A Multi Criteria Approach for Selecting Third Party Logistics Provider using Analytical Hierarchical Processing (AHP) - Insights from Edible Oil Industry

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Abstract— *Edible oils constitute an important component of food expenditure in every household and thus a big market for the industry. As distribution is mainly dependent on third party logistics, there is an increasing need to analyse the complexity and make decisions pertaining to selecting a new third party logistics provider (3PL). The use of 3PL providers yield some benefits such as reduced logistics costs and fixed logistics assets, improved order fill rates and shortened average order-cycle lengths and cash-cash cycles. Logistics service provider selection is a complex multi – criteria decision making process; in which, decision makers have to deal with the optimization of conflicting objectives such as quality, cost, and delivery time.*

In this context, this study proposes an evaluation framework and methodology for selecting a suitable 3PL provider using a multi criteria decision making technique - Analytical Hierarchical Process (AHP). The factors that were considered for the study are operational factors, service factors and financial factors in the outbound logistics of the edible oil industry. Four logistics providers were used in this study. The findings of this study provide insights to the logistics managers on the systematic evaluation in the selection of the logistics providers using both qualitative and quantitative factors as well as how to deal effectively when there are conflicting factors.

Keywords—Analytical Hierarchical Programming, Edible Oil Industry, Multi Criteria Decision Making, Vendor Selection.

I. INTRODUCTION

Edible oil is one of the important constituents of Indian food. Different oils are used in different states according to their availability and custom-oriented food habits. Major edible oils manufactured in Tamil Nadu are groundnut oil, gingely oil, coconut oil and sunflower oil. Although edible substitutability features prevail among these oils, constraints imposed by social, cultural and value systems together with demographic implications resulting in supply and demand imbalances and scarcities threatening the supply position necessitated a study of the present kind. It is also often reported that many oil mills are in deplorable conditions and new entrepreneurs are reluctant to start new units.

The demand for edible oils in India has shown a steady growth at a CAGR of 4.43% over the period from 2001 to 2011. The growth has been driven by improvement in per capita consumption, which in turn is attributable to rising income levels and living standards. However, the current per capita consumption levels of India (at 13.3 Kg/year for 2009 - 10) are lower than global averages (24 kg /year). The Indian edible oils market continues to be underpenetrated and given the positive macro and demographic fundamentals it has a favourable demand growth outlook over the medium-to-long term. The Indian edible oil industry is highly fragmented, with the presence of a large number of participants in the organised and unorganised sectors. This has resulted in severe competition and inherently thin profitability margins. Further, the profitability of market participants has also been vulnerable to risks emanating from weak harvests; commodity price volatility and forex movements.

II. SUPPLIER SELECTION PROCESS

The role of purchasing in supply management has received and continues to receive increasing attention as the years go by. Purchasing enhances efficiency and competitiveness among other benefits but to realize these benefits it is imperative to select and continue to choose the right supplier. Some of the factors firms consider include trust and commitment, adequate finance, quality, reliable delivery times, adequate logistic technological capabilities (Cox, 1999). Materials delivery, quality, cost/price, financial position, communication and technology is recognized as the commonly used criteria, a fact confirmed from empirical results as well as in previous literature. However other criteria such as ISO

certification, reliability, credibility, good references and product development were are also necessary. This shows that focus is shifting from solely relying on quantitative factors to include qualitative criteria (Harps, 2000).

Many authors agree that the following factors makes the supplier selection decision making process complicated (Vera and Pullman, 1998). These factors are (1) multiple criteria: Both qualitative and quantitative (2) Conflict amongst criteria: Conflicting objectives of the criteria (3) involvement of many alternatives: Because of high competition (4) internal and external constrains imposed on Buying process. However, it takes a lot of work effort and patience to develop this partnership. Since, the right supplier selection process encompasses different functions such as purchasing, quality etc. within the company; it is a multi-objectives problem, encompassing many tangible and intangible factors in a hierarchical manner. Effective supplier means suppliers who can supply the right amount of materials or services at the right time, at right price and the right quality.

Over the last two decades the world economy has been dramatically changed due to various reasons. The environment of business is characterized by rising complexity, uncertainty, instability and volatility. Companies have to do re-thinking that traditional methods and strategies for doing business to the pressure of changing market conditions, intensified global competition, radical change in technology and shorter product life cycle. Managers are now realizing that no matter how strong and resourceful their firms might be, they are no longer able to maintain a competitive advantage at every step in the value chain in all national market, nor are they able to maintain a cutting edge in the wide range of technologies required for the design, development manufacturing and marketing of new products (Hanfield and Nicholas, 2007).

Supplier selection is generally considered as five phase process starting from the realization of the need for a new supplier, determination and formulation of decision criteria; pre-qualification; final supplier selection; to the monitoring of the supplier selection (Choy and Lee, 2002). At first, evaluation and assessment task needs the identification of decision characteristics against which the potential suppliers are to be assessed. Next evaluation seals are selected in order to measure the appropriateness of a supplier. The next step is to assign weight to attributes to identify the significance and contribution of each criterion to the supplier evaluation and assessment. Then an attribute may comprise of several sub attributes. The last stage is to evaluate potential suppliers against the characteristics identified at the beginning (Choy and Lee, 2002).

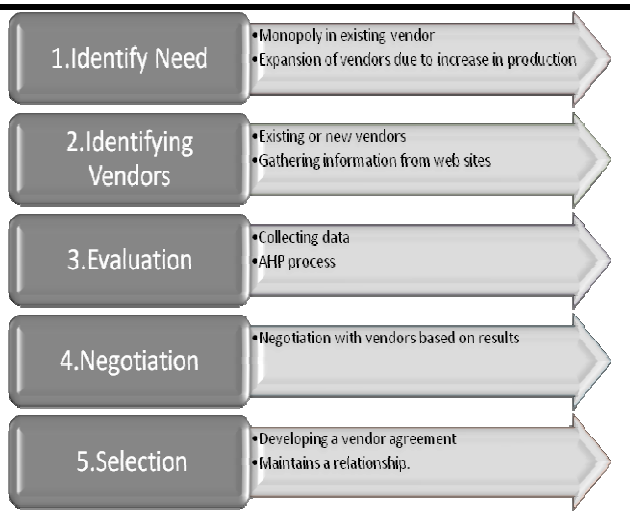

Fig. 1: Supplier Selection Process

of the paper. The contents of each section may be provided to understand easily about the paper.

III. FACTORS AFFECTING SELECTION

Stanley and Gregory (2001) came up with the supplier selection criterion which has since gained a lot of fame. Their model consists of;

1. Cost Criteria

The aim of this criterion is to identify vital element of cost associated with purchase. The most common cost related with a product is purchase price, transportation cost and taxes (Stanley and Gregory, 2001). Operational costs are also being considered during the supplier selection. The operational cost includes transaction processing; cost of rejects etc. but it requires more effort to estimate. Thus, cost is very important criterion for selection of right suppliers. The cost factor has been measured based on the importance of the following cost/price dimensions in supplier selection in telecommunication industry: raw material cost, cost due to delay, cost of inspection, after sales service, rework cost, engineering cost and labor cost. Profit maximization cannot be achieved without the cost minimization.

2. Price

The firm always requires the minimum price of the product to increase the profitability. The firm therefore must find a low-cost supply base where it can minimize manufacturing cost related to the production of the Product. Basically, price containment leads to supplier attractively.

3. Distribution Cost

This contains the lengthy distribution channel cost, transport expenses, inventory cost, handling and packaging Cost, damages during transportation and insurance costs. Since every business enterprise is out to procure at least cost possible, cost management brings a

lot of business to suppliers who offer least cost, holding other factors constant.

4. Technical Capability

Suppliers' need competent technical or service, ability ensure future to improvements in performance and promote successful development efforts. Especially, this is very important when the firm's strategy included development of technology. These technical criteria insist company to shift into the global market place. This factor has been measured on the basis of the importance of the following technical dimensions: compliance with quantity, compliance with due date, compliance with packaging standard, production planning systems of suppliers, and maintenance activities of suppliers, plant layout and material. The production facilities and ability of the supplier to increase its capacity should also be taken into account to Judge the best one. The potential production capability of each supplier should be analyzed to meet a specified Production plan and also to develop a new product according to the market demand (Harps, 2000).

5. Quality Assessment

Quality assessment is a key factor of suppliers by which they can improve and maintain quality and delivery performance. It Quality and availability of product depends on this criterion. This factor has been measured on the basis of the importance of the following quality dimensions: management commitment, product development of suppliers, process improvement of suppliers, quality planning and quality assurance in supply chain, quality assessment in production, inspection and experimentation and quality staff of supplier (Beamon, 1999). The rejection rate of the product is defined in the terms of the number of parts rejected by the customers in fixed time period because of some quality problems.

6. Service Levels

The performance of the supplier in providing service to the manufacturer is the prime criteria to decide its suitability for a particular product.

7. Delivery

The ability of the supplier to follow the predefined delivery schedule is always the prime criteria for selection in this fast moving world. This means that suppliers who keep their promises are easier and profitable to work with.

8. Lead Time

This is the time between order and placement of material and the actual delivery. Shorter the lead time, the better the supplier. Every purchasing firm will be comfortable when the lead time is shortest possible. Long lead time has the impression that the specific supplier is less efficient or he just has more customers than he can serve thus delaying deliveries (Beamon, 1999).

9. Ease of Communication

The ease of communication and negotiability with the suppliers decide the long-term relation between the supplier and manufacturer. Since languages, business customs, ethics and communication devices vary from country to country, good suppliers should be best communicators; good message in good time.

10. Supplier's Profile

The performance and past history of the suppliers help in taking decisions for its selection. The components of a suppliers profile are summarized below:

(i) Financial Status

The financial status of the supplier can be analyzed by getting the information about the annual turnover of the Supplier and their financial structure based on the past history. The economic status of that affect the currency is exchange rate, local price control and so forth. This can result in higher hidden costs for international sourcing and into during the supplier selection. A good supplier should have a good financial base so that in case of delayed payments, supply is not hindered (Awino, 2002).

(ii) Response of Customers

The response of the customers towards the supplier is one of the important factors to decide the performance of the supplier. Suppliers with good customer base should be preferred than the others. Customer numbers cannot lie, where the customers are, the deal is good.

(iii) Performance History

The performance history of the supplier should be analyzed carefully keeping in mind the competitive nature of the supplier, its past production schedule, response to market, and its ability to make commercial relations and business references. It is easy to get a profile of ageing supplier easier than new suppliers. Research shows that, old suppliers are more experienced and more stable in business.

(iv)Risk Factor

Owing to a number of exogenous factors influencing international sourcing, global supplier selection is much riskier than its domestic counterpart. Consequently, the global supplier selection decision is most strongly affected by perceived risks. They can be stated as below:

(v) Geographical Location

The location of the supplier and its physical and social status should be analyzed properly before selection of global partner. The home country of the supplier, the location of plant, the nature of natural calamities, and other factors should be checked before the selection because for long-term relation it may create problems in the supply of the goods.

IV. DATA ANALYSIS TECHNIQUE

In the process choosing the third-party logistics

providers, the methods are mainly two types of qualitative and quantitative. Supplier selection methods are mainly qualitative experience to determine the method, public tender law, selection method consultation, benchmarking method, etc. Currently, domestic and international supplier selection method for the study focused on quantitative models. From the collection of literature, the most commonly used logistic model for supplier selection and evaluation are as follows:

1. Analytical Hierarchical Process (AHP)

Yahya Kingsman[1999) tried to get vendor evaluation criteria and their corresponding weights. Tongguo Wu, Leifu Gao (2005), Jiani Zhao, (2005), Jian Liu (2007) using AHP to select suppliers of logistics. Huayi Shan, Yaorong Cheng (2007) used ANP to carry out the third-party logistics providers and selection.

2. Data Envelopment Analysis (DEA)

Yao Chen、Joe Zhu (2003) used both parties two stages game model to simplify DEA model, to establish a efficiency interval, and to select suppliers. ChuanXu Wang (2004) used the SE-DEA method; YongRui Duan, Tian Peng, WeiPing Zhang (2004), Ao Chen (2007), also used the DEA method to select and evaluate the third party logistics provider.

3. Fuzzy Comprehensive Evaluation Method

CebeciU[10] (2001), LiJiang Zhao (2003), KaiYuan Liu (2004), ChengWu Fang, XunPing Lei (2005), MinTun Li (2006), YiXin Shi, DanSong zhang (2006), a large number of studies used fuzzy comprehensive evaluation method to select and evaluate the third party logistics supplier.

4. Statistical Analysis Method

Rong Chen (2007) adopted the principal component analysis method. ChunXia Chen, ZhiBin Yu (2007) adopted the fuzzy clustering method to select the third party logistics supplier.

V. ANALYTIC HIERARCHY PROCESS

Analytic Hierarchy Process (AHP), introduced by Thomas Saaty (1980), is an effective tool for dealing with complex decision making, and may aid the decision maker to set priorities and make the best decision. By reducing complex decisions to a series of pair wise comparisons, and then synthesizing the results, AHP helps to capture both subjective and objective aspects of a decision. In addition, AHP incorporates a useful technique for checking the consistency of the decision maker's evaluations, thus reducing the bias in the decision making process.

How AHP works

AHP considers a set of evaluation criteria, and a set of alternative options among which the best decision is to be made. It is important to note that, since some of the criteria could be contrasting, it is not true in general that the best option is the one which optimizes each single criterion, rather the one which achieves the most suitable trade-off among the different criteria.

AHP generates a weight for each evaluation criterion according to the decision maker's pair wise comparisons of the criteria. The higher the weight, more important is the corresponding criterion. Next, for a fixed criterion, the AHP assigns a score to each option according to the decision maker's pair wise comparisons of the options based on that criterion. The higher the score better is the performance of the option with respect to the considered criterion. Finally, AHP combines the criteria weights and the options scores, thus determining a global score for each option, and a consequent ranking. The global score for a given option is a weighted sum of the scores it obtained with respect to all the criteria.

VI. SELECTING THIRD PARTY LOGISTICS PROVIDER USING ANALYTICAL HIERARCHICAL PROCESSING

The study is based on an edible oil manufacturer in Tamilnadu which manufactures around 800 MT of products daily, most of which is distributed around southern states. The company outsources primary transportation from factory to Clearing and Forwarding Agents (CFA) here. There are around 40 CFAs around Tamil Nadu and Karnataka. Most of the logistics is handled by single transporter. The study focuses on the expansion of its logistics with respect to transportation and identifies an alternative vendor to transport the additional increase in production without affecting the performance of existing vendor and to identify, evaluate and select new vendors to move finished goods around Tamil Nadu on basis of different factors. Data for the study were a combination of both primary and secondary from the company and websites of vendors.

The factors considered for the study are as follows:

- Operational Factors
  - Number of own fleets
  - Branch offices
  - Level of information
- Service factors
  - Customer Satisfaction
  - Timely Delivery
- Financial factors
  - Freight rate
  - Bill submission

AHP can be implemented in three simple consecutive steps:

- Computing the vector of criteria weights.

- Computing the matrix of option scores.
- Ranking the options.

AHP is a systematic method for using hierarchies to structure a decision problem. The first step is to determine the criteria. The criterion in this study is to select a vendor. AHP is a theory of measurement which uses both subjective and objective criteria. AHP uses pair wise comparison which is more accurate than scoring method. Pair wise comparisons are used to determine the relative importance of each alternative in terms of each criterion. In this approach the decision-maker has to express his opinion about the value of one single pair wise comparison at a time. Usually, the decision-maker has to choose his answer among 10-17 discrete choices. Each choice is a linguistic phrase. Some examples of such linguistic phrases are: "A is more important than B", or "A is of the same importance as B".

Intensity of Importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Weak importance of one over another	Experience and judgment slightly favor one activity over another
5	Essential or strong Importance	Experience and judgment strongly favor one activity over another
7	Demonstrated Importance	An activity is strongly favored and its dominance demonstrated in practice
9	Absolute importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values between the two adjacent judgments	When compromise is needed
Reciprocals of above nonzero	If activity i has one of the above nonzero numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i.	

A case in which pair wise comparisons are expressed as differences (instead of ratios) was used to define similarity relations and is described by Triantaphyllou (1993). The following paragraphs examine the issue of quantifying pair wise comparisons. Since pair wise comparisons are the keystone of these decision-making processes, correctly quantifying them is the most crucial step in multi-criteria decision-making methods which use qualitative data.

Pair wise comparisons are quantified by using a scale. Such a scale is a one-to-one mapping between the set of discrete linguistic choices available to the decision maker and a discrete set of numbers which represent the importance, or weight, of the previous linguistic choices. The scale proposed by Saaty is depicted in table 1. Other scales have also been proposed by others. An evaluation of 78 different scales appears in Triantaphyllou et al. (1994). All the alternative scales depart from some psychological theories and develop the numbers to be used based on these psychological theories.

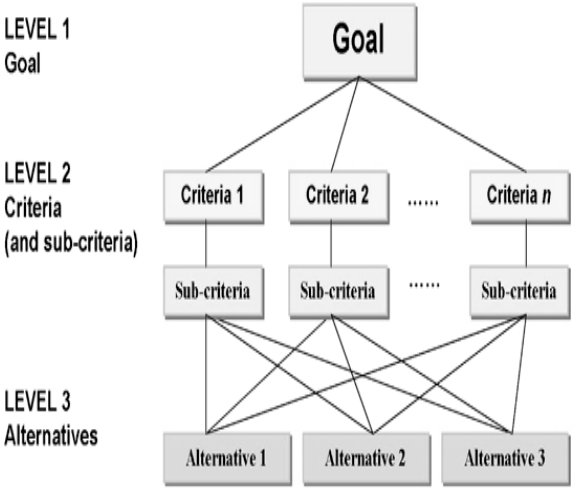

Fig. 2:AHP Overview

In 1846 Weber stated his law regarding a stimulus of measurable magnitude. According to his law a change in sensation is noticed if the stimulus is increased by a constant percentage of the stimulus itself (Saaty, 1980). That is, people are unable to make choices from an infinite set. For example, people cannot distinguish between two very close values of importance, say 3.00 and 3.02. Psychological experiments have also shown that individuals cannot simultaneously compare more than seven objects (plus or minus two) (Miller, 1956). This is the main reasoning used by Saaty to establish 9 as the upper limit of his scale, 1 as the lower limit and a unit

difference between successive scale values.

The values of the pair wise comparisons in the AHP are determined according to the scale introduced by Saaty (1980). According to this scale, the available values for the pair wise comparisons are members of the set: {9, 8, 7, 6, 5, 4, 3, 2, 1, 1/2, 1/3, 1/4, 1/5, 1/6, 1/7, 1/8, 1/9}

The pair wise comparison procedure is a part of Analytic Hierarchical Process (AHP) and the step wise analysis is as follows.

The hierarchy table is constructed which has the objective at the top level. The next hierarchy indicates the main criteria for the study. The third branch indicates the sub-criteria for each main criterion and at the bottom of table gives the alternatives for study which includes all the vendors used for the study.

Once the problem is defined and the hierarchy structured, the next step is to construct a pair wise comparison matrix of the relative contribution or impact of each element on each governing objective or criterion in the adjacent upper level. In such a matrix of the elements by the elements, the elements are compared in a pair wise manner with respect to a criterion in the next level. In comparing the i.j elements, people prefer to give a judgement which indicates the dominance as an integer. Thus, if the dominance does not occur in the i,j position while comparing the i th element with the j th element then it is given in the i position as aji and its reciprocal is automatically assigned to aji.

Factor-Operational services

Factor	Branch office	Own fleet	Level of information
Branch office	1	3	3
Own fleet	0.33	1	0.11
Level of information	0.33	3	1
Total	1.67	7	4.11

Pairwise Matrix

NORMALIZED MATRIX

Factor	Own fleet	Branch office	Level of information	Total	Avg	Consistency Measure
Branch office	0.43	0.43	0.73	1.59	0.53	3.67
Own fleet	0.14	0.14	0.03	0.31	0.10	3.08
Level of information	0.43	0.43	0.24	1.10	0.37	2.33
					C.I	0.01
					R.I	0.58
					C.R	0.03

Factor-Service level

Factor	Customer Satification	Type of vechile used	Timely Delivery
Customer Satification	1	0.25	3
Type of vechile used	4	1	5.00
Timely Delivery	0.33	0.20	1
Total	5.33	1.45	9.00

Pairwise Matrix

NORMALIZED MATRIX

Factor	Customer Satification	Type of vechile used	Timely Delivery	Total	Avg	Consistency Measure
Customer Satification	0.19	0.17	0.33	0.69	0.23	3.07
Type of vechile used	0.75	0.69	0.56	2.00	0.67	3.17
Timely Delivery	0.06	0.14	0.11	0.31	0.10	3.02
					C.I	0.04
					R.I	0.58
					C.R	0.07

Factor-Financial

Factor	Freight Ra	Bill Submission
Freight Rate	1	7
Bill Submission	0.125	1
Total	1.13	8.00

Pairwise Matrix

NORMALIZED MATRIX

Factor	Freight Ra	Bill Submission	Total	Avg	Consistency Measure
Freight Rate	0.89	0.88	1.76	0.88	1.94
Bill Submission	0.11	0.13	0.24	0.12	1.93
			C.I	-0.06	
			R.I	0.58	
			C.R	-0.11	

From the above tables, for operational factors, high preference is given to branch office, because it will help to communicate with them frequently in case of emergency; for service level, high preference is given to type of vehicle, because it is major factor when it comes to transporting huge volume and for financial factors, high preference is given to freight rate, because it accounts major of logistics cost. In all these three factors, the value of C.R is less than 0.1.

Next obtain all n(n-1)/2 judgements specified by the set of matrices.

The next step is to extract the relative importance implied by the previous comparisons. That is, how important are the three alternatives when they are considered in terms of the identifying a new vendor? Saaty asserts that to answer this question one has to estimate the right principal eigenvector of the previous matrix. Given a

judgment matrix with pairwise comparisons, the corresponding maximum left eigenvector is approximated by using the geometric mean of each row. That is, the elements in each row are multiplied with each other and then the n-th root is taken (where n is the number of elements in the row). Next the numbers are normalized by dividing them with their sum

An evaluation of the eigen value approach can be found in (Triantaphyllou and Mann, 1990). An alternative approach for evaluating the relative priorities from a judgment matrix is based on a least squares formulation and is described in (Triantaphyllou et al., 1990a and 1990b). One of the most practical issues in the AHP methodology is that it allows for slightly non-consistent pairwise comparisons. If all the comparisons are perfectly consistent, then the following relation should always be true for any combination of comparisons taken from the judgment matrix: aij = aik akj.

However, perfect consistency rarely occurs in practice. In the AHP the pairwise comparisons in a judgment matrix are considered to be adequately consistent if the corresponding consistency ratio (CR) is less than 10% (Saaty, 1980). The CR coefficient is calculated as follows. First, the consistency index (CI) needs to be estimated. This is done by adding the columns in the judgment matrix and multiply the resulting vector by the vector of priorities (i.e., the approximated eigenvector) obtained earlier. This yields an approximation of the maximum eigenvalue, denoted by 8max. Then, the CI value is calculated by using the formula: CI = (8max - n)/(n - 1). Next the consistency ratio CR is obtained by dividing the CI value by the Random Consistency index (RCI) as given in table 4.7.

When these approximations are applied to the previous judgment matrix it can be verified that the following are derived:

8max = 3.136, CI = 0.068, and CR = 0.117. If the CR value is greater than 0.10, then it is a good idea to study the problem further and re-evaluate the pairwise comparisons (this was not done in the numerical example in this paper).

Table 4.7: RCI values for different values of n.

N	1	2	3	4	5	6	7	8	9
RCI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45

After the alternatives are compared with each other in terms of each one of the decision criteria and the individual priority vectors are derived, the synthesis step is taken. The priority vectors become the columns of the decision matrix (not to be confused with the judgment matrices with the pairwise comparisons). The weights of importance of the criteria are also determined by using pairwise comparisons.

Therefore, if a problem has M alternatives and N criteria, then the decision maker is required to construct N judgment matrices (one for each criterion) of order MxM and one judgment matrix of order NxN (for the N criteria). Finally, given a decision matrix the final priorities, denoted by AiAHP, of the alternatives in terms of all the criteria combined are determined.

Decision Matrix

Factor/Vendors	Operation	Financial	Service Factors		Priority of factors		Decision
MAA	0.62	0.65	0.36	*	0.07	=	0.58
KRL	0.25	0.25	0.36		0.71		0.28
VDOO	0.08	0.08	0.12		0.22		0.09
Kataria	0.05	0.06	0.07				0.06

All the three vendors are evaluated based on the selection criteria using AHP based on operational, service and financial factors. Financial factors were considered more important. The decision matrix shows that the highlighted vendor is highly rated. Hence using multi dimensional decision making vendor selection can be made more holistic.

VII. CONCLUSION

This study aimed at using multi dimensional criteria for decision making and proposed a method for calculating relative index to compare vendor alternatives with a view to enter in a most favorable relationship with appropriate third party logistics provider leading to an effective and responsive supply chain. The method helps to obtain ordinal rankings of the available choices and is illustrated with the help of a situation from the edible oil industry. The methodology involves application of the analytic hierarchy process to relatively compare the choices. When new vendors approach any industry for business, no performance data of these new vendors is available. Only some subjective data can be available, based on which one cannot take correct decisions. The method discussed provides an appropriate tool for ranking new vendor alternatives for outsourcing. The model discussed can include maximum no. of vendor performance attributes and can be customized for particular industry. Future work can also include validation of this methodology using other examples from industry.

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