two alternatives at a time.
2. It can take complex conditions into consideration where variety of weights are assigned to the same issue. Weights can be assigned to Judge's opinions also.
3. It is a formal approach in which consensus can be achieved on the various evaluation factors and their effect on final decisions.

4. Interrelationship among the criteria can be established.
5. The hierarchy of the AHP is very effective and useful in structuring the issues.
6. Inconsistent judgments can be tracked by the consistent ratio.
7. It is a very good tool for qualitative and subjective component criteria.
8. Applying AHP approach in group decision making results in better communication, good clarity in understanding the issues which are to be modeled.
9. It can be applied in any organization with any level of expertise as the inputs are normalized.

Limitations of AHP methodology (Shahroodi *et al*., 2012) –

1. It is a complex method.
2. Its decisions are based on the judgments of the experts which may be biased.

The AHP divides the decision problem into the following steps (Saaty, 1990; 2001).

1. Define an objective of the problem and determine its goal.
2. Structure the hierarchy from the top (objectives from a decision-makers viewpoint) through intermediate levels (criteria on which subsequent levels depend on) to the lowest level, which typically contains a list of alternatives.
3. Employ a pair-wise comparison approach. Saaty (2001) developed the original scale for pair-wise comparisons (Table 2). The pair-wise comparison matrix A, in which the element a_{ij} of the matrix is the relative importance of the i^{th} factor on the j^{th} factor, could be calculated as

$$A = [a_{ij}] = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ 1/a_{12} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ 1/a_{1n} & 1/a_{2n} & \cdots & 1 \end{bmatrix} \quad (1)$$

4. There are $n\ (n\text{-}1)$ judgments required developing the set of matrices in step 3. Reciprocals are automatically assigned to each pair-wise comparison, where n is the matrix size.
5. Hierarchical synthesis is now utilized to weight the eigenvectors according to weights of criteria.
6. Having made all pair-wise comparisons, consistency is identified by using the Eigen value $\lambda \max$, to calculate the consistency index, Saaty (1990) proposed that, the largest Eigen value, $\lambda \max$ will be

$$\lambda \max = \sum_{j=1}^{n} a_{ij} \frac{W_j}{W_i} \quad (2)$$

Where: $\lambda \max$ is the principal or largest Eigen-value of positive real values in a judgment matrix;
W_j is the weight of j^{th} factor
W_i is the weight of i^{th} factor.

7. Consistency test: Each pair-wise comparison contains numerous decision elements for the consistency index (CI), which measures the entire consistency judgment for each comparison matrix and the hierarchy structure. Saaty (1990) utilized the CI and consistency ration (CR) to assess the consistency of the comparison matrix. The CI and CR are expressed as

$$\text{CI} = \frac{\lambda \max - n}{n-1} \quad (3)$$

Where, n is the matrix size

$$\text{CR} = \frac{\text{CI}}{\text{RI}} \quad (4)$$

Where, RI is the random index for the matrix size (m). The value of RI depends on the number of items being compared and is given in Table 3. The judgment consistency can be checked by taking the CR of CI with the appropriate value. The CR is acceptable if it does not exceed 0.10.

Table 2. Scale for pair-wise comparisons (Saaty, 1980).

Numerical rate	Judgment
1	Factor i and j are equal important
3	Factor i is weak important
5	Factor i is strong important
7	Factor i is demonstrated important
9	Factor i is absolute important
2, 4, 6, 8	Intermediate values between the two adjacent judgment
Reciprocal	If the important rate of factor i to j is R_{xy}, then the important rate of factor j to i is $R_{yx}=1/R_{xy}$

Table 3. Average random consistency index (RI) (Alonso and Lamata, 2006).

n	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**19**	**20**
RI	0	0	0.524	0.881	1.108	1.248	1.341	1.405	1.45	1.485	1.626	1.634

4. Case study

This section of the paper will demonstrate the model for the selection of 3PLSP using the AHP methodology. To demonstrate the practical application of the model discussed above Indian cement manufacturing industries were considered. In this paper, the problem statement is to identify and rank the criteria for the selection of the most appropriate 3PLSP for Indian cement manufacturing industries.

4.1 Identification of selection criteria

For the sample population, experts from academia, experienced professionals/practitioners involved in the management of the cement manufacturing industries were chosen as they have the keen ability to compare and grade the criteria for the selection of 3PLSP. Saaty (2001) mentioned that small sampling size (<10 responses) is required if the data is collected from the experts. This is because professionals or practitioners share consistent belief which declines the need for a significant sample size and the sample size selected for this research work is 9. Questionnaires were distributed to the professionals/practitioners, brainstorming session was conducted followed by interviews for the selection of 3PLSP and twenty most important criteria were identified (Table 4). The analysis on these criteria was done using analytic hierarchy process (AHP), which is the tool for multi-criteria decision making (MCDM) approach. The normalized pair-wise comparison matrix of the identified criteria is shown in the Table 5.

4.2 Validation

The consistency ratio of each matrix size measures the variation from the pure inconsistency. The consistency threshold for 3 x 3 matrix is 5 % and for 4 x 4 matrix it is 8 % (Saaty, 1994). The acceptable consistency ratio should be less than 10 % (Vargas, 1982), although a ratio of less than 20 % is considered tolerable (Ho *et al*., 2005; Saaty, 1990; 1977; Wedley, 1993).

After applying the AHP methodology to the identified selection criteria, the following values were obtained- largest principal Eigen value of the comparative matrix

$\lambda \max = 26.151$, Consistency Index (CI) = 0.3289, and the Consistency Ratio (C.R) =19.81%, which is in the critical acceptable range (10 % < 19.81 % < 20 %).

5. Results & Discussion

After analyzing twenty identified criteria by applying the AHP method the results obtained along with the rankings is shown in Table 6. The factor having highest rank is the cost of service and the second factor is compatibility with the users. The quality of service, reputation of vendor, performance measurement are at third, fourth and fifth positions. At the positions of sixth, seventh, eighth, ninth & tenth level is flexibility in billing, long-term relationship, willingness to use logistics manpower, quality of management & information sharing and mutual Trust. The last ten low-ranking factors in the descending order are fixed asset, operational performance, experience in similar product, Information technology capacity, delivery performance, financial performance, employee satisfaction level, market share, geographical spread and range of services provided and flexibility in operation & delivery.

Table 4. Identified selection criteria.

Sr. No	Selection Criteria
1	Compatibility with the Users
2	Cost of Service
3	Quality of Service
4	Reputation of Vendor
5	Performance Measurement
6	Willingness to Use Logistics Manpower
7	Flexibility in Billing
8	Long-Term Relationship
9	Quality of Management
10	Information Sharing and Mutual Trust
11	Operational Performance
12	Information Technology Capacity
13	Fixed Asset
14	Experience in Similar Product
15	Delivery Performance
16	Employee Satisfaction Level
17	Financial Performance
18	Market Share
19	Geographical Spread and Range of Services Provided
20	Flexibility in Operation and Delivery

Table 5. The normalized pair wise comparison matrix.

S.NO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.1599	0.3432	0.1818	0.1697	0.1789	0.0849	0.0849	0.1263	0.1052	0.0687	0.11561	0.0913	0.10307	0.0616	0.07064	0.0737	0.0632	0.0733	0.06159	0.062271
2	0.06	0.1287	0.4415	0.3607	0.2534	0.2122	0.2062	0.1263	0.1139	0.1146	0.08841	0.1034	0.09095	0.0951	0.03803	0.054	0.0583	0.0388	0.06981	0.043956
3	0.0685	0.0227	0.0779	0.1697	0.2534	0.2405	0.2062	0.0804	0.149	0.084	0.08841	0.0913	0.07882	0.0951	0.0815	0.0835	0.0632	0.0646	0.05338	0.062271
4	0.06	0.0227	0.0292	0.0636	0.1044	0.099	0.1334	0.1378	0.0789	0.1298	0.10201	0.1034	0.06669	0.0727	0.0815	0.0638	0.0632	0.0646	0.05338	0.062271
5	0.04	0.0227	0.0137	0.0273	0.0447	0.1556	0.1334	0.1492	0.149	0.1298	0.11561	0.1034	0.10307	0.0951	0.09237	0.0589	0.0292	0.0302	0.04517	0.043956
6	0.08	0.0257	0.0137	0.0112	0.0122	0.0424	0.0971	0.1378	0.0526	0.0535	0.07481	0.073	0.05457	0.0951	0.0815	0.0835	0.0535	0.056	0.06159	0.047619
7	0.0685	0.0227	0.0137	0.0112	0.0122	0.0159	0.0364	0.1263	0.1139	0.1146	0.08841	0.1034	0.09095	0.0951	0.07064	0.0737	0.0632	0.056	0.06159	0.047619
8	0.0436	0.0351	0.0334	0.0273	0.0103	0.0106	0.0099	0.0344	0.149	0.1298	0.07481	0.0791	0.09095	0.0727	0.09237	0.0835	0.0729	0.0733	0.06981	0.062271
9	0.04	0.0297	0.0137	0.0112	0.0079	0.0212	0.0084	0.0061	0.0263	0.0687	0.11561	0.0913	0.10307	0.0616	0.07064	0.0737	0.0632	0.0733	0.06159	0.062271
10	0.0533	0.0257	0.0212	0.0174	0.0079	0.0182	0.0073	0.0061	0.0088	0.0229	0.05441	0.0426	0.04851	0.0671	0.0326	0.0344	0.0535	0.0517	0.03696	0.025641
11	0.0282	0.0297	0.018	0.0147	0.0079	0.0116	0.0084	0.0094	0.0046	0.0086	0.0204	0.0487	0.07276	0.0336	0.03803	0.054	0.0583	0.0388	0.02874	0.062271
12	0.032	0.0227	0.0156	0.0127	0.0079	0.0106	0.0064	0.0079	0.0053	0.0098	0.00765	0.0183	0.04851	0.0448	0.0652	0.0295	0.034	0.0474	0.04928	0.032967
13	0.0282	0.0257	0.018	0.0147	0.0079	0.0141	0.0073	0.0069	0.0046	0.0086	0.0051	0.0068	0.01819	0.0727	0.0815	0.0638	0.0827	0.0646	0.03285	0.047619
14	0.0436	0.0227	0.0137	0.0112	0.0079	0.0075	0.0064	0.0079	0.0072	0.0057	0.0102	0.0068	0.0042	0.0168	0.07064	0.0737	0.0632	0.0733	0.06159	0.054945
15	0.0369	0.0552	0.0156	0.0127	0.0079	0.0085	0.0084	0.0061	0.0061	0.0115	0.00874	0.0046	0.00364	0.0039	0.0163	0.0638	0.0827	0.0646	0.06981	0.047619
16	0.032	0.0351	0.0137	0.0112	0.0103	0.0075	0.0073	0.0061	0.0053	0.0098	0.00556	0.0091	0.0042	0.0034	0.00376	0.0147	0.0729	0.0388	0.02874	0.043956
17	0.0369	0.0322	0.018	0.0147	0.0224	0.0116	0.0084	0.0069	0.0061	0.0062	0.0051	0.0078	0.00321	0.0039	0.00288	0.0029	0.0146	0.0733	0.06981	0.054945
18	0.0282	0.0429	0.0156	0.0127	0.0192	0.0098	0.0084	0.0061	0.0046	0.0057	0.0068	0.005	0.00364	0.003	0.00326	0.0049	0.0026	0.0129	0.06981	0.062271
19	0.032	0.0227	0.018	0.0147	0.0122	0.0085	0.0073	0.0061	0.0053	0.0076	0.00874	0.0046	0.00682	0.0034	0.00288	0.0063	0.0026	0.0023	0.01232	0.062271
20	0.0282	0.0322	0.0137	0.0112	0.0112	0.0098	0.0084	0.0061	0.0046	0.0098	0.0036	0.0061	0.0042	0.0034	0.00376	0.0037	0.0029	0.0023	0.00217	0.010989

Table 6. The final rankings of criteria obtained by AHP method.

S. No.	Weights	%	Ranking	Selection Criteria
1	0.11398	11.39795	**2**	Compatibility with the users
2	0.134915	13.49154	**1**	Cost of service
3	0.105724	10.57238	**3**	Quality of service
4	0.079628	7.962783	**4**	Reputation of vendor
5	0.079127	7.912729	**5**	Performance measurement
6	0.060369	6.036903	**8**	Willingness to use logistics manpower
7	0.064308	6.430752	**6**	Flexibility in billing
8	0.06276	6.276006	**7**	Long term relationship
9	0.05047	5.047032	**9**	Quality of management
10	0.031809	3.180908	**10**	Information sharing and mutual trust
11	0.029834	2.983411	**12**	Operational performance
12	0.025424	2.542374	**14**	Information technology capacity
13	0.030603	3.06025	**11**	Fixed asset
14	0.028464	2.846438	**13**	Experience in similar product
15	0.026722	2.672153	**15**	Delivery performance
16	0.018173	1.817317	**17**	Employee satisfaction level
17	0.020085	2.008533	**16**	Financial performance
18	0.016368	1.636806	**18**	Market share
19	0.012321	1.232089	**19**	Geographical spread and range of services provided
20	0.008916	0.891643	**20**	Flexibility in operation and delivery

6. Conclusion

The 3PLSP activities have become very popular industrial practices in the current scenario. This research paper investigated and quantitatively modeled approach to select 3PL service providers for Indian cement manufacturing industries. The results of the study showed that the compatibility with the users and cost of service are the most significant criteria, and geographical spread and range of services provided, flexibility in operation and delivery are found to be the least important.

It may be noted that an AHP approach gives logical results and helps the managers of the industry to visualize and analyze the effect of various selection criteria on the final decision to be taken and directs the 3PLSP choice towards a logical decision-making process, which can be advantageous to all the cement manufacturers wanting to hire a third party to provide logistics services.

Işıklar (2007) used fuzzy sets theory for logistics outsourcing and found that performance, cost, and quality are important. Peng (2012) analyzed the 3PLSP selection criteria for the frozen food industry using AHP approach and concluded that transportation cost, and operation speed are among the relevant criteria from the selection perspective. Kannan *et al*. (2009) developed a hierarchical model using ISM and fuzzy TOPSIS methodology for battery manufacturing industries and stated that willingness and attitude is the significant selection criterion, which is similar to the

compatibility with the user parameter of this research work. Liu and Wang (2009) used integrated fuzzy for the selection of 3PLSP for electronics industries and found that customer service is very important and experience in the similar industry is not relevant criteria. Asuquo *et al*. (2014) evaluated the 3PLSP selection factors for a shipping industry using AHP tool and stated that reputation is the most important factor for the selection of 3PLSP. All these results of other researchers are very much in parallel with the findings of the present research.

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) and Cirpin and Kabadayi (2015) highlighted that a factor namely flexibility is one of the most important parameters in deciding the 3PLSPs selection. Liu and Wang (2009), Garg (2016), Narkhede et al.(in press) and Govindan *et al*. (2012) found that logistics information system were among the significant selection parameters for the 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.

There are two limitations of the research- 1. In this study only 20 relevant selection criteria are considered, there may be other criteria which are not included in this model, but may affect the selection process. Further considering more criteria will give good results. 2. The present model is developed by respecting the judgments of the expert panel from cement manufacturing industries, which may be biased and, in turn, affects the accuracy of the results.

Also, in the present research, AHP methodology is used for identifying 3PLSP selection criteria and to rank them. The same may be done by using other MCDM tools to get a good accuracy of results or for the validation purposes. The integrated approach may be utilized like AHP- IRP (interpretive ranking process), or AHP- TOPSIS (technique for order preference by similarity to ideal solution), etc. In future authors would like to validate the present model by using structural equation modeling (SEM) methodology also commonly known as linear structural relationship approach.

7. Managerial Implications

The selection of a responsive 3PL service provider enhances the overall performance of the supply chain by improving the service level, quality, delivery and operational performance, which increases the reputation of the organization. The use of internal and external resources efficiently yields to reduction of prices of the commodities or services, resulting in customer satisfaction, improves the long-term relationship and increased market share for the organization. It is the need of time for every organization to progress and survive in a competing environment. Therefore, 3PLSP selection problem is one of the most significant issues of a supply chain management. The 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 3PLSP's and proposed a decision model. It directs the 3PLSP's selection problem towards 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 3PLSP's selection process.

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