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MODELING OF INTANGIBLES: AN APPLICATION IN UPSTREAM SUPPLY CHAIN - A CASE STUDY OF FOOD INDUSTRY

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ABSTRACT

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. XYZ 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. Issues like vendor selection, vendor rating, Configuration of supply chain, supplier integration and supplier involvement in new product development are dealt with just to show the wide area of applicability of proposed models. Available packages like "EXPERT CHOICE" and "LINDO" are used to get solutions of illustrative problems. 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.

Keywords: *Inbound supply chain, intangibles, ANP, AHP, supplier integration, vendor selection.*

Introduction

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 consumed in each unit sale. The pressure on supply line is enormous due to 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

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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 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 et al (2001) 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 et al (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 analytic Hierarchy process 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.

Selection of Vendor

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 LP for appropriate vendor selection.

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: An Introduction

PQR coffee company limited, south Asia's largest retailer of fine specialty coffees, was established in Feb.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. The other coffee retailers in India are Café Coffee Days and Qwikey. Café coffee days has around 145 outlets with annual turn over around Rs. 200 crore.

Following points are highlighted to get first hand introduction of PQR coffee company.

- In all there are 130 outlets and corners in India and abroad.
- Expected annual turnover of Rs. 60 crores, an increase of 25 % over last year.
- Average footfalls of 1.2 millions a month.
- Wholly owned outlets in India and franchise model for Lanka and Dubai outlets.
- It has tie-ups with brands such as Planet M, Crossword and Taj hotels to open espresso corners in their premises.
- Concentrating on core competence of specialty coffee and hence outsourcing food items, which are available at stores as fusion food with coffee.

- Numerous varieties of hot and cold beverages like coffee, tea, soft drinks etc and food items of more than 30 varieties.
- Expansion plan in south Asian countries like China, Malaysia, Singapore, Thailand, Hong Kong, and UAE.
- Presently Turner Morrison has sold it's stocks to Sterling group which now commands 60% stake, Tata has 34.4 % and remaining are with employees.
- PQR is in top 15 coffee companies in the world.
- PQR plans to be second largest player in retail coffee outlets after Starbucks of USA with more than 6000 outlets.
- PQR has joint venture arrangement with JEWELEX Trading Ltd. of Sri Lanka and has set up PQR coffee Lanka Pvt. Ltd.

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.

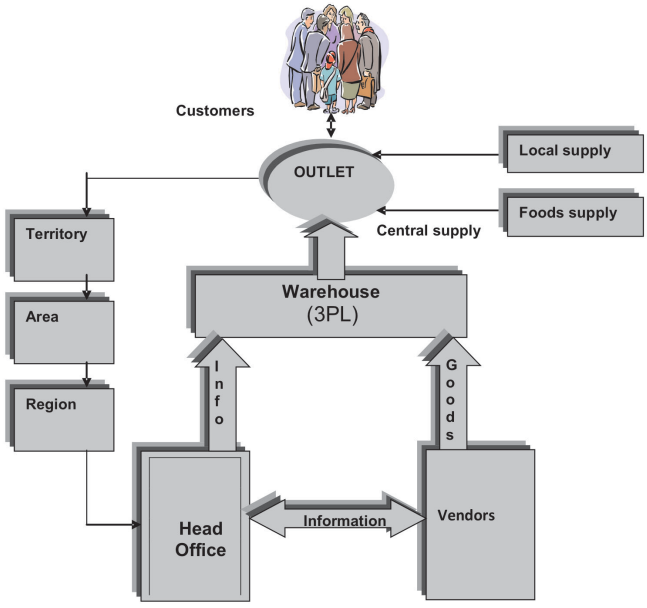

Figure 1: Supply Chain of PQR Coffee Company

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 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 this purpose 1-year contract has been signed with Safexpress Pvt. Ltd. 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 24-36 hours. 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 below. Kindly put your preferences for each criteria depending upon your subjective assessment by putting (Ö) in appropriate column.

Table 1: The Parameter for Selection of the Vendor

S.No.	Attribute	Extremely Important	Very Important	Moderately Important	Very Little Important	Not at all Important
Logistic Criterion						
1	Lead time					
2	Responsiveness					

3	Flexibility					
4	Delivery condition					
Technological Criterion						
5	Capacity to meet the demand					
6	New product development capacity					
7	Improvement efforts					
8	Problem solving capacity					
9	Patents and Intellectual property rights					
Business Criterion						
10	Reputation of vendor					
11	Goodwill					
12	Management skills					
13	Compatibility					
14	Brand Image					
Relationship Criterion						
15	Easy communication					
16	Past experience					
17	Reachability					
18	Trust					

Based on the response of experts on the attributes following hierarchy has been formed and used in ANP software “SUPER DECISIONS”

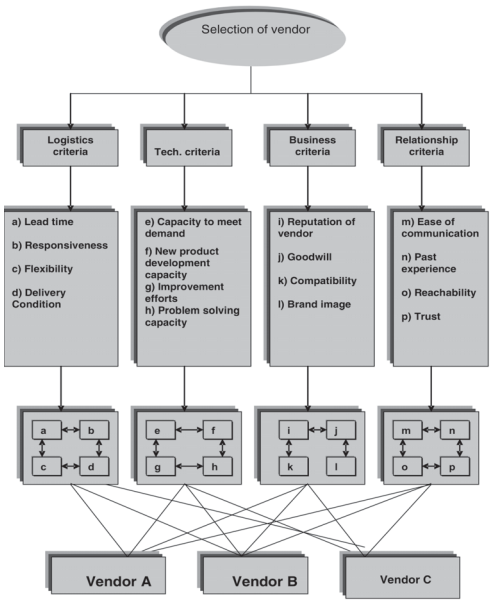

Figure 2: Representation of ANP based evaluation model for the selection of vendor.

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 in color and is smooth in texture. It has a sweet dark chocolate flavour with well-rounded cocoa, vanila and dairy notes.
2. Chemical: Specifications

Table 2: Chemical Specifications

Total soluble solids	66.0-69.0 %
PH value	6.05-6.55
Viscosity (Brookfield)	More than 5000 cps

3. Microbiology

Table 3: Microbiological Specifications

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

4. Packaging: It must be sufficient to protect the product throughout distribution and shelf life.

Table 4: Packaging Specifications

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

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, Ingredient declaration.
6) Shelf life: 6 months from the date of manufacturing.
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 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

- Vendor A- Existing supplier
- Vendor B- Back up supplier
- 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 logistics, technological, business and relationship criteria as its nodes.

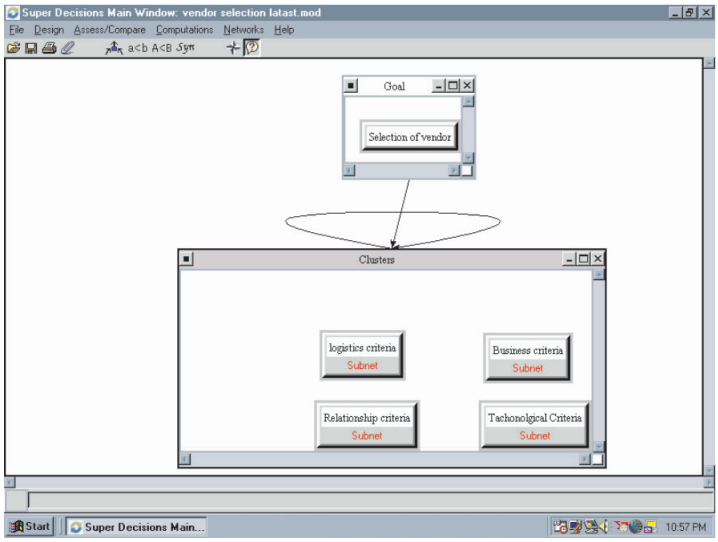

Figure 3: The Design of the Problem.

Step 2: The clusters and nodes under all 4 subnets are shown in Figure 4. Each subnet consists of two clusters i.e. Attributes and Alternatives.

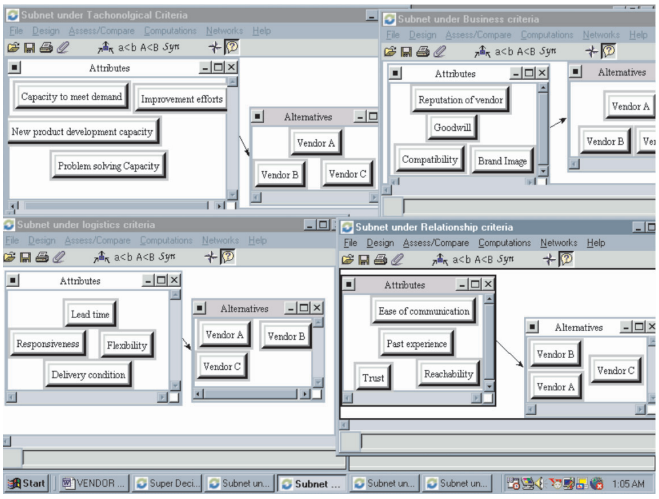

Figure 4: Various Subnets with Clusters

Step 3: Node Comparisons: This involves comparison of nodes with respect to a control criterion. A sample comparison is shown in Figure 5

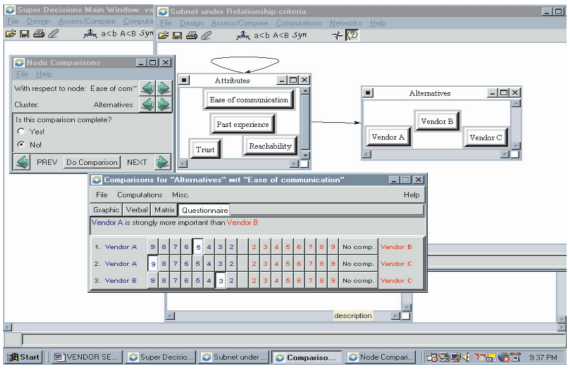

Figure 5: Node Comparisons

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. One such limiting supermatrix is shown on Figure 6

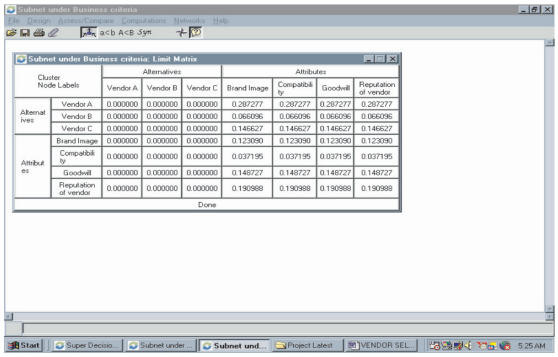

Figure 6: Limiting Super Matrix for Subnet Business Criteria

Step 5: The Values obtained at the subnet level are raised to the goal level and limit matrix is obtained for goal.

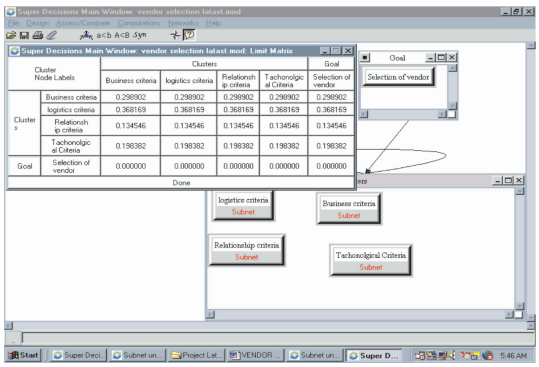

Figure 7: Limit Matrix at Goal Level

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

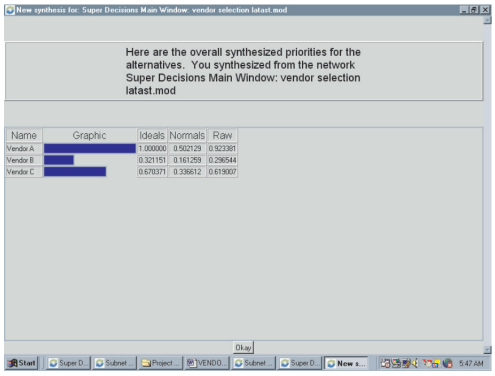

Figure 8: Synthesis for the Goal

Step 7: Sensitivity analysis: In this the variations in the priority of the 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.

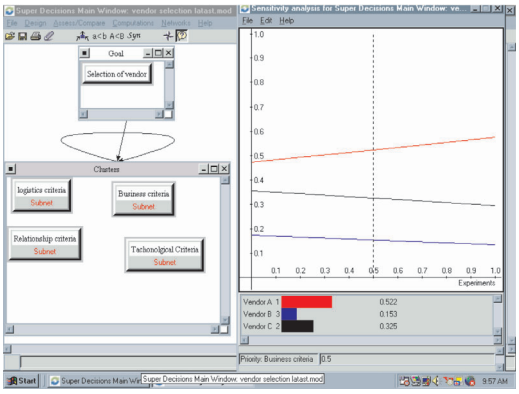

Figure 9: Sensitivity Analysis

Result of ANP Modeling

Based on the priorities obtained from ANP, vendor A has highest priority coefficient of 0.502 followed by vendor C with 0.336 and last placed is vendor B with overall priority of 0.161. 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, 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 technological and logistics capabilities of the vendor C as compare to vendor B. Thus it is suggested that, the vendor B be replaced by vendor C 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. This pilot study is done to suggest the procedure to the PQR Company. The details of the ANP solution regarding sugar and tomato ketchup vendor selection are presented in appendices C and D. The complete results for vendor selection are given in table 5

Table 5: Final Results of Vendor Selection Problem

Serial No.	Product	Vendors	Priorities	Remarks
1	Hot Chocolate Fudge	Vendor A	0.502	Select vendor A
		Vendor B	0.161	
		Vendor C	0.336	
2	Sugar Sachet	Vendor D	0.370	Select vendor F
		Vendor E	0.226	
		Vendor F	0.403	
3	Tomato Ketchup	Vendor G	0.247	Select vendor H
		Vendor H	0.581	
		Vendor I	0.170	

Vendor Rating in PQR Coffee Company

Presently there is no formal vendor rating system is in place in PQR coffee company and there is no assessment procedure for vendor performance. This is largely due to absence of continuous quality check as the vendors are directly supplying to the warehouse owned by the 3PL provider and from there the material is transported to the outlets directly, but the laboratory setup to perform necessary quality checks is located only at the PQR's corporate office. Also there is lot of gap between performance measurement system that must be followed and what is actually being followed. In fact many parameters like wrong deliveries, no. of rejections, short deliveries and service level etc. are not been recorded meticulously and thus for vendor rating no input is available. In consultation with the management of PQR coffee company the template for the vendor rating is designed and a formal start of vendor rating system has been proposed. The parameters, which have been decided with the expert opinion and informal consultation, are grouped in four main criteria

Financial Criteria

This has been considered to be the most important criterion as the management feels that supply chain of PQR has to be lean with acceptable quality and strict adherence to delivery schedule. As the company is new and the break even is yet to be achieved, the financial

parameters like volume discounts, credit terms, cash discounts, product price, return on total assets etc. are considered very important.

Quality Criteria

PQR coffee company is catering to a niche segment of the society and offering premium quality specialty coffee range along with variety of superior quality fusion food. The quality of the raw material is of paramount importance to the PQR as the core competence of the company lies in providing the differentiated food, beverages and drink products. Selected few criteria under the quality head are quality policy followed, % rejection, Quality assurance facilities with availability of equipments and laboratory setup.

Delivery Criteria

The geographical spread and low volumes of consumption of raw material makes the delivery most challenging preposition in PQR's supply chain. The JIT environment in which the food and drink supply chains operate adds to the complexities of distribution. This naturally makes it imperative that the suppliers have to be absolutely spot-on with their quantity and time schedule to ensure uninterrupted operations at outlet level. The sub criteria under this head are reliability in delivery, willingness to accept small order, proactive use of information technology, and flexibility in terms of meeting variations in demand are considered to be extremely important.

Business criteria

There are few products, which are directly used by the consumers without undergoing any change in appearance. For example sugar sachets, crockery, cutlery, paper napkins, certain sauces, jams and jellies. This gives a chance to customer to really evaluate the PQR on the basis of the kind of raw material they are using. This results in conscious effort on the part of PQR to be associated with the best suppliers available in the market. This means that ability of the supplier to supply the intended product with brand name of PQR is a highly desirable parameter.

Methodology

Forced Decision matrix method is considered to be appropriate method as it gives due weightage to different parameters on the basis of subjective judgement made by the involved people. This method is systematic, scientific and yet it is simple to understand. Any vendor rating system has to be easily understood by the supplier and has to give objective values to make desired comparisons. The involvement of intangibles like reputation, integrity, brand image etc. is another reason to use decision matrix method. The management of PQR Company emphasized that the system should be easy to understand and transparent so that vendors' confidence can be built to achieve real benefits from vendor rating system. The decision matrix method consists of following steps.

Step 1: Identify the attributes of rating. This is done in consultation with the management of PQR Coffee Company and attributes are decided as mentioned above.

Step 2: Pairwise comparison of the attributes is done to evaluate the weightages for each attribute. For example financial and service criteria are compared with each other and the more important attribute is assigned weightage of 1 and less important of 0. Each attribute is compared with every other attribute and thus n*(n-1) comparisons are done.

Step 3: The weightages given to the different attributes are added up for each attribute. Adjusted weight is calculated by adding 1 to weight of each attribute so that least important attribute should also carry some weight instead of 0 weights. Adjusted weight is then divided by the

summation of all adjusted weights, to give the attribute weightage coefficient for each attribute.

Step 4: Pairwise comparison of vendors in respect of each attribute is done and weightage of 1 is given to superior supplier and 0 to other.

Step 5: These results are tabulated and the supplier weightage coefficient is thus obtained in similar fashion as explained above.

Step 6: The above two types of coefficient are combined by multiplying for each attribute and for each supplier. These are then added up to give the total weightage and this is ranked for the appropriate decisions for the vendors.

Calculation of Weightages for Criteria

Table 6: Pairwise Comparison between Four Major Criteria

	F	*Q*	*D*	*B*	*Wt.*	*Ad. Wt.*	*Wj = Ad. Wt. /Σ Ad. Wt.*
F	-	0	1	1	2	3	0.3
Q	1	-	1	1	3	4	0.4
D	0	0	-	1	1	2	0.2
B	0	0	0	-	0	1	0.1

Where

Q Quality criteria; F Financial criteria; D Delivery criteria;

B Business criteria

And for sub criteria under criteria Quality

	Q1	Q2	Q3	Q4	Wt.	Ad. Wt.	Wj = Ad. Wt. / Σ Ad. Wt.	Overall Weight = Wt of Q * Wj
Q1	-	1	1	1	3	4	0.4	0.4*0.4 = 0.16
Q2	0	-	0	1	1	2	0.2	0.4*0.2 = 0.08
Q3	0	1	-	1	2	3	0.3	0.4*0.3 = 0.12
Q4	0	0	0	-	0	1	0.1	0.4*0.1 = 0.04

Table 7: Pairwise Comparison between Sub Criteria under Quality Criteria

Where

Q1 % rejection; Q2 Quality policy followed; Q3 Quality assurance facilities (equipments and laboratory setup); Q4 Quality certifications

For financial criteria

Table 8: Pairwise Comparison between Sub Criteria under Financial Criteria

	F1	F2	F3	F4	Wt.	Ad. Wt.	Wj = Ad. Wt. / Σ Ad. Wt.	Overall Weight = Wt of F * Wj
F1	-	1	1	0	2	3	0.3	0.3*0.3 = 0.09
F2	0	-	0	0	0	1	0.1	0.3*0.1 = 0.03
F3	0	1	-	0	1	2	0.2	0.3*0.2 = 0.06
F4	1	1	1	-	3	4	0.4	0.3*0.4 = 0.12

Where

F1 Credit terms; F2 Cash discounts; F3 Volume discounts

F4 Product price

For delivery criteria

Table 9: Pairwise Comparison between Sub Criteria under Delivery Criteria

	D1	D2	D3	D4	Wt.	Ad. Wt.	Wj = Ad. Wt. / Σ Ad. Wt.	Overall Weight = Wt of D * Wj
D1	-	0	1	1	2	3	0.3	0.2*0.3 = 0.06
D2	1	-	1	1	3	4	0.4	0.2*0.4 = 0.08
D3	0	0	-	1	1	2	0.2	0.2*0.2 = 0.04
D4	0	0	0	-	0	1	0.1	0.2*0.1 = 0.02

Where
D1 Reliability in delivery; D2 Willingness to accept small order
D3 Proactive use of information technology
D4 Flexibility in terms of meeting variations in demand
For business criteria

Table 10: Pairwise Comparison between Sub Criteria under Business Criteria

	B1	B2	B3	B4	Wt.	Ad. Wt.	Wj = Ad. Wt. / Σ Ad. Wt.	Overall Weight = Wt of B * Wj
B1	-	1	1	1	3	4	0.4	0.1*0.4 = 0.04
B2	0	-	1	1	2	3	0.3	0.1*0.3 = 0.03
B3	0	0	-	0	0	1	0.1	0.1*0.1 = 0.01
B4	0	0	1	-	1	2	0.2	0.1*0.2 = 0.02

Where

B1 Ability of the supplier to speak Barista's language; B2 Reputation of the supplier

B3 Length of time in business; B4 Potential of working in supply chain environment

In this fashion we have calculated the weightages for all criteria. In order to avoid mistakes in pairwise comparison following checks can be applied after pairwise comparisons are complete.

- Loop must not be formed.
- One of the weights must be zero.
- No two weights should be identical.

Pairwise Comparison of Vendors

For each of the sub criteria selected above the vendors are compared and weights of 1 and 0 are assigned depending upon the efficiency of the vendor towards that attribute. For example suppose for a given item presently three suppliers are supplying then pairwise comparison of the suppliers will be done say for % rejection

Table 11: Pairwise Comparison between Suppliers

	S1	S2	S3	Wt.	Ad. Wt	Wi = Ad. Wt. / Σ Ad. Wt.
S1	-	1	0	1	2	0.333
S2	0	-	0	0	1	0.167
S3	1	1	-	2	3	0.5

Similarly for all other attributes pairwise comparison will be done and the weigthage of each of the supplier on each of the criterion is calculated.

Overall Rating

Multiplying the weightages of sub criteria and suppliers and adding all of them together gives

the overall rating for vendors.

Table 12: Template for Calculating Over all Rating for Vendors

Sub criterion & Wj / Supplier	Q1 .16	Q2 .08	Q3 .12	Q4 .04	F1 .09	F2 .03	F3 .06	F4 .12	D1 .06	D2 .08	D3 .04	D4 .02	B1 .04	B2 .03	B3 .01	B4 .02	Over all Rating = Wi*Wj
S1																	
S2																	
S3																	

Based on the performance following rating can be awarded:

- *Strong Positive:* Solid provider of the strategic products, services or software. Potential customer must consider this vendor a strong strategic choice.
- *Positive:* Demonstrate strength in specific areas but is largely opportunistic. Continue incremental investment.
- *Promising:* Shows potential in specific areas, however, initiative of vendor has not fully evolved or matured. Watch for a change in status and consider scenario for short and long term impact.
- *Caution:* Faces challenges in one or more areas. Understand challenges in relevant areas. Assess short and long term benefits/risks to determine if contingency plans are needed.
- *Strong Negative:* difficulty in responding to problems in multiple areas. Exit immediately.

Advantages

Following advantages of proposed vendor rating system are envisaged:

1. It provides scientific platform to apply the subjective judgments.
2. It has potential to incorporate large number of criteria and sub criteria in evaluating the performance of vendors.
3. Potentially large number of suppliers can be evaluated.
4. It is simple and easy to understand.
5. It provides necessary transparency.
6. Revision can be done frequently.
7. Opinion of more than one expert can be sought in pairwise comparison to take in to account the multi-person decisional input.
8. The supply chain department is responsible for this exercise but the opinion of the other department like operations, new product development, finance can also be informally included in pairwise comparison.
9. The weightages can be suitably varied for specific product requirements to get best fit.

Implementation Plan

The techniques suggested in this paper are scientific, logical and useful for modeling of intangible factors as demonstrated. Use of Analytic Network Process for vendor selection is unique approach and it encompasses tremendous potential to become a very effective tool for comprehensive analysis. At present vendor rating system does not exist and proposed decision matrix model should be implemented. The proper implementation of these techniques will result in savings owing to reduction in rejections, inspection costs and time, quality assurance cost,

and cost of wrong decisions. However pitfall lies in lack of sincerity and dedication in implementation of these techniques.

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. In model development, Analytic Network Process and Analytic Hierarchy Process are dealt with. The inherent capacity of these two techniques to include intangibles in finding out the priority coefficient is the precise reason for their extensive use. The two processes along with relevant software are understood and used to solve upstream supply chain related issues like vendor selection, inbound distribution, supplier integration and new product development etc. Supplier integration in supply chain is becoming sort of essential and allocation of intangible resources is an unresolved problem. Decision related to choice of strategy in new product development is dealt with using AHP and solution is obtained by using "Expert Choice". 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 framework for vendor selection. In all 9 vendors are considered for 3 different products and ANP is used to get priorities based on 16 decision criteria. This paper demonstrates the strength of multi- criteria decision-making (MCDM) tools. With the growing complexities in business world and influence of number of intangible factors, they can prove to be extremely essential 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.

References

- Asanuma.B (1989), "Manufacturer supplier relationship in Japan and the concept of relation specific skill", *Journal of Japanese and International Economies*, 3, 1-30.
- Cebi Ferhan and Bayraktar Demet (2003), "An integrated approach for supplier selection", *Logistics Information Management*, 16(6), 395-400.
- Eastham J.F., Sharples Liz, Ball S.D. (2002), *"Food Supply Chain Management: Issues for the Hospitality and Retail Sectors",* Published by Butterworth Heinemann Linacre house, Jordan Hills, Oxford OX2 8DP Woburn.
- Fearne Andrew and David Hughes (2000), "Success factors in the fresh produce supply chain", *British Food Journal*, 102(10), 760-772.
- Ghodsypour, S.H. and O'Brian,C. (1998), "A decision support system for supplier selection using an integrated analytic hierarchy approach and linear programming", *International Journal of Production Economics*, 56/57, 199-212.
- Goffin, K., Szwejczewski, M. and New, C. (1997), "Managing supplies: when few can mean more", *International Journal of Physical Distribution and Logistics Management*, 27(7), 422-436.

- Hall Richard, Andriani Pierpaolo (1998), "Management focus: Analyzing intangible resources and managing knowledge in a supply chain context", *European Management Journal*, 16(6), 685-697.
- Lee J W., Kim S.H. (2000), "Using ANP and Goal programming for interdependent information system project selection", *Computers and Operations Research*, 27, 367-382.
- Mandal A. and Deshmukh S.G., 1994, "Vendor selection using interpretive structural modeling (ISM), *International Journal of Or\operations and Production Management,* 14(6), 52-59.
- Narsimhan, R. (1980), "An analytic approach to supplier selection", *Journal of Purchasing and Materials Management*, summer 1980, 27-32.
- Sarkis, J. and Talluri, S. (2002), "A model for strategic supplier selection", *Journal of Supply Chain Management,* 38(1), 18-23.
- Shin H., Collier D. A and Wilson D.D. (2000), "Supply management orientation and supplier buyer performance", *Journal of Operations Management*, 18, 317-333.
- Spekman, R.E (1988), "Strategic supplier selection: Understanding long term buyer relationship", *Business Horizons*, 75-81.
- Wagner J., Ettenson R and Parrish J. (1989)," Vendor selection among retail buyers: An analysis by merchandise division, *Journal of Retailing*, 65, 58-77.
- Weber C.A., Current J.R., and Benton W.C. (1991), "Vendor selection criteria and methods", *European Journal of Operational Research*, 50, 2-18.