International Business Management 10 (20): 4801-4807, 2016
ISSN: 1993-5250

Subject: Selecting the Best Supplier Using Analytic Hierarchy Process Method (Case Study: Ice Cream Factory of Asal Kurdistan)

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Abstract: In recent years, selecting the proper suppliers in the supply chain has become an important strategic issue. Thus, the nature of these decisions is usually complex and unstructured. Moreover, the process of selecting proper suppliers, capable of providing buyer's requirements in terms of quality products and reasonable prices in a timely and appropriate size is one of the most essential activities to create the appropriate supply chain. On the other hand, food industry is as one of the most important industries in the country that to supply their raw materials require planning. Thus, one of the areas which require serious study is supply chain management and suppliers in the food industry. The aim of this study is to select suitable suppliers of Ice cream factory of Asal Kurdistan. This assessment is done based on twelve criteria in three major categories including criteria related to the characteristics of the suppliers, the criteria related to product performance and the criteria related to the services provided by the suppliers of goods. To evaluate suppliers based on the criteria stated, Analytic Hierarchy Process (AHP) is used. The resulting output shows the score of each supplier. According to the results obtained, Isfahan Nan Gostar Company was selected as the best supplier with the highest score in the five criteria of price, quality, timely delivery, production capacity and accountability of the supplier, respectively.

Key words: Selecting the suppliers, Analytic Hierarchy Process (AHP), asal ice cream factory, accountability, capacity

INTRODUCTION

Recently supply chain management and selection of suppliers have received great attention in management literature. In the 1990s, many factories were in search of a way to cooperate with suppliers so that they improve management performance and competitiveness.

With the increasing importance of purchasing, procurement of activities become more important and since most organizations today are dependent on suppliers' direct and indirect consequences in most industries, costs of materials and poor decisions seem more exacerbated. The cost of raw materials and component of the products make major part of the cost of the product in such circumstances procurement can play a key role in the efficiency and effectiveness of the organization and it has a direct impact on reducing costs and profitability, In fact selecting the appropriate set of suppliers for a company over many years, selecting supplier with flexibility working with whom is very important and vital for the success of a company is emphasized (Zhang *et al*., 2003).

Currently, there is no distinct mechanisms for supplier selection in Asal ice cream factory, so this study tries to identify criteria to evaluate suppliers then identifies weights of the identified criteria using expert opinion and in the next step, using AHP, it tries to rank suppliers and eventually select the best supplier.

Literature review

Ice-cream ingredients: Ice cream compounds are of great diversity but in general, we can say that ice cream is composed of the following materials:

- Fresh milk without fat or condensed milk
- Milk fat: this includes frozen cream, butter or oil
- MSNF (milk solids nonfat ingredients): dried milk, whey solids, condensed milk without fat
- Sweeteners including sugar, corn syrup, lactose and fructose and so on
- Stabilizers including gelatin, pectin propylene glycol, sodium alginate, carboxymethyl cellulose
- Emulsion makers including mono and di menu glycerides, lecithin glycol and its esthers and derivatives of ethylene oxide
- Mineral salts including calcium and magnesium oxides, sodium citrate, di sodium phosphate and tetra sodium pyrophosphate crystal

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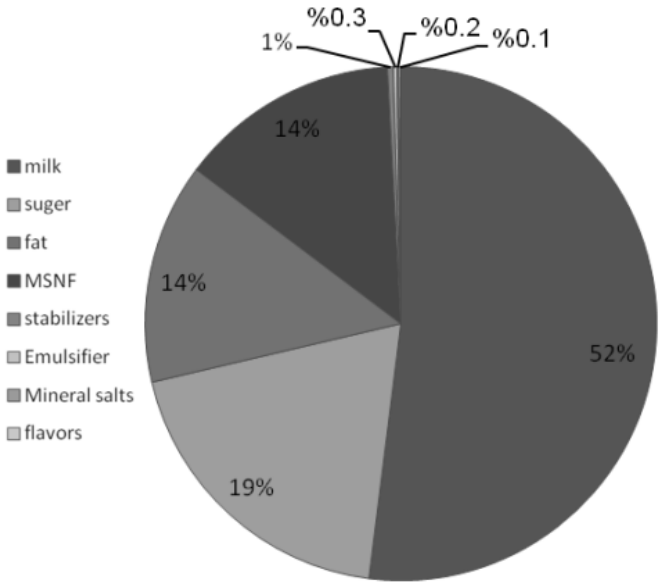

Fig. 1: Ice-cream ingredients

Table 1: Steps of preparing ice cream (Chegeni and Meshkat, 2006)

Factors	Stages
Weighing	In the first stage, the raw materials are weighed accurately according to the instructions
Mixing	In this stage, first liquid components and then dissolved solids in the water and then insoluble materials are added
Pasteurization	Mixed materials are heated for a short time so that the microorganisms in them are separated and ice cream can be stored for a long time
Homogenization	At this point, fat in the mixture is broken into smaller particles and lead to full fat emulsion in the remaining mixture
Processing	Material are poured into special dispensers so that milk proteins and stabilizers absorb the maximum water, the fat is crystallized and viscosity of the mixture increases and all this leads to a softness and smoothness of ice cream
Freezing 1	This step is done in the freezers and fridges
Snapping	After the ice cream is taken out of the freezer, it enters the filling snap
Packing	After snapping, it enters packing to be packed and other information of the is written on them
Freezing 2	After packing, the ice cream is frozen inside the tunnels also known as hardening up to 30 degrees and then kept in cold storage at 18-degrees

- Flavors including vanilla, solids and liquid chocolate, cocoa powder and coffee, fruit essences, colors and other additives to the food that is consumed in the form shown below in Fig. 1

Ice-cream production stages: In summary, ice cream making process includes steps that are outlined in Table 1.

About Asal ice cream factory: Asal ice cream cooperative 1900 whose first phase was operationalized in 2009 and the second phase in 2015 I located in an area of 6000 m^2 in Industrial Park No. 1 Sanandaj and now has 42 employees with annual production of 30,000 tons of ice-cream and sends 85% of its production to Iraq and Southern Provinces of Iran.

With regard to the establishment of its own 3000 livestock in March 2014 with a production capacity of 20 tons of milk, the company provides its basic needs in this area and gets other raw materials including powdered milk, sugar, oil, chocolate and other necessary additives from three main suppliers: Pishgaman Sadiq Co, Isfahan Nan Gostar Company and Rezvan Cmpany that this study examines with these suppliers.

Supplier selection process: De Boer *et al.* (2001) identified four stages in the suppliers' selection process, there are some techniques and methods for each of these steps in the literature of supplier selection these four steps are.

Defining the problem: Decision making methods to solve problems are the methods that help the decision maker for accurate search about the need for a decision and the options that seem available (Aissaoui *et al*., 2007). In the literature of supplier selection, no specific research was found on the stage of defining the problem.

The formulation of decision criteria: Generally, for two reasons, the decision to select supplier becomes complex: first there are two main types of criteria when making

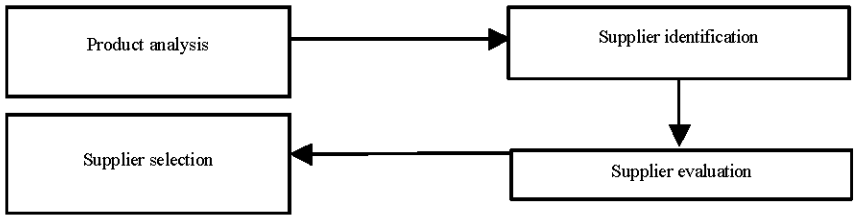

Fig. 2: Supplier selection process (De Boer *et al*., 2001)

decisions about suppliers, objective and subjective criteria. In addition, another factor that complicates decision-making is the number of criteria that may be in conflict with each other. As a result, there is a need for creating exchange between conflicting tangible and intangible factors to find the best supplier. In compensation models, weakness on one criterion can be offset through high performance in other criteria (Aissaoui *et al*., 2007). For formulating criteria, two scientists (Mandal and Deshmukh, 1994) suggest interpretive structural modeling as a technique based on group judgment to identify and summarize the relationship between supplier selection criteria through a graphical model.

Selection of the initial potential suppliers: The purpose of this step is the reduction of inefficient options and changing series supplier set to a limited but acceptable number. Among the options available, using an elimination method can exclude suppliers that have failed to provide the complete satisfaction laws (Aissaoui *et al*., 2007).

The list of the most important methods used in this phase include: Group methods, data envelopment analysis, cluster analysis and case-based reasoning system (De Boer *et al*., 2001).

The final selection: Most published studies about supplier selection are related to the final selection stage. The most widely used techniques in this stage are: Weighted Linear models, mathematical programming models, statistical models, models based on artificial intelligence and total cost of ownership models (De Boer *et al*., 2001) (Fig. 2).

MATERIALS AND METHODS

AHP method: AHP is one of the most famous Multiple Attribute Decision Making (MADM) technique (Saaty, 2001) that was developed by Thomas Saaty used when decision making faces several competing options and decision criteria. The criteria raised may be quantitative and qualitative. The base of this decision-making method is paired comparisons. AHP method is based on the following principles: drawing hierarchical tree, developing and determining priorities and logical consistency of judgment. AHP is widely used in solving numerous complex decision making problems. In the first step, a decision problem is structured in a hierarchical way. AHP initially divides a complex multi-criteria decision-making problem into related decision criteria and easier decision-making options (divides decision-making problems into some easier problems). A hierarchical structure has at least three levels: in the first row, there is the ultimate goal of the problem in the second row, there is the option to define multiple criteria (if sub-criteria exist, they are placed in this row) and options for decision are in the last row (Albayrak and Erensal, 2004).

The second step is to compare options and criteria. When a decision-making problem is divided into smaller problems and yet simpler and its hierarchical structure is created, then it attempts to determine the relative importance of each of the criteria in each of the levels. Pairwise comparisons start from the first level and complete in the last level and specify the superiority of an option to the other option. In each of these levels, criteria are determined based on effect and compared based on the criteria outlined in higher levels (Albayrak and Erensal, 2004).

In AHP, multiple pairwise comparisons are done based on a nine-point scale proposed by Saaty (Table 1). In the final step, it must be ensured that there is a logical consistency between pairwise comparison because AHP output quality is strongly related to compatibility of pairwise comparison. So at this stage, inconsistency rate should be calculated.

First, maximum eigenvalues of matrix of pairwise comparisons (λmax) should be calculated. Then inconsistency index is calculated from the following equation:

$$II = \frac{\lambda max - n}{n - 1}$$

n in the above equation represents the number of rows or columns in comparison matrix (number of criteria).

Table 2: Nine scale comparison of the degree of importance (Habibi *et al*., 2014)

The degree of importance	Definition	Description
1	Equal importance	Two elements have the same importance
3	Relatively preferred	An element is preferred to the other element
5	High preference	An element is highly preferred to the other element
7	Very high preference	An element is very highly preferred to the other element
9	Extremely preferred	An element is extremely highly preferred to the other element
	Facultative value in judgments 2, 4, 6, 8	

In the next step, inconsistency rate is calculated as:

$$IR = \frac{II}{IRI}$$

It should be noted that IIR (random inconsistency index) is extracted from the concerning table and if the inconsistency rate is less than or equal to 0.1 (IR = 0.1), then we conclude that there is consistency in pairwise comparisons. Otherwise, it is necessary for the decision maker to reconsider the pairwise comparisons (Table 2).

Previous studies: A lot of research is done concerning supplier selection process each of which has paid attention to the issue from a particular aspect. Some of them are mentioned below.

Ghodsypour and O'Brien (1997) created a decision support system for reducing the number of suppliers based on supply optimization strategy. They used a mixed-integer programming with analytic hierarchy process and considered capacity constraints and limitations of budget and the quality of the buyer.

In another study in 1998, they offered a combined model of AHP and linear programming model to help managers in their choice of suppliers that considers both quantitative and qualitative factors in purchasing activity.

Weber *et al.* (2000) used a combinatorial optimization approach including multi-objective programming and used DEA approach. In this approach, first a multi-objective programming was used for supplier selection and then assess the efficacy of suppliers selected based on several criteria, DEA approach was applied.

Wang *et al.* (2004) designed a decision-making methodology for supply chain that makes manager able to select suitable suppliers. In this methodology, AHP and goal programming techniques are used.

Research method: This study, based on the result or purpose is applied research and considering the method is descriptive research. In this study, to collect information about the content description and literature, library method has been used with reference to books and articles, using interviews and questionnaires. In this study, the standardized pairwise comparisons questionnaire (Habibi *et al*., 2014) is used.

Therefore, it is valid to measure. Moreover, to determine the reliability of the questionnaire, Cronbach's alpha coefficient is used where the number 0.824 obtained is confirmed. The research population included managers and experts or executives of purchase of Asal ice cream cooperative 1900 who are 25 people and are experts in the field of research and has sufficient information and selected as the sample size. This research has been done in the spring of 2016. In this study, the criteria derived from previous models are used, but to complete and further credit the research criteria, brainstorming technique is used and after 3 rounds (times) of turning of this technique, the saturation point is reached. Finally, in order to select the best supplier, AHP method and expert choice software are used.

Research questions: The research questions are as follows:

- What are the most important criteria for evaluating suppliers in Asal ice cream cooperative?
- How is the ranking of suppliers in the supply chain in Asal ice cream cooperative according to the criteria identified?
- What is the best suppliers according to the results of the study?

Research model: Regarding the overall objective, as to select the best supplier, in the first step, to identify and prioritize of the effective criteria in the selection of suppliers, by literature review and according to the experts of the company, twelve criteria in three categories including: including criteria related to the characteristics of the suppliers, the criteria related to product performance and the criteria related to the services provided by the suppliers of goods were selected as the most important criteria in selecting the suppliers.

Criteria related to the supplier: The supplier criteria are if the qualified supplier assesses its technology strategy. These criteria are created to measure important aspects of the business of the supplier that in this research include:

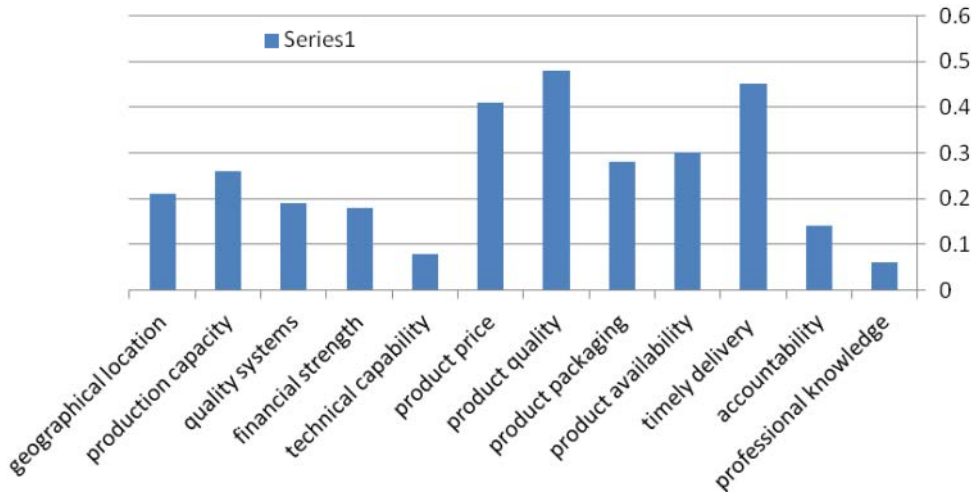

Fig. 3: Determining the relative importance of the criteria for selecting the best supplier

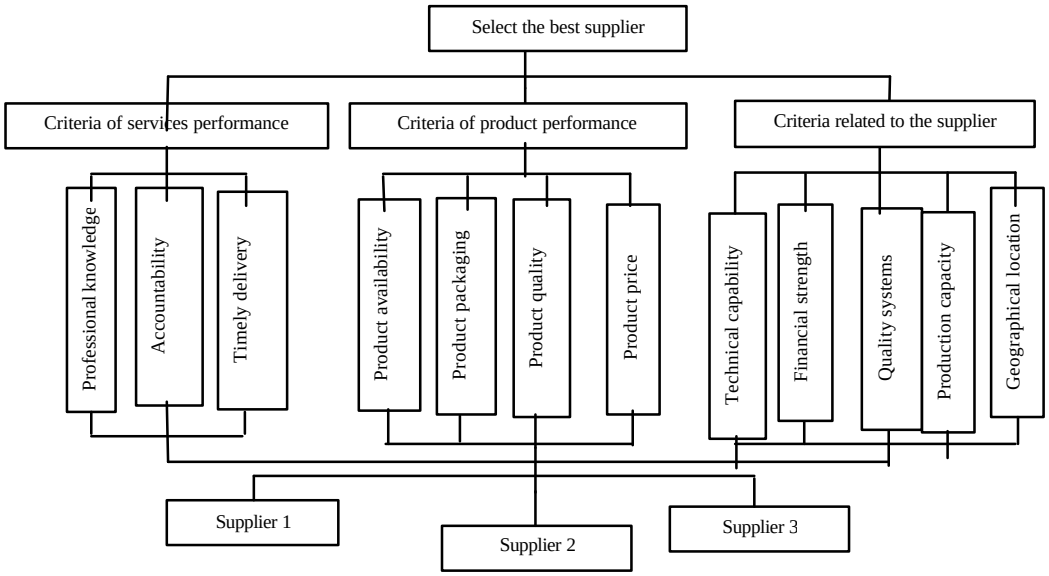

Fig. 4: Hierarchy decision tree

geographical location, quality systems, production capacity, technical capability and financial strength.

Criteria related to product performance: Product performance criteria can be used to evaluate the characteristics of the purchased product. This category of criteria depends on the product type and in this study include: product quality, product price, product packaging and product availability.

Criteria related to services performance: Service performance criterion is used to evaluate the characteristics of services provided by suppliers and this research include accountability, professional knowledge and timely delivery.

Determining the relative importance of the criteria for selecting the best supplier: Then pairwise comparisons between criteria to select the best supplier are done and using AHP method, the relative importance of weight each of these criteria is determined (Fig. 3 and 4).

In the next step, to use AHP method, first hierarchy decision tree must be designed, the tree consists of three levels. The first level is categorizing criteria, which contains standards for suppliers, product performance standards criteria and service criteria, at the second level, there are the criteria identified in the previous level to evaluate suppliers and in the third level, there are the major suppliers of the company that are three suppliers and finally hierarchy decision tree is drawn as follows.

Table 3: Pairwise comparison matrix of suppliers according to the criteria of suppliers

Suppliers	Supplier 1	Supplier 2	Supplier 3
Supplier 1	(1, 1, 1)	(1,1,89,3)	(7,1,4,68)
Supplier 2	(3, 2.4, 10)	(1, 1, 1)	(4, 9, 4, 7, 6)
Supplier 3	(0.73, 0.9, 0.32)	(0.18, 0.25, 0.13)	(1, 1, 1)

Table 4: Pairwise comparison matrix of suppliers according to the criteria of product performance

Suppliers	Supplier 1	Supplier 2	Supplier 3
Supplier 1	(1, 1, 1)	(2,2.8,0.5)	(4.9, 5.2,7)
Supplier 2	(2.8, 3.1, 1.9)	(1, 1, 1)	(2,3.6,3.4)
Supplier 3	(0.14, 0.33, 0.21)	(0.18, 0.25, 0.13)	(1, 1, 1)

Table 5: Pairwise comparison matrix of suppliers according to criteria of services performance

Suppliers	Supplier 1	Supplier 2	Supplier 3
Supplier 1	(1, 1, 1)	(1,1,89,3)	(7,1,4,68)
Supplier 2	(0.3, 0.2, 0.5)	(1, 1, 1)	(0.2, 2.54, 0.32)
Supplier 3	(0.73, 0.9, 0.32)	(0.18, 0.25, 0.13)	(1, 1, 1)

Consistency rate: 0.041

Table 6: Chart rank vendors in AHP method using the software expert choice

Alternatives	Values
Supplier 1	0.635
Supplier 2	0.279
Supplier 3	0.086

RESULTS AND DISCUSSION

At this stage, we deal with the priority of each decision elements using pairwise comparison matrices information making use of the information, the questionnaire of paired comparisons was designed and used to calculate weights of the three providers. For this purpose, 25 questionnaires were distributed among managers, experts or purchase executives and its different units and 23 questionnaires were returned. Results obtained from the questionnaires were examined and compared by matrix of paired comparisons and in the next step to calculate the relative weights, first the numbers of pairwise comparison matrices were normalized and then their row averaged are obtained in Table 3-5.

With the identification of weight of each criterion and using expert choice software, the problem is solved and the results are as follows which shows that suppliers 1 with the highest score in first priority and suppliers 2 and 3 are in next ranks in Table 6.

CONCLUSION

The results to identify the parameters are so that for the manufacturers quality of raw materials is of considerable importance. If milk and raw material of suppliers are not of good quality, product quality is also greatly reduced. In fact, the principle GIGO = Garbage in Garbage out which states that if the raw materials are undesirable the product will be unfavorable. After product quality, price becomes very important. For the producer in the current conditions, when the food profit is not so high and consumer purchasing power make the cost as one of the most important criteria has been replaced by other criteria and commodity prices is very important. The delay in transport of raw materials, due to being perishable and the high cost of depot and maintenance, they are bought in short-term and must be submitted regularly to the factory, which can impose irreparable harm to the factory production line and profitability. Therefore, manufacturers should strengthen their relationship with those suppliers that are determined to send raw materials to the factory and prevent a delay in sending and sleep of the production line. Other identified criteria to evaluate suppliers as shown in Fig. 4 are in the fourth to twelfth rank that are as gauges to assess manufacturing capacity, financial strength, technical strength, professional knowledge, accountability, accessibility, geographic location, product packaging and deployment of quality systems, all considered as criteria to measure suppliers.

Finally, it should be stated that the process of supplier and manufacturer communication is not only limited to the purchase and Asal ice cream factory expects that suppliers have proper support for the sale of their raw materials. Therefore, accountability regarding the amount, quality, source of raw materials and so on are all of those good qualities that a supplier must have. With respect to the fact that evaluation criteria of the suppliers have been specified, researchers have addressed evaluating and ranking suppliers using analytic hierarchy process.

The results obtained indicate that Isfahan Nan Gostar Cohas the highest weight and the highest rank. This shows that in terms of decision-makers, long-term cooperation and engagement with this supplier can bring a better future for the factory. Second-largest supplier is Rezvan Company that has a good market share. Finally, the last rank is for Pishgaman Sadiq Co. According to the results, it is suggested.

Plant managers and decision makers interact with suppliers based on the prioritized list because in the method presented in this study, it is tried to use both the criteria and viewpoints of the managers, so that a more realistic and reliable pattern is obtained to select suppliers.

Thus, this can greatly guarantee profitability and long-term engagement. In other words, it can be stated that the model presented in this study tries to move based on this reality. Thus, by relying on this study, the company can reduce the corresponding costs and maximize purchase utility.

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