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Ozden Bayazit

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Ozden Bayazit
Central Washington University, Washington, District of Columbia, USA

Abstract

Purpose – To provide a good insight into the use of analytic network process (ANP) that is a multiple criteria decision-making methodology in evaluating supplier selection problems.

Design/methodology/approach – Supplier selection problems are multi-objective problems which have many qualitative and quantitative concerns. In this study, an ANP model is proposed in evaluating supplier selection process as a framework to help managers.

Findings – It is shown that ANP can be used as a decision analysis tool to solve multi-criteria supplier selection problems that contain interdependencies.

Research limitations/implications – ANP is a complex methodology and requires more comparisons than the traditional AHP and it increases the effort.

Originality/value – Provides an effective framework to guide managers for evaluating suppliers.

Keywords Vendor relations, Supplier relations, Analytical hierarchy process, Decision making

Paper type Research paper

Introduction

Strong competitive pressure forces many organizations to provide their products and services to customers faster, cheaper and better than the competitors. Managers have come to realize that they cannot do it alone without satisfactory vendors (Handfield and Nichols, 1999). Therefore, the increasing importance of supplier selection decisions is forcing organizations to rethink their purchasing and evaluation strategies and hence the selection of suppliers has received considerable attention in the purchasing literature (Ellram, 1990; Weber *et al.*, 1991; Nydick and Hill, 1992; Weber and Current, 1993; Verma and Pullman, 1998; Ghodsypour and O'Brien, 1998; Karpak *et al.*, 2001; Boer *et al.*, 2001; Park and Krishnan, 2001; Handfield *et al.*, 2002; Bhutta and Huq, 2002).

Studies over the years have addressed a variety of criteria that are important in vendor selection. The major premise of these studies is that many organizations spend a considerable amount of time evaluating their supply chain partners by the fact the strategic importance of supplier selection. Ellram (1990) examined the issue of supplier selection with the use of case studies of firms involved in buyer-supplier relationships. She developed some additional factors that should be considered in the selection of supply partners besides quality, cost, on-time delivery, and service. These factors were categorized into four groups: Financial issues, organizational culture and strategy, technology and a group of miscellaneous factors. She also concluded that there is no single model that fits every situation. Weber *et al.* (1991) reviewed 74 articles which address vendor selection criteria in manufacturing and retail environment published from 1966 to 1991. They provided a comprehensive view of the criteria that might be considered in supplier selection decisions. They showed that quality, delivery and net price have received the great amount of attention. Production facility, geographical

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location, financial position and capacity generated an intermediate amount of attention. Nydick and Hill (1992) considered four criteria in supplier selection: quality, price, delivery, and service. Research carried out among 139 managers by Verma and Pullman (1998) was designed to study how managers tradeoff among quality, cost, on-time delivery, delivery lead-time and flexibility attributes when choosing a supplier. They indicated that managers perceive quality to be most important supplier attribute, followed by on-time delivery and cost. Park and Krishnan (2001) examined the supplier selection practices among 78 small business executives and adopted 15 criteria from Ellram's (1990) study: strategic fit, top management compatibility, management attitude/outlook for the future, feeling of trust, compatibility across levels and functions of buyer and supplier firms, supplier's organizational structure and personnel, assessment of current manufacturing facilities/capabilities, assessment of future manufacturing capabilities, supplier's design capabilities, supplier's speed in development, economic performance/financial outlook, financial stability, supplier's safety record, business references, and supplier's customer base. Karpak *et al.* (2001) considered cost, quality and delivery reliability as vendor selection criteria. Handfield *et al.* (2002) focused on environmental issues in supplier evaluation. Bhutta and Huq (2002) used four criteria to evaluate suppliers: manufacturing costs, quality, technology, and service.

A number of quantitative approaches have been applied to vendor selection problems such as total cost ownership (TCO), analytic hierarchy process (AHP), linear programming, statistical approaches, etc. The main purpose of this paper is to show how the analytic network process (ANP) may be served as a decision analysis tool for supplier selection problems. The ANP is a new theory that extends the AHP to cases of dependence and feedbacks recently introduced by Saaty(2001b). Although the AHP has been extensively implemented, the ANP has not been implemented much yet. Some examples of ANP applications include re-engineering, supply chain performance, logistics, quality function deployment, energy policy planning, and project selection decisions (Hamalainen and Seppalainen, 1986; Partovi and Corredoira, 2002; Sarkis and Talluri, 2002; Agarwal and Shankar, 2002; Partovi, 2001; Lee and Kim, 2000; Ashayeri *et al.*, 1998; Meade and Sarkis, 1998; Sarkis, 1998; Sarkis, 1999).

In this study for the first time the ANP has been implemented to supplier selection problem. We proposed an ANP model to choose the best supplier. This paper organized in five sections. First, a review of the quantitative approaches to vendor selection problems is presented. The methodology of the study is explained next followed by an illustrative application of the ANP. Finally overall conclusion is described.

Existing vendor selection methods

A number of studies have been devoted to examining vendor selection methods. The common conclusion of these studies is that the multiobjective nature of supplier selection decisions (Karpak *et al.*, 2001; Nydick and Hill, 1992; Ghodsypour and O'Brien, 1998; Boer *et al.*, 2001). Weber *et al.* (1991) reviewed the quantitative approaches to vendor selection problems. According to this study, linear weighting models, mathematical programming models and statistical/probabilistic approaches have been the approaches the most utilized. Nydick and Hill (1992) and Akarte *et al.*(2001) showed how the AHP can be used to structure the supplier selection process. Addition to traditional AHP, fuzzy analytic hierarchy process approach is proposed by several authors (Zaim, *et al.*, 2003; Kahraman, *et al.*, 2003). Weber and Current (1993) developed a multiobjective programming approach to assist the purchasing manager in making vendor selection decisions. Ghodsypour and O'Brien (1998) proposed an integration of an AHP and linear programming model in choosing the best supplier. Boer *et al.* (2001) presented a review of decision methods reported in the literature for supporting the supplier selection process. They showed that several suitable Operations Research methods such as data envelopment analysis, total cost approaches, linear programming, linear weighting models, statistical methods, artificial-intelligence-based models have been used so far in the purchasing literature. Karpak *et al.* (2001) developed a visual interactive goal programming model to solve a multiple-replenishment purchasing problem. Bhutta and Huq (2002) presented two approaches (AHP and TCO) related to supplier selection decision and provided a comparison. Handfield *et al.* (2002) proposed an AHP model that included relevant environmental criteria in supplier selection decision. Cebi and Bayraktar (2003) structured a supplier selection problem using an integrated lexicographic goal programming and AHP model. The activity-based costing approach is also used in the literature (Dogan and Sahin, 2003).

Methodology

The ANP is the generalization of the AHP. ANP includes the AHP as a special case and can be used to treat more sophisticated decision problems than the AHP. The ANP makes possible to deal systematically with all kinds of dependence and feedback in a decision system.

The ANP is a coupling of two parts. The first consists of a control hierarchy or network of criteria and sub-criteria that control the interactions in the system under study. The second is a network of influences among the elements and clusters (Saaty, 2001a).

A decision problem that is analysed with the ANP is often studied through a control hierarchy or network. A decision network is structured of clusters, elements, and links. A cluster is a collection of relevant elements within a network or sub-network. For each control criterion, the clusters of the system with their elements are determined. All interactions and feedbacks within the clusters are called inner dependencies whereas interactions and feedbacks between the clusters are called outer dependencies (Saaty, 1999). Inner and outer dependencies are the best way decision-makers can capture and represent the concepts of influencing or being influenced, between clusters and between elements with respect to a specific element. Then pairwise comparisons are made systematically including all the combinations of element/cluster relationships. ANP uses the same fundamental comparison scale (1-9) as the AHP. This comparison scale enables the decision-maker to incorporate experience and knowledge intuitively (Harker and Vargas, 1990) and indicate how many times an element dominates another with respect to the criterion. It is a scale of absolute (not ordinal, interval or ratio scale) numbers. The decision maker can express his preference between each pair of elements verbally as equally important, moderately more important, strongly more important, very strongly more important, and extremely more important. These descriptive preferences would then be translated into numerical values 1, 3, 5, 7, 9, respectively, with 2, 4, 6, and 8 as intermediate values for comparisons between two successive judgments. Reciprocals of these values are used for the corresponding transposed judgments. Table I shows the comparison scale used by ANP.

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favour one activity over another
5	Strong importance	Experience and judgment very strongly over another, its dominance demonstrated in practice
7	Very strong importance	An activity is favoured very strongly over another; its dominance demonstrated in practice
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation
2, 4, 6, 8	For compromise between the above values	Sometimes one needs to interpolate a compromise judgment numerically because there is no good word to describe it

Table I.
The fundamental scale

Following all pairwise comparisons, the synthesized results would come up. Finally, the synthesized results of the control systems are combined to determine the best outcome. The result is a set of priorities of the alternatives.

The ANP methodology is explained step-by-step approach as following. All the intricacies of the methodology are not explained because of page limitations but the general approach to enable the reader to follow the paper intelligently. Saaty (2001b) explains the methodology fully in his book.

Step 1 – model construction

Determine one network for each control criterion. Determine all the criteria, which affect the decision. Determine the clusters for each network. One cluster will be the alternatives. Combine the relevant criteria into same clusters.

Step 2 – formulating the interdependencies and performing paired comparisons between the clusters/elements

For each control criterion construct a cluster versus a cluster matrix with one or zero as an entry depending on whether a cluster on the left side, influences or does not influence a cluster represented at the top of this matrix. Repeat the similar process for criteria versus criteria matrix. Again with one or zero as an entry depending on whether a criterion on the left side influences or does not influence a criterion represented at the top of this matrix. Perform the following paired comparisons to derive eigenvectors and to form a supermatrix.

- *Cluster comparisons.* Perform paired comparisons on the clusters that influence a given cluster with respect to control criterion. Weights derived from this process will be used to weight the elements in the corresponding column blocks of the supermatrix corresponding to the control criterion.
- *Comparisons of elements.* Perform paired comparisons on the elements within the clusters. Compare the elements in a cluster according to their influence on an element in another cluster to which they are connected (or on elements in their own cluster).
- *Comparisons for alternatives.* Compare also the alternatives with respect to all the elements.

Step 3 – constructing supermatrix
The outcome of the process above is unweighted supermatrix. It shows the pairwise comparisons of the criteria. In the unweighted supermatrix, the columns may not be column stochastic. Multiply the blocks of the unweighted supermatrix by the priority of corresponding influencing cluster and obtain stochastic matrix, which consists of columns all add up to one. Raise the supermatrix to large power to capture first, second, third degree influences. Take the powers of supermatrix until the differences between consecutive matrix elements less than very small number. To obtain the final priorities of all the elements in the limit matrix, normalize each block. Finally select the highest priority alternative.

Selecting the best supplier: an illustrative problem

The ANP methodology is applied to the assessment of the suppliers. The purpose of this illustrative ANP model is to select the best supplier. In this section the illustrative problem is explained.

Step1 – model construction
The first step is to structure the model to be evaluated. The purpose of this model is to select the best supplier. Three suppliers (Suppliers A, B, and C) are identified and ten decision attributes (quality, on-time delivery, price, flexibility, delivery lead-time, top management capability, personnel capabilities, process capability, financial capability, and market share) are determined to evaluate those alternatives. The relevant factors are clustered into supplier's performance and supplier's capability clusters. Then three suppliers are clustered into the alternatives cluster. Therefore, three clusters in the model are supplier's performance, supplier's capability and alternatives. This is a simple network model. Figure 1 is a view of the overall ANP model. Interdependencies are represented by straight arrows among the clusters and a looped arc within the same cluster in the figure below. The directions of the arcs signify dependence.

Step 2 – formulating the interdependencies and performing paired comparisons between the clusters/elements
The next step in the formulating the model was performing pairwise comparisons between clusters and criteria.

First, we formulated interrelationships among all factors. When formulating these relationships, each criterion is considered as a controlling factor for a pairwise comparison matrix. The question asked when formulating these relationships was: *With respect to a specific factor, which of a pair of factors more influenced?* For example, with respect to market share criterion, which one more affects market share, quality or flexibility, quality or price? After formulating interdependencies, pairwise comparisons are performed with respect to all those factors that have an impact on other factors within their own cluster or other clusters of the network. In this case, the factors in a cluster are compared according to their influence on a factor in another cluster to which they are connected (or on factors in their own cluster). To reflect interdependencies in the networks, pairwise comparisons among all the factors are conducted and these relationships are evaluated. Table II illustrates an example pairwise comparison matrix for the market share criterion. It shows that quality has the most influence on market share with a priority of 0.366, followed by price with 0.234. In evaluating a partner,

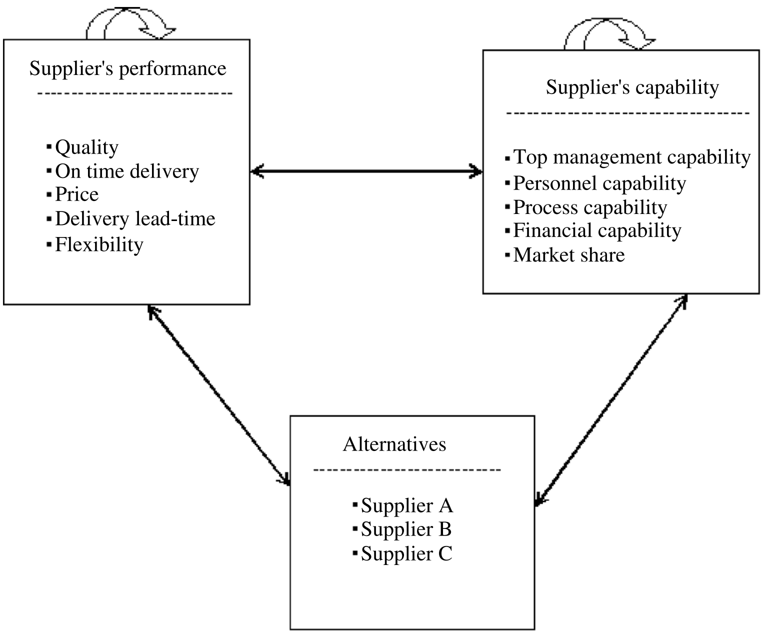

Figure 1.
Overall ANP model

	F	OD	P	Q	Priorities
DLT	1/3	1/2	1/2	1/4	0.079
F		3	1/2	1/2	0.208
OD			1/2	1/3	0.111
P				1/2	0.234
Q					0.366

Notes: F – flexibility, OD – on-time delivery, P – price, DLT – delivery lead-time, Q – quality

Table II.
Pairwise comparison matrix for market share as controlling factor, C.R. = 0.043

quality standards and price of the product provided by the supplier, performance in lead-time and on-time delivery requirements, and the responsiveness of the supplier to changes in purchase quantities and due dates influence supplier's market share.

Table III shows the pairwise comparison matrix for the alternatives with respect to quality criterion. In comparing the three suppliers based on quality, we asked which supplier is more preferred with respect to determining the best supplier under quality

Quality	Supplier A	Supplier B	Supplier C	Priorities
Supplier A	1	2	5	0.570
Supplier B			4	0.333
Supplier C				0.097

Table III.
Comparing the alternatives with respect to quality criterion, C.R. = 0.023

criterion. Supplier A appears superior to the other two alternatives according to quality criterion.

Since all the factors within the clusters affect the alternatives, the alternatives then were compared with respect to each cluster criteria. Table IV indicates the pairwise comparison matrix for Supplier A with respect to supplier's capability cluster criteria. Market share received the highest priority with 0.358.

After performing pairwise comparisons between factors and alternatives, we compared clusters to establish the weights in a cluster matrix. Through cluster comparisons the weighted priorities are calculated as to their impact on each cluster. The question when comparing the clusters was; for example, "Does supplier's performance or supplier's capability influence supplier selection more?"

The eigenvectors of the pairwise comparisons of the clusters are summarized in Table V. It shows how much clusters are influenced by each cluster. For example, the cluster of supplier's performance influences the cluster of supplier's capability (0.5397), and the cluster of alternatives (0.7500). Since there is an inner dependency within the cluster of supplier's performance, it influences itself as well (0.6795). The cluster of alternatives is influenced by all the clusters except itself because this entry has zero indicating no effect within the cluster.

Step 3 – constructing supermatrix

The next step is to construct the supermatrix. Tables VI-VIII illustrate unweighted, weighted and limit supermatrices of the factors within the network. The values in the cluster matrix are used to weight the unweighted supermatrix by multiplying the value in the (alternatives, supplier's performance) cell of the cluster matrix times the value in each cell in the (alternatives, supplier's performance) component of the unweigted supermatrix to produce the weighted supermatrix. Every component is weighted this way – a single number from the cluster comparison matrix is used to multiply all the numbers in the respective component in the unweighted supermatrix (Saaty, 2001a).

Table IV.
Pairwise comparison matrix for Supplier A based on supplier's capability cluster criteria, C.R. = 0.087

Supplier A	MS	PC	PRC	TMC	Priorities
FC	1/2	2	2	1/2	0.187
MS		3	2	3	0.358
PC			1	1/2	0.107
PRC				2	0.168
TMC					0.180

Notes: MS – market share, PC – personnel capability, PRC – process capability, TMC – top management capability, FC – financial capability

Table V.
Cluster weights matrix

	Supplier's performance	Supplier's capability	Alternatives
Supplier's performance	0.6795	0.5397	0.7500
Supplier's capability	0.2111	0.2969	0.2500
Alternatives	0.1093	0.1634	0.0000

		Alternatives			Supplier's capability					Supplier's performance			
		A	B	C	FC	MS	PC	PRC	TMC	DLT	F	OD	P	Q
Alternatives	A	0.000	0.000	0.000	0.108	0.169	0.249	0.634	0.270	0.121	0.258	0.549	0.225	*0.570*
	B	0.000	0.000	0.000	0.344	0.443	0.655	0.174	0.085	0.558	0.105	0.209	0.674	*0.333*
	C	0.000	0.000	0.000	0.546	0.387	0.095	0.191	0.644	0.319	0.637	0.240	0.101	*0.097*
Supplier's capability	FC	*0.187*	0.325	0.201	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.124
	MS	*0.358*	0.141	0.253	0.000	0.000	0.000	0.000	0.000	1.000	1.000	1.000	1.000	0.186
	PC	*0.107*	0.148	0.139	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.168
	PRC	*0.168*	0.188	0.205	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.325
	TMC	*0.180*	0.198	0.202	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.197
Supplier's performance	DLT	0.000	0.192	0.181	0.000	*0.079*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	F	0.247	0.141	0.253	0.000	*0.208*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	OD	0.221	0.201	0.247	0.000	*0.111*	0.000	0.000	0.000	1.000	0.549	0.000	0.000	0.000
	P	0.210	0.306	0.238	1.000	*0.234*	0.000	0.000	0.000	0.000	0.209	0.000	0.000	0.000
	Q	0.322	0.161	0.080	0.000	*0.366*	0.000	1.000	0.000	0.000	0.240	0.000	0.000	0.000

Table VI.
Unweighted supermatrix

Table VII.
Weighted supermatrix

		Alternatives			Supplier's capability					Supplier's performance			
		A	B	C	FC	MS	PC	PRC	TMC	DLT	F	OD	P	Q
Alternatives	A	0.000	0.000	0.000	0.025	0.039	0.249	0.147	0.096	0.013	0.028	0.187	0.077	0.194
	B	0.000	0.000	0.000	0.080	0.103	0.654	0.040	0.003	0.061	0.011	0.007	0.229	0.114
	C	0.000	0.000	0.000	0.127	0.090	0.095	0.045	0.228	0.035	0.069	0.082	0.034	0.033
Supplier's capability	FC	0.047	0.082	0.050	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.081
	MS	0.089	0.035	0.063	0.000	0.000	0.000	0.000	0.000	0.211	0.211	0.658	0.658	0.122
	PC	0.027	0.037	0.035	0.000	0.000	0.000	0.000	0.645	0.000	0.000	0.000	0.000	0.111
	PRC	0.042	0.047	0.051	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.214
	TMC	0.045	0.049	0.051	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.129
Supplier's performance	DLT	0.000	0.144	0.136	0.000	0.061	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	F	0.185	0.105	0.189	0.000	0.159	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	OD	0.165	0.150	0.185	0.000	0.086	0.000	0.000	0.000	0.679	0.374	0.000	0.000	0.000
	P	0.157	0.229	0.178	0.767	0.179	0.000	0.000	0.000	0.000	0.142	0.000	0.000	0.000
	Q	0.242	0.121	0.060	0.000	0.281	0.000	0.767	0.000	0.000	0.163	0.000	0.000	0.000

Table VIII. Limit matrix

		Alternatives			Supplier's capability					Supplier's performance				
		A	B	C	FC	MS	PC	PRC	TMC	DLT	F	OD	P	Q
Alternatives	A	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082
	B	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
	C	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054
Supplier's capability	FC	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
	MS	0.191	0.191	0.191	0.191	0.191	0.191	0.191	0.191	0.191	0.191	0.191	0.191	0.191
	PC	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
	PRC	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038
	TMC	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028
Supplier's performance	DLT	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033
	F	0.067	0.067	0.067	0.067	0.067	0.067	0.067	0.067	0.067	0.067	0.067	0.067	0.067
	OD	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103
	P	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109
	Q	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129

Table VI shows the pairwise comparisons of the factors. The priorities obtained from pairwise comparison matrices above are highlighted in Table VI. The weighted supermatrix (Table VII) illustrates the weighting of the blocks of the unweighted supermatrix by the corresponding priority from the corresponding eigenvector of comparisons of the clusters obtained from Table V. The entries of the weighted supermatrix itself give the direct influence of any factor on any other factor. The weighted supermatrix has some zeros indicating no interaction. For example, delivery lead-time does not affect process capability. On the other hand delivery lead-time (0.061), flexibility (0.159), and quality (0.281) influence market share. Process capability (0.214) influences quality. Table VIII shows the stable priorities of all the factors. From it the priorities of all the factors and alternatives are extracted and normalized. The priorities of all the factors in the limit matrix normalized to one for each cluster. Thus, final priorities are obtained. The final priorities for all factors and the alternatives are given in Table IX.

The first column of Table IX has the global priority with respect to entire model, that is, the global priorities sum to one. The second column has the priorities normalized by cluster so that the priorities of the factors in each cluster sum to one. As shown in Table IX, Supplier B received the highest ranking with 42.4 per cent, indicating that Supplier B is the best supplier. It has the highest overall priority of 0.424.

Conclusion

Over the years a number of studies have been devoted to examining selection of suppliers. Evaluating supply chain partners is a strategic decision process. Supplier selection problems are multi-objective problems which have many qualitative and quantitative concerns. Although several quantitative techniques have been applied including AHP, linear programming, statistical approaches, etc. this paper has presented the ANP as a decision analysis tool in supplier selection problems. The ANP is a new methodology, which incorporates feedback and interdependent relationships among decision attributes and alternatives. It is capable of handling both quantitative and qualitative criteria and capturing more realistic results. The ANP enabled us to incorporate ten decision attributes and to deal with interdependencies among them.

Clusters	Factors	Priorities -normalized by cluster	Priorities from limiting matrix
Alternatives	Supplier A	*0.345*	0.082
	Supplier B	*0.424*	0.100
	Supplier C	*0.231*	0.054
Supplier's capability	Financial capability	0.078	0.025
	Market share	0.590	0.191
	Personnel capability	0.125	0.040
	Process capability	0.119	0.038
	Top management capability	0.087	0.028
Supplier's performance	Delivery lead-time	0.076	0.033
	Flexibility	0.151	0.067
	On-time delivery	0.232	0.103
	Price	0.247	0.109
	Quality	0.293	0.129

Table IX.
The final priorities of the factors and the alternatives

The ANP leads additional insights not possible with traditional AHP. Interdependencies exist in most of real-world supplier selection problems. So the proposed model can be used by organizations for a supplier selection process that involves various criteria and contains interactions – with some modifications, since there will be company specific criteria- as a framework.

In a decision problem, decision makers might feel that some factors are more important than the others affecting final preference of the alternatives. If there are some feedback and interdependencies among the factors, an unimportant factor may turn out to be far more important than even the most important one. So, there need to be a methodology like ANP to capture more realistic results. In our research, we have identified ten factors affecting supplier evaluation. We found factors most effecting supplier selection process, their relative importance and influences on the objective of our decision-making model. Since the ANP is capable of dealing with all kinds of feedback and dependence in a decision system, it provides a more accurate approach when modelling a complex decision environment. ANP deals with uncertainty and complexity and provides insights that other traditional methods could miss. The power of the ANP lies on its use of ratio scales to capture all kinds of interactions and make accurate predictions, and, even further, to make better decisions.

The factors affecting supplier selection could be quantitative as well as qualitative. There are many qualitative concerns when assessing the factors critical to supplier evaluation. Some of the factors included in our decision model were difficult to quantify. For example, many qualitative factors such as top management capability, personnel capabilities were included in the model. The ANP enabled us to incorporate both quantitative and qualitative factors, which are very important in assessing factors affecting supplier evaluation.

Although our model provides a framework for supplier selection problems, there are some limitations of the model. One of the limitations in the model is that the ANP requires more comparisons than the AHP and it increases the effort. However, complex decisions may require complex methodology. Yet, clustering the factors helps to lessening the number of pairwise comparisons. Another limitation might exist in case if there are several alternatives in the decision model. In terms of making a number of pairwise comparisons, it would be quite demanding. Currently a large number of alternatives can be dealt with using ratings approach of AHP to identify the most preferable alternatives. Then, remaining few alternatives can be more precisely evaluated.

In future research it would be good to show how the proposed model can be used for an application of real-world problem.

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