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Full Length Research Paper

An application of supplier selection in supply chain for modeling of intangibles: A case study of multinational Food Coffee industry

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The objective of this paper is to present a comprehensive method for the evaluation and selection of suppliers' offers in food industry. The supplier/vendor selection is a decision-making problem at the strategic management level that involves a semi-structured process. The inclusion of both tangible and intangible criteria in evaluation and selection of the best among the offers provided by various suppliers is a complex problem. Along with this the complexity of supply chain relationships and enterprise strategies especially within enterprise clusters aggravates decision making. Application of supply chain concepts has been made in service industry as no such work has been attempted earlier. Personnel qualification roster (PQR) coffee company is selected which is offering specialty coffee along with fusion food through its more than 130 outlets. Food and drink supply chain is relatively new domain and in India not much work has been done. Analytic hierarchy process (ANP) is solved with the help of software "super decisions". The case study validates the applicability of proposed models and provides insight in to the role of intangible factors in decisions related to supply chain. The recommendations made will not only result in stream lining of supply chain processes in PQR coffee company but will result in substantial savings also due to reduced lead time, reduced inventory level, better service level and effective control and coordination among the partners.

Key words: Inbound supply chain, intangibles, analytic hierarchy process (ANP), vendor selection.

INTRODUCTION

Decision making in supply chain is crucial as it involves multi-criteria, multi- level, multi-objective and multi-personal decisions. The emphasis on higher co-operation and co-ordination among the partners of supply chain is key issue, which requires strategies suitable to system-optimal performance where the point of focus shifts from local to global optimal. Decisions at the interface between supplier and manufacturer depend on trade-offs between various factors. Some of the factors are tangible and general in nature, while some other are situation specific and intangible in nature. Multi-criteria decision making tools like AHP and ANP are gaining wide applicability and attempt has been made to make use of them in issues related to inbound supply chain. The priority coefficients thus found by these techniques are used in optimization techniques to get desired results. Application of supply chain concepts has been made in service industry as no such work has been attempted earlier.

The uninterrupted supply of small quantities of the raw materials, paper and packaging material, crockery, cleaning and clothing materials and fresh materials to scattered outlets all across the country is biggest challenge faced by PQR Coffee Company. There is large number of items in inventory list, a big supplier base and fluctuating demand with long duration of realization of paybacks as small quantities of raw material are

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consumed in each unit sale. The pressure on supply line is enormous due to Just-In-Time (JIT) environment of supply with weekly supply schedule, small storage space at outlets and short life cycles of ingredients. The use of 3PL provider at one hand takes off the burden from the company's shoulder but at the same time creates problem due to inadequate communication, lack of control and poor coordination. The stream lining of supply can only be achieved by aligning all suppliers in the chain with the distributing agency and inbound logistics. Vendor selection plays significant role in the future relations and capability to work in supply chain environment.

The suppliers can be the biggest assets to the organization but poor choice can make them biggest liability also. This paper, thus deals with issues related to supply. Firstly a new model for inventory classification is proposed to classify items so that appropriate strategy can be adopted. For select items vendor selection model based on analytic hierarchy process (ANP) is proposed to show procedure involved and steps in software "super decisions" are shown using windows for easy understanding. There is no vendor rating system presently in order at PQR coffee company and thus a suitable, easy to comprehend and yet simple in nature vendor rating model based on decision matrix is proposed for existing vendors. A brief theoretical orientation of each issue is presented to show the work already done and to justify the selection of prioritizing model. A brief implementation plan is presented to show involvement of cross-functional team.

LITERATURE REVIEW

Ghodsypour and Brian (1998) mentioned that supplier selection decision-making problem involves trade-offs among multiple criteria that involve both quantitative and qualitative factors, which may also be conflicting. In other words, buyer-supplier relationship based on only the price factor has not been appropriate in supply chain management. Consideration must also be given to other important strategic and operational factors such as quality, delivery, flexibility etc. Supplier selection decisions must include strategic and operational factors as well as tangible and intangible factors in the analysis, Sarkis et al. (2002); Weber et al. (1991) have proposed multi objective approach to vendor selection. Their methodology provides a useful decision support system for a purchasing manager faced with multiple vendors and tradeoffs such as price, delivery reliability and product quality. Wagner et al. (1989) have evaluated the relative importance of quality, cost, delivery performance and other supplier attributes. According to seventy four articles discussing supplier selection criteria, quality was perceived to most important followed by delivery performance and other supplier attributes, Weber (1991). In supply chain context other criteria like ability to work as strategic alliance, technological compatibility, adoptability to new management style, ability to participate in product development etc. have become extremely important. Mandal and Deshmukh. (1993) used interpretive structural modeling (ISM) for vendor selection and identified 11 most important criteria. Good suppliers can help manufactures during the development of new products and processes, with long term quality improvements and cost reductions and can provide enhanced delivery performances, Goffin et al. (1997).

Cebi et al. (2003) used an integrated approach for supplier selection in which supplier selection problem has been structured as an integrated lexicographic goal programming and AHP model including both quantitative and qualitative conflicting factors. Cabi et al. (2003) carried out vendor selection for a Turkish manufacturing company, which has been operating for almost 40 years in production of dry mixed food and drink products. They proposed that in the food company, the most important factors are quality, delivery and cost. Although, rich literature is available for vendor selection process but use of ANP is not tried and in this section an attempt has been made to model intangible factors in vendor selection relevant in the context of PQR coffee company. Some of these criteria are interdependent and thus ANP is fit to be used as prioritizing tool.

The decision making in vendor selection often involves intangible factors like brand image, supplier's reputation, ability to innovate, adoptability to change etc. which are non quantifiable and thus making the job of decision maker tough as one has to rely on subjective and intuitive thinking. Some of these factors are interdependent also and degree of interdependency varies from context to context leading to further complications. However, intangibles can be quantified through relative measurement (priorities).

These priorities along with normalized measure of tangibles can be used in a linear programming model for optimization of desired objective functions. ANP is used for finding out the priority coefficients, which can be used in limited partnership (LP) for appropriate vendor selection.

BACKGROUND OF ANP

AHP and ANP are multicriteria decision-making tools, which are argued to possess qualitative (decision model development) and quantitative (decision model analysis) components. AHP models a hierarchical decision problem framework, which consists of multiple levels specifying unidirectional relationships. ANP models a network structure that relaxes the hierarchical and unidirectional assumptions in AHP to allow interdependent relationships in the decision making framework. Although, the two decision tools possess the same qualitative and quantitative procedures to structure and analyse a decision problem, ANP needs further quantitative steps to solve a network decision problem. For

details of the ANP method, refer to Saaty (1996). Those who want to skip the complicated mathematical algorithm and look for using any commercially available ANP software, consult the website of expert choice. Inthis study, only a brief description of the method is provided, which is based on Cheng and Li (2001) who suggested that ANP is composed of four qualitative (1 to 4) and five quantitative (5 to 9) steps:

1) To state the decision problem – The topmost level is to state the decision problem. This starts the decomposition of further levels down the structure until final level that is usually the scenarios or alternatives to be selected.
2) To make sure that the decision problem is to be solved by ANP – As already stated, ANP is used to structure a decision problem into a network form. For solving strictly hierarchical model, AHP is sufficient.
3) To structure the unstructured decision problem – The topmost decision problem level is abstract in nature. It must be decomposed into a set of manageable and measurable levels until the level of criteria for assessing the scenarios or alternatives.
4) To determine who the raters are – Those who are responsible for making the decision are the raters for completing a questionnaire.
5) To design a questionnaire for eliciting data from raters – It is suggested to use the pairwise comparison, which can elicit more information to assign weights to the rated elements. It is common to use the 9-point priority scale to estimate the relative importance between paired elements (Saaty, 1980).
6) To calculate the eigenvector of each of the developed matrices – Each decomposed level with respect to a higher level forms a matrix. It is necessary to calculate the eigenvector for the elements of this matrix. For the algorithm, refer to Saaty (1980) or Cheng and Li (2001).
7) To measure the consistency ratio (CR) of each of the matrices to find out the inconsistency of rating – One of the best reasons to use pairwise comparison and matrix is to measure the CR to ascertain that raters are consistent in rating. If the CR value cannot pass the acceptable level, it is certain that the raters rated arbitrarily or mistakenly.
8) To form the supermatrix by the eigenvectors of the individual matrices (also known as submatrices) (Saaty, 1996) – The eigenvectors of each of the developed matrices should gather together to form a supermatrix.
9) To compute the final limit matrix – In order to compute the final limit matrix, the supermatrix, which has been ensured of column stochastic, has to raise to high power until weights have been converged and remain stable (Sarkis, 2002).

METHODOLOGY

A set of criteria covering wide range of parameters is submitted in the form of table and opinion of expert is taken to select pertinent criteria for vendor selection in the context of PQR coffee company. Apart from this an unstructured opinion is also sought. Cost being one of the most important parameters has not been included in this analysis as the alternatives chosen are cost competitive and thus a detailed analysis is required to select one of them on the basis of comprehensive analysis of various other factors and ultimately the priorities obtained with ANP can be seen in the context of cost parameter and an appropriate decision can be taken. The priorities obtained from the ANP can be directly used in linear programming model as the coefficients in the objective function to get the required distribution of the demand among the suppliers which can satisfy a set of constraints related to lead time, plant capacity of supplier etc. Since PQR Company is buying the hot chocolate fudge from a single source, as the demand is not very high, there is no need of applying the optimizing tool here.

CASE: PQR COFFEE COMPANY

PQR coffee company limited, south Asia's largest retailer of fine specialty coffees, was established in February, 2000 to recreate the ambience and experience of the typical Italian neighborhood espresso bars. PQR coffee aims to provide a comfortable place for people to relax and unwind over a cup of coffee.

PQR coffee company was established by Turner Morrison group as specialty coffee retailer offering fine espresso based beverages. It places strong emphasis on the quality of coffee beans and the process of preparing, rich aromatic coffee. This 100% Arabica coffee is sourced from Tata coffee's plantations in Karnataka, India. The Tata coffee company is in strategic alliance with PQR with 34.3% stakes in the company. TCL is currently exclusive supplier of coffee blends to PQR for its entire range of offerings. This alliance has given TCL access to the value added market through PQR's expanding consumer base while PQR is benefited by access to TCL's technical and blend experience on specialty coffee.

Supply chain of PQR

Supply chain operations of PQR are of paramount importance as geographical differences and distances among various retail outlets are very high. India, with its diversity and cultural differences, is not comparable to any other country of the world. Here every few hundred kilometers, there is change in language, traditions, habits, taste and behavioural patterns. PQR has its outlets in all major cities of India like Delhi, Mumbai, Kolkata, Chennai, Bangalore, Hyderabad, Chandigarh, Goa, Pune, Ahmedabad, Lucknow, Kanpur, Shimla, Ludhiana, Baroda, Jaipur and Dehradun. It has its international operations at Lanka and Dubai. Figure 1 shows supply chain of company.

We can broadly classify operations of PQR's supply chain into three categories.

(1) Central supply chain
(2) Local supply chain.
(3) Foods supply chain.

Central supply chain

PQR has 4 regional offices at Delhi, Mumbai, Bangalore and Kolkata. There is a centralized supply chain for dry items, which have sufficient shelf life. PQR head office at Delhi manages supply of 134 items comprising of raw materials, paper and packing items, cleaning material, crockery/cutlery, stationery and uniform, merchandising items etc. However, there are few vendors who have the capability of supplying directly to the regional centers and an understanding to affect this has been evolved; still the bulk of material movement occurs from Delhi. The vendors for these

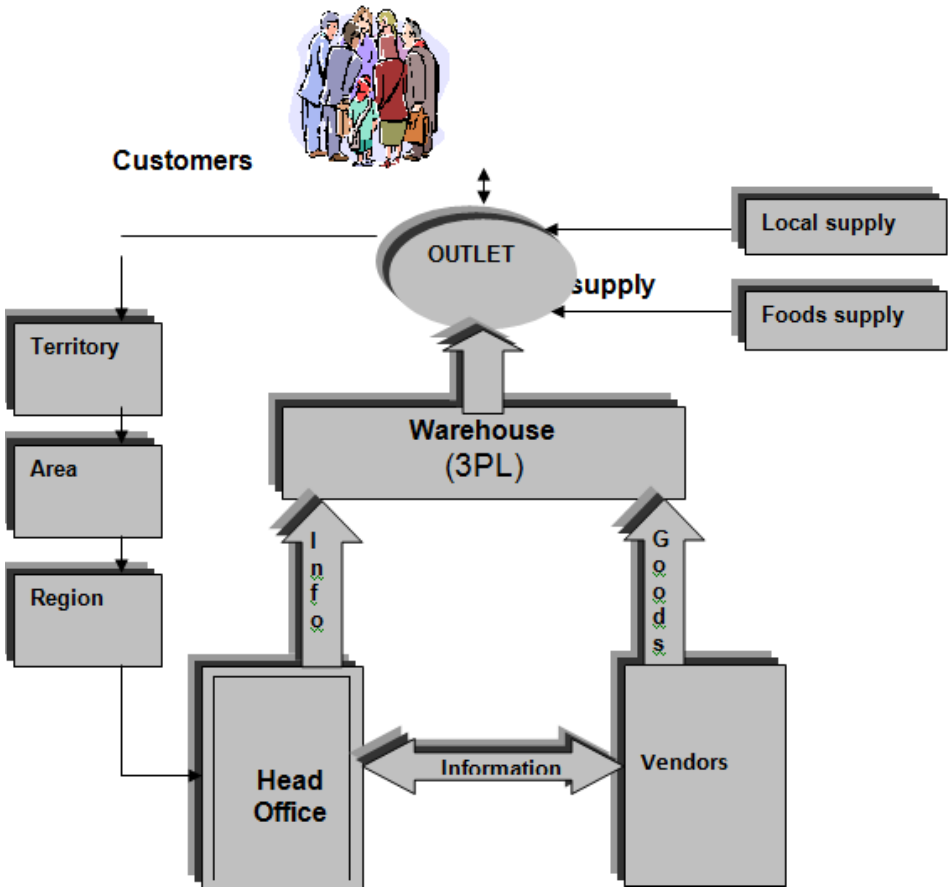


Figure 1. Supply chain of PQR coffee company.

materials are mostly located around Delhi and there are more than 100 vendors presently.

Company has 3PL arrangement for all its logistics needs including warehousing, record keeping, consolidating, transporting and distributing various items of centralized supply chain. For thispurpose 1-year contract has been signed with Safepress private limited. Safexpress is among the topmost 3PL providers in the country with Rs. 300 crore turnovers and a fleet of 2500 dedicated vehicles. The Safex also controls the distribution to various outlets from warehouse. The various details of this supply chain are discussed under sub heading of “mapping of current procedure”.

Local supply chain

Perishable items like milk, cream, ice cream, ice cubes and other milk-based products are sourced locally and each city has its own supplier base. In case of more than one outlet in a city, all are sourcing from same vendors to get economies of means.

Food supply chain

To focus on core competence of providing specialty coffee, PQR has no kitchen in its outlets. All eatables like sandwiches, tikka, pasta, rolls, desserts and ice creams ,etc are sourced from outside. For this purpose local suppliers are identified and contracts are signed. For example in case of Delhi, care caterers and Taj Tacs are supplying sandwiches, fusion meals and desserts, snacks respectively. A cold supply chain with temperature ranging between 4 and 6 degree centigrade is maintained for daily supply of these items, which have shelf life of 24 to 36 h. In case of few outlets, which run all around the clock, there is second supply of food items in the evening. The outlets pass on the daily sales data to head office electronically using e-mail.

Vendor selection parameters

Vendor selection is multi-criteria, multi-people and multi-layer decision-making process, which requires a great deal of analysis of many variables most of which are intangible in nature. Few pertinent attributes are listed in Table 1. Kindly put your preferences for each criteria depending upon your subjective assessment by putting (√) in appropriate column. Based on the response of experts on the attributes hierarchy has been formed, shown in Figure 2 and used in ANP software “super decisions”

Vendor selection for hot chocolate fudge

This ingredient is used in large quantity with average consumption (including all regions) of 4500 kg worth around Rs.500000 per month. Following specifications are mentioned by the product development department of the organization:

(1) Description: The product is dark brown I n color and is

Table 1. The parameter for selection of the vendor.

No.	Attribute	Extremely important	Very important	Moderately important	Very little important	Not at all important
Cost criterion						
1	Produc price					
2	Cost reduction plan					
Service criterion						
3	Flexibility					
4	Problem solving					
5	Reaction to demand					
Quality criterion						
6	Product specification					
7	Supplier's certification					
8	Durability					
9	Ergonomic quality					
Cycle time criterion						
10	Delivery lead time					
11	Development speed					
Suppliers profile criterion						
12	Reputation					
13	Financial status					
14	Market share					
15	Production facility of capacity					
16	Advertising					
Risk Criterion						
17	Low quality of delivered product					
18	Production delays					
19	Delivery delays					
Relationship criterion						
20	Compatibility with levels and Functions of buyer firm					
21	Supplier customer base					
22	Ability to identify needs					
23	Supplier availability					

smooth in texture. It has a sweet dark chocolate flavourwith well-rounded cocoa, vanila and dairy notes.
(2) Chemical: Specifications is shown in Table 2
(3) Microbiology: it is shown in Table 3
(4) Packaging: It must be sufficient to protect the product throughout distribution and shelf life. Packing parameters are shown in Table 4.
(5) Labeling: Each unit and corrugated box shall be properly labeled to indicate - Product name, Net wt., batch no., Date of manufacture, Manufacturer's address, and ingredient declaration.
(6) Shelf life: 6 months from the date of manufacturing.

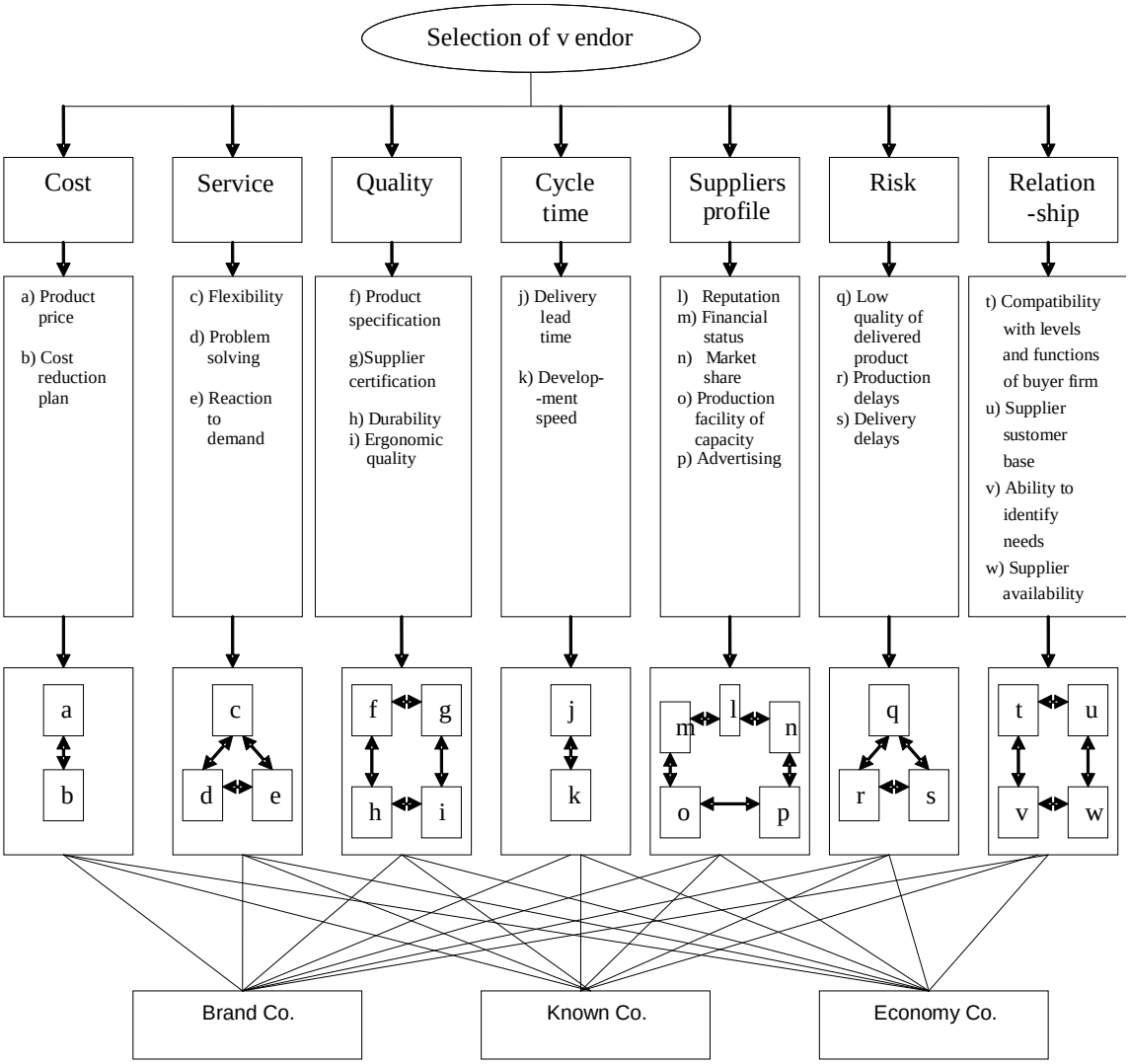


Figure 2. Representation of ANP based evaluation model for the selection of vendor.

Table 2. Chemical specifications.

Total soluble solids	**66.0 to 69.0 %**
PH value	6.05 to 6.55
Viscosity (brookfield)	More than 5000 cps

Table 3. Microbiological specifications.

Standard plate count	**Less than 5000**
Yeast and mould	Less than 100

(7) Storage: Ambient – well-sealed corrugated box in a cool, dry place.
(8) Continuity guaranty: All shipments shall be uniformly high quality, and shall have been prepared and stored under strictly sanitary conditions, in accordance with good manufacturing practices (GMP's) and shall conform to all provisions of the prevention of food adulteration act, as amended.

Presently there is only one supplier catering to the need of the hot chocolate fudge and there is one supplier earmarked as back up

Table 4. Packaging specifications.

Type	Multilayered plastic film
Pack size	1 Kg. per unit
Box capacity	12 units per box

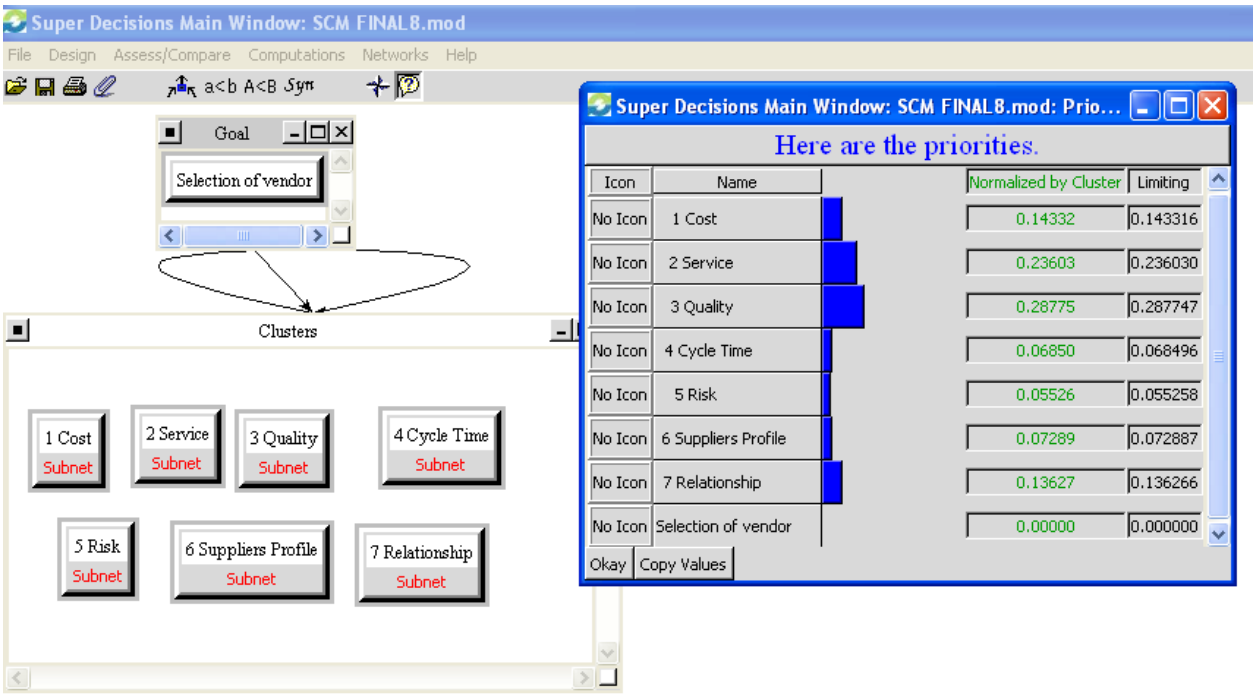


Figure 3. The design of the problem.

supplier. Recently a new company has pitched for supply of the product and a comparison between these three suppliers is done to find out their relative priorities based on number of factors. The identity of the suppliers is not disclosed and they are named as

a. Vendor A- existing supplier
b. Vendor B- back up supplier
c. Vendor C- new supplier

The pairwise comparison input is obtained from the supply chain manager (vendor development) and available information about the supplier with the organization along with general opinion of other supply chain staff. Software super decision is used to save the precious time of concerned people and to show the practicability of the approach. However, the method has been explained to managers to get their full involvement. The following steps are involved in modeling the problem using the software.

Step 1

Formation of network with goal, clusters and subnets: The problem is first designed in the software by making clusters and the corresponding nodes and connections. The vendor selection problem is designed as hierarchical network with the goal as the topmost cluster. This is linked to another cluster containing cost, service, quality and cycle time, etc criteria as its nodes. The network is shown in Figure 3.

Step 2

The clusters and nodes under all 7 subnets are shown in Figure 4. Each subnet consists of two clusters that is attributes and alternatives.

Step 3

Node comparisons: This involves comparison of nodes with respect to a control criterion. One of node comparison is shown in Figure 5

Step 4

Generation of weighted and limiting supermatrix: In this step, the generation of the weighted and the limiting supermatrices for all the four sub networks. The unweightage supermatrix of problem is shown in Table 7. Then clusters' priority weights were calculated by using expert opinion. Multiply this priority weight by the unweightage supermatrix had the weightage matrix.the final step is calculation of the limiting priorties of weighted super matrix which is

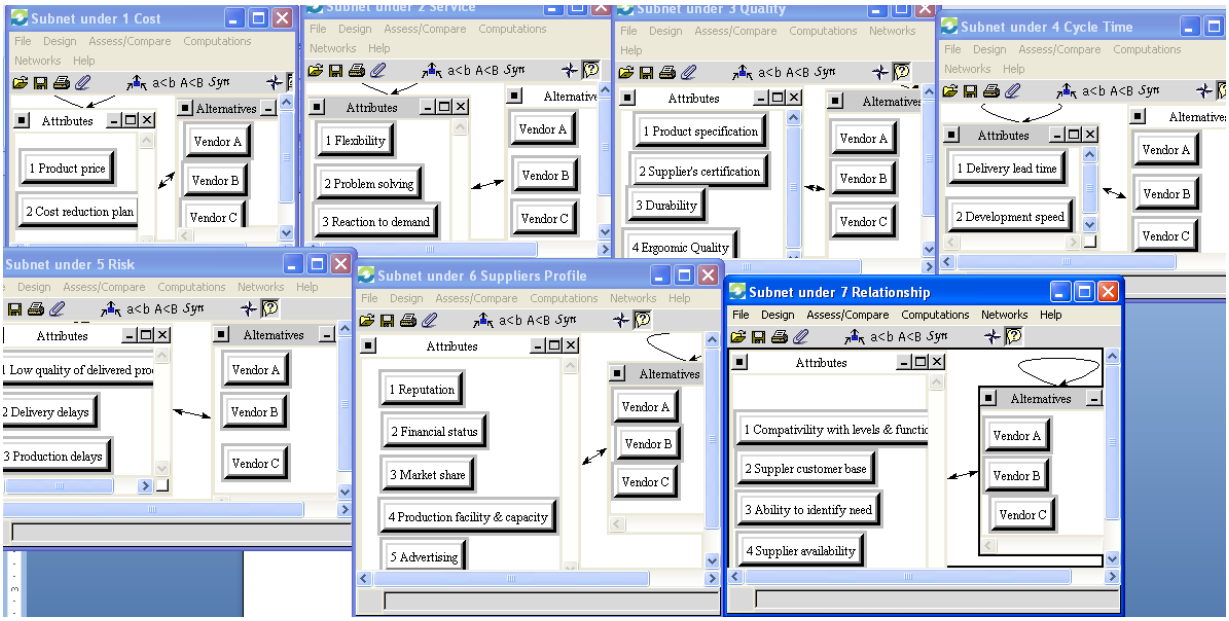


Figure 4. Various subnets with clusters.

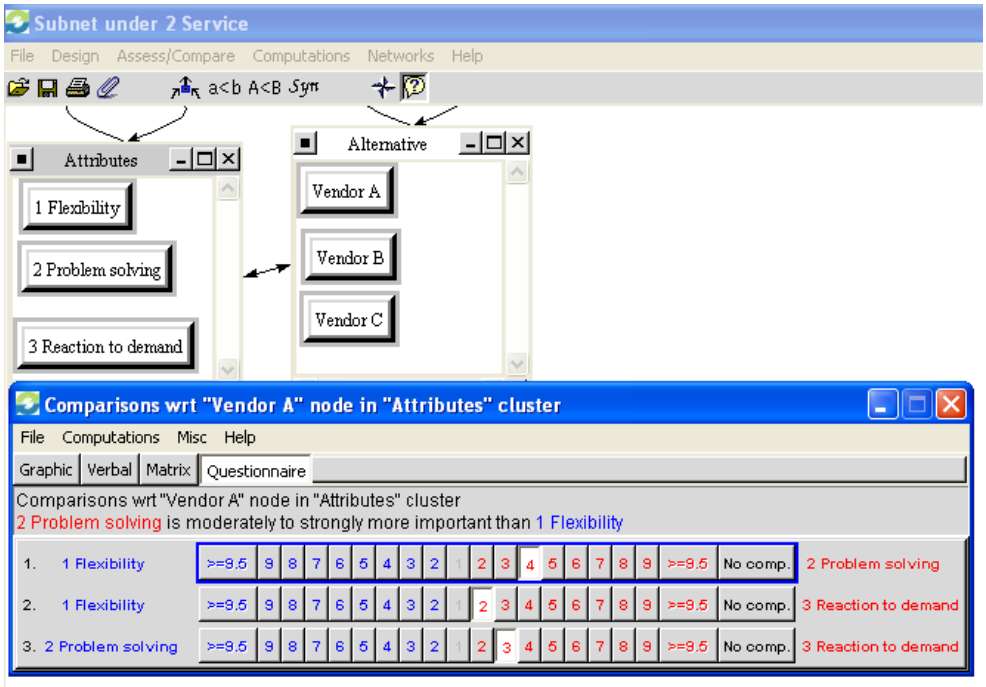


Figure 5. Node comparisons.

shown in table 8. One of the factor's limiting supermatrix is shown in Figure 6

Step 5

The score obtained at the subnet level are raised to the goal level and limit matrix is obtained for goal. Figure 7 shows weighted score for each cluster.

Step 6

The values obtained from the synthesis are taken at the level of the goal and overall synthesis for the model is achieved as shown in Figure 8.

Step 7

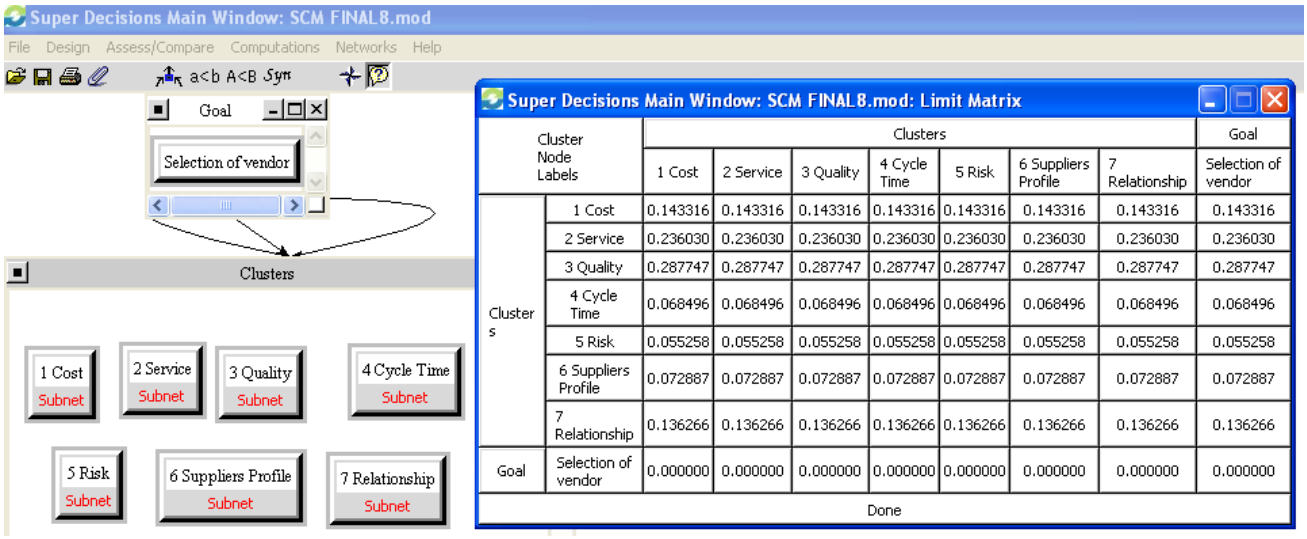
Sensitivity analysis: In this the variations in the priority of the

Subnet under 2 Service: Limit Matrix

Cluster Node Labels		Alternative			Attributes		
		Vendor A	Vendor B	Vendor C	1 Flexibility	2 Problem solving	3 Reaction to demand
Alternative	Vendor A	0.252208	0.252208	0.252208	0.252208	0.252208	0.252208
	Vendor B	0.163576	0.163576	0.163576	0.163576	0.163576	0.163576
	Vendor C	0.084216	0.084216	0.084216	0.084216	0.084216	0.084216
Attributes	1 Flexibility	0.144099	0.144099	0.144099	0.144099	0.144099	0.144099
	2 Problem solving	0.183909	0.183909	0.183909	0.183909	0.183909	0.183909
	3 Reaction to demand	0.171992	0.171992	0.171992	0.171992	0.171992	0.171992

Done

Figure 6. Limiting super matrix for subnet business criteria.



Cluster Node Labels		Clusters							Goal
		1 Cost	2 Service	3 Quality	4 Cycle Time	5 Risk	6 Suppliers Profile	7 Relationship	Selection of vendor
Clusters	1 Cost	0.143316	0.143316	0.143316	0.143316	0.143316	0.143316	0.143316	0.143316
	2 Service	0.236030	0.236030	0.236030	0.236030	0.236030	0.236030	0.236030	0.236030
	3 Quality	0.287747	0.287747	0.287747	0.287747	0.287747	0.287747	0.287747	0.287747
	4 Cycle Time	0.068496	0.068496	0.068496	0.068496	0.068496	0.068496	0.068496	0.068496
	5 Risk	0.055258	0.055258	0.055258	0.055258	0.055258	0.055258	0.055258	0.055258
	6 Suppliers Profile	0.072887	0.072887	0.072887	0.072887	0.072887	0.072887	0.072887	0.072887
	7 Relationship	0.136266	0.136266	0.136266	0.136266	0.136266	0.136266	0.136266	0.136266
Goal	Selection of vendor	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Done

Figure 7. Limit matrix at goal level.

alternatives with respect to change in the weightage of the control criteria can be observed. One such graph is presented in Figure 9 to show the variations in the priorities of the alternative with respect to business criteria. Table 5 shows score of vendor with repect to each factor. It tells about ranking of vendor with respect to various factors.

RESULTS AND DISCUSSION

Based on the priorities obtained from ANP, vendor A has highest priority coefficient of 0.448 followed by vendor B with 0.326 and last placed is vendor C with overall priority of 0.226. Clearly vendor A is best choice. The vendor A is also the present supplier and is also supplying to famous brands like Mc-Donald etc. and the case company is more or less in good touch with this supplier. The results are indicators of the personal preferences which the analyst has as the pairwise comparison are based on his knowledge, word of mouth information available to him and judgments. One of reasons could be the first hand experience of the present supplier, which the analysts have in comparison to the here-say, and written details of other two alternatives. One more important point is that the vendor A is located very close to Delhi as compare to other vendors. This has bearing on the lead-time, ease of communication, person-to-person contact and trust. This suggests that the case company should strengthen the tie with vendor A and should try to forge a strategic alliance with vendor A. It is worth while to mention here that this supplier is supplying many other items like syrup,

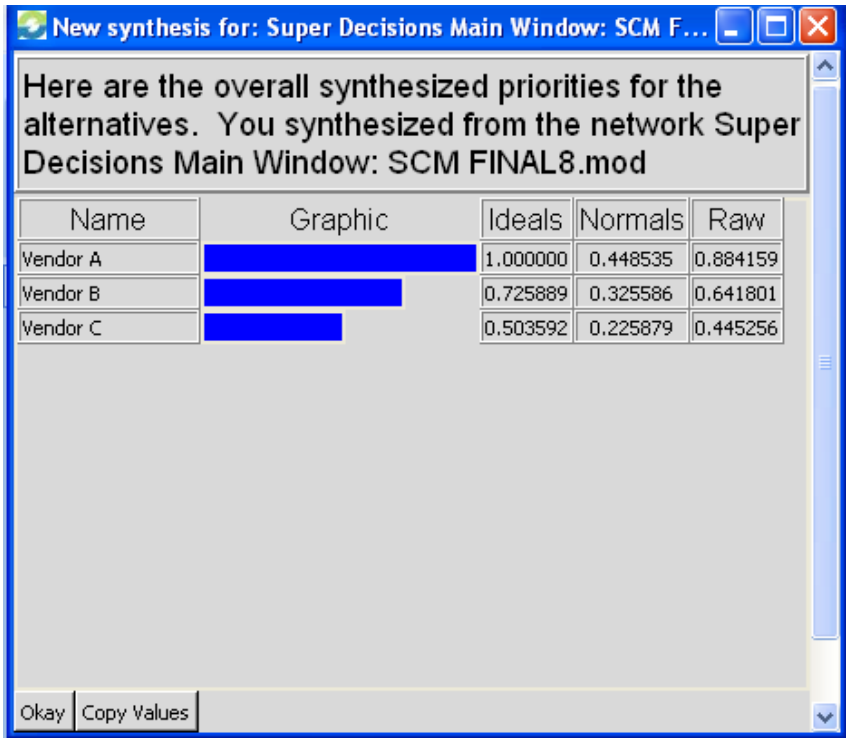


Figure 8. Synthesis for the goal.

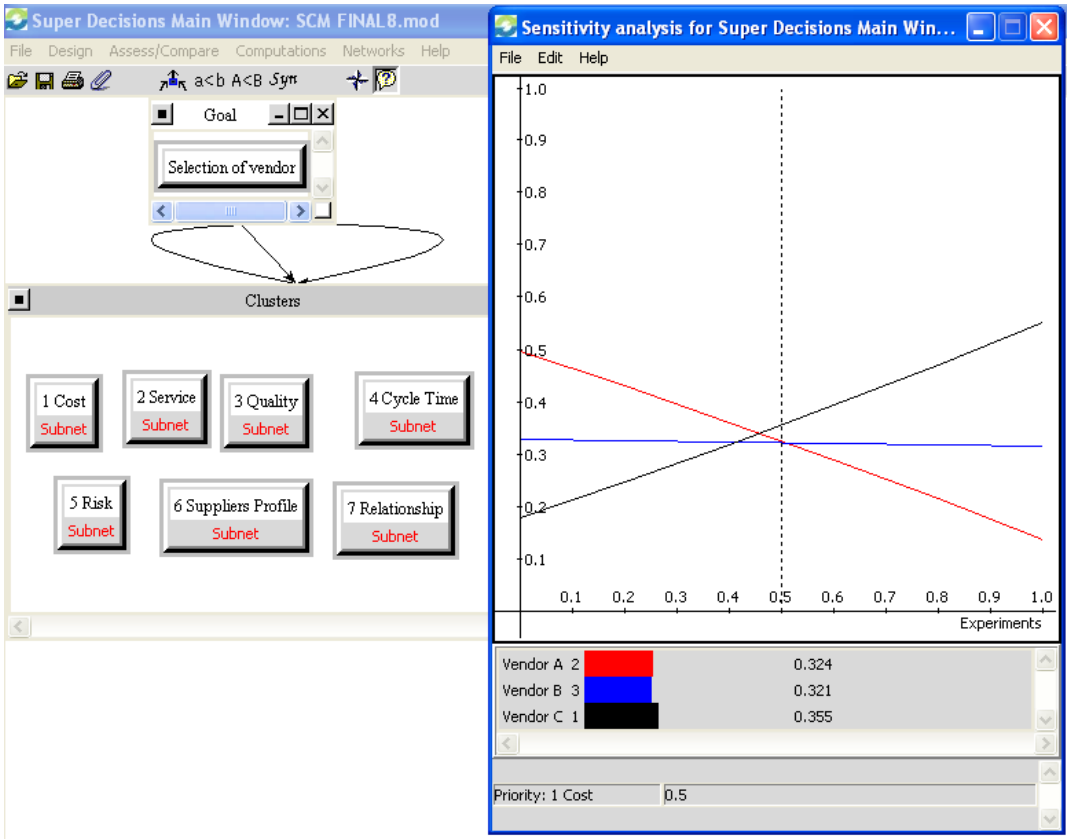


Figure 9. Sensititivity analysis with respect to cost.

Table 5. Score of vendor with different attribute.

Attribute	Vendor A		B		C	
	Total priority	Rank	Total priority	Rank	Total priority	Rank
Cost	0.2158	2	0.2512	1	0.1484	3
Service	0.2531	1	0.1631	2	0.0838	3
Quality	0.2535	1	0.1677	2	0.0788	3
Cycle time	0.2636	1	0.1622	2	0.0742	3
Risk	0.1564	3	0.1614	2	0.1821	1
Suppliers profile	0.2677	1	0.1604	2	0.0720	3
Relationship	0.2645	1	0.1588	2	0.0767	3

Table 6. Final results of vendor selection problem.

Serial no.	Product	Vendor	Priorities	Remarks
		A	0.448	
1	Hot chocolate fudge	B	0.326	Select vendor A
		C	0.226	
		D	0.370	
2	Sugar sachet	E	0.226	Select vendor F
		F	0.403	
		G	0.247	
3	Tomato ketchup	H	0.581	Select vendor H
		I	0.170	

sauces and other topping to the case company. However the priority of the back up vendor is lower than the new vendor considered and this is attributed to better quality and flexibility capabilities of the vendor B as compare to vendor C. Thus it is suggested that, the vendor C be replaced by vendor B for back up vendor. Although, at present all the three supplier selected for analysis are individually capable for supplying the total quantity but as the PQR Company is planning to expand at fairly rapid rate, which will result in rise in demand and there fore option must be kept open to buy from more than one supplier at a time. This will minimize the risk and provide economy in transportation and other logistics cost due to large geographical spread of the outlets. Similar studies are carried out for sugar sachet, tomato ketch-up and in all 9 vendors are evaluated (Appendix 2). The complete results for vendor selection are given in Table 6.

Conclusion

With the advent of revolution in communication and information technology, supply chain management has got significant momentum and is acknowledged as vital strategic function in most organizations. The performance measure of supply chain is important building block for decision-making. The existing models are not adequate in taking intangible factors in to consideration. To take a system optimal decision, trade offs between many conflicting enablers has to be analyzed. In present study issues related to inbound supply chain are chosen. To identify the specific key intangibles qualitative techniques, like SWOT, PEST, and NGT etc can be used. Vendor selection using ANP is a unique attempt and showed promising results. The theoretical analysis of various issues is very convincing and motivates one to go for real case study. Thus application of models is verified by taking real case study of PQR coffee company, which is a key player in food and drink outlets chain in India and abroad. Since emphasis is on incorporating intangibles in decision-making, that's why service industry is chosen. Service industries do not have an out bound supply chain as service providers are also producers of service. Due to perishability of service a very strong inbound supply chain is essential and this provided lot of scope for such a study. The use of ANP provides an unparallel frame-work for vendor selection. In all 9 vendors are considered for 3 different products and ANP is used to get priorities based on 21 decision criteria. With the growing com-plexities in business world and influence of number of intangible factors, they can prove to be extremely essen-tial and are in fact inevitable. The recommendations to

case company are based on the details provided by the managerial staff of the PQR coffee company and they are highly context specific and may not be useful for other organizations of similar nature.

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APPENDIX

Appendix 1

Table 7. Unweighted supermatrix of supplier selection by using ANP.

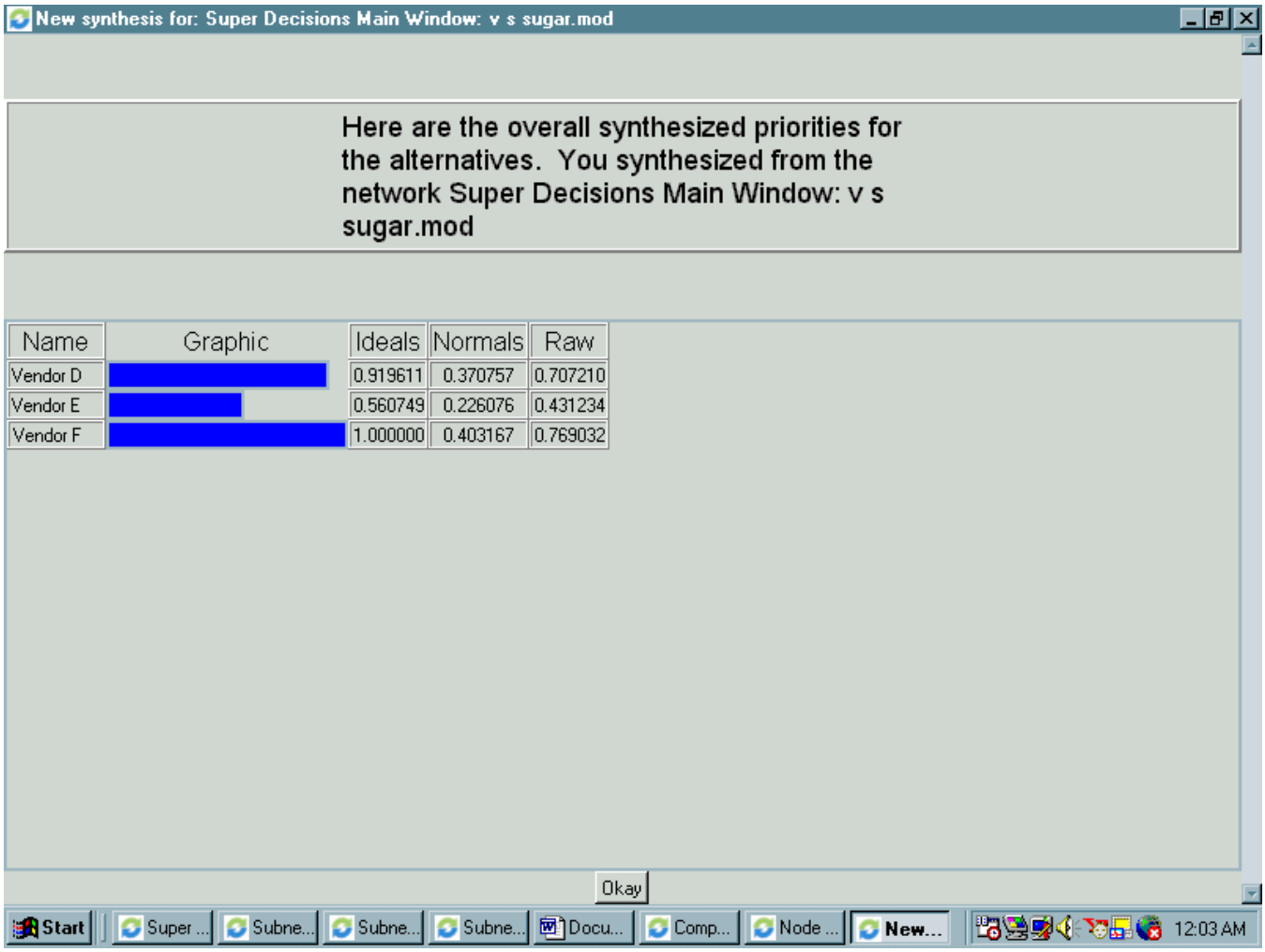
Criteria		Cost		Service			Quality				Cycle time		Risk			Supplier profile					Relationship			
		a	b	c	d	e	F	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w
Cost	a	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	b	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Service	c	0	0	0	0.75	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	d	0	0	0.5	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	e	0	0	0.5	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quality	f	0	0	0	0	0	0	0.6	0.28	0.29	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	g	0	0	0	0	0	0.29	0	0.14	0.11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	h	0	0	0	0	0	0.33	0.3	0	0.61	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	i	0	0	0	0	0	0.38	0.2	0.57	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cycle time	j	0	0	0	0	0	0	0	0	0	0	1		0	0	0	0	0	0	0	0	0	0	0
	k	0	0	0	0	0	0	0	0	0	1	0		0	0	0	0	0	0	0	0	0	0	0
Risk	l	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.25	0	0	0	0	0	0	0	0	0
	m	0	0	0	0	0	0	0	0	0	0	0	0.8	0	0.75	0	0	0	0	0	0	0	0	0
	n	0	0	0	0	0	0	0	0	0	0	0	0.2	0.75	0	0	0	0	0	0	0	0	0	0
Supplier profile	o	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.14	0.14	0.15	0.07	0	0	0	0
	p	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.33	0	0.31	0.46	0.18	0	0	0	0
	q	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.15	0.22	0	0.32	0.25	0	0	0	0
	r	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.45	0.57	0.48	0	0.5	0	0	0	0
	s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.07	0.065	0.076	0.77	0	0	0	0	0
Relationship	t	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.63	0.69	0.71
	u	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.15	0	0.09	0.09
	v	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.47	0.21	0	0.19
	w	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.38	0.15	0.22	0

Table 8. Limited Super matrix of supplier selection by using ANP.

Criteria		Cost		Service			Quality				Cycle time			Risk		Supplier profile					Relationship			
		a	b	c	d	e	F	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w
Cost	a	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26
	b	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Service	c	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
	d	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
	e	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Quality	f	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
	g	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
	h	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
	i	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Cycle time	j	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
	k	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
Risk	l	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
	m	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
	n	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Supplier profile	o	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
	p	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
	q	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
	r	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
	s	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Relationship	t	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
	u	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
	v	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
	w	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09

Appendix 2

Vendor selection for sugar sachets.



Vendor selection for tomato ketchup.