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A Hybrid Model for Supplier Selection in Outsourcing: Evidence from Shima Film Company in Iran

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Abstract: Outsourcing is one of the important strategies acknowledged by firms recently. However, outsourcing needs a more intelligent and informed decisions in the organizations. In this study, we propose a new hybrid Multiple Criteria Decision-Making (MCDM) model, which addresses the dependent relationships between the various criteria. Decision-makers tend to hold diverse opinions about their preferences due to incomplete information and knowledge, or inherent conflict between various departments. We further used the fuzzy preference programming and the Analytic Network Process (ANP) to form a model for the selection of partners for outsourcing providers. The proposed model can help practitioners improve their decision making process, especially when criteria are numerous and inter-related. Finally, regarding the importance of subject, we will analyze the results while conducting a case study.

Keywords: Fuzzy logic, MCDM, outsourcing, supplier selection

INTRODUCTION

If the local organization to be defined as an organized entity that has some governmental characteristics and also has administrative, financial and political autonomy and its purpose is to provide public services to local people with maximum efficiency and effectiveness (Aktas *et al*., 2011). Outsourcing is a useful method for adjusting the boundaries of the firm in response to external economic pressures. It enables the firm to consolidate its strategy by restructuring its activities in order to stimulate growth of its core business. This involves a fundamental change in strategy (Bustinza *et al*., 2010). In order to ensure that outsourcing is successful, firms should balance the strategies of vertical integration and externalization (Rothaermel *et al*., 2006) and analyze in detail the impact of these decisions on their results, by studying all the variables involved in this process. The result the firms' increased efficiency and ability to focus on core competencies-has produced real profits and increased customer satisfaction.

Nevertheless, ineffective outsourcing activities, derived from improper strategies or methods, will lead to a loss of core competencies and capabilities, exposure to unexpected risk and even business failure (Wang and Yang, 2007). A more scientific decision making process for choosing outsourcing providers is very important in order to increase the success rate of outsourcing. Therefore, in this study after investigating the effective criteria on the supplier selection, we will offer a model for selecting the supplier. Regarding to this that selecting the supplier in the process of outsourcing is the multi-criteria decision making issue and on the other hand, existence of an ambiguity and non-specific preferences of individuals, the use of fuzzy logic is inevitable, therefore in this research, the main indices of supplier was identified and the fuzzy multi-criteria decision method making were prioritized.

RESEARCH LITERATURE

Outsourcing: For persons who are involved in the production and manufacturing, the question of" what should be made in inside and what should be purchased from outside?" is not a new question (Beasley *et al*., 2009). Current studies have related positive effects of manufacturing outsourcing to production volume flexibility or market value, but negative effects to innovation capabilities, quality, speed and on-time delivery, For example, Dabhilkar and Bengtsson (2008) found positive direct effects of outsourcing on volume flexibility. The focal firm can improve its responsiveness to variability in demand by outsourcing peak demand to suppliers (Hsiao *et al*., 2010).

According to Jiang *et al*. (2007) core business-related outsourcing is positively related to outsourcing firms' market value. It demonstrates a positive signal to

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the stock market. They mention that firms, recognizing that they cannot be world class in every activity and function involved in producing their products, are moving toward business strategies based on 'core competencies' that help maintain their competitive advantage in serving customers.

The majority (around 70%) of US industry appears to have had negative experiences with outsourcing (Verma, 2005). This negative experience might be the result of the lack of comprehensive evaluation to discover the best candidates for outsourcing. Therefore, there have been a number of studies determining the most effective manner of selecting outsourcing providers. For example, Hsu and Hsu (2008) presented an entropy-combined Technique for Order Preference by Similarity to the Ideal Solution (TOPSIS) based decision-making method for medical information system outsourcing. Sarder *et al*. (2006) conducted outsourcing SWOT analyses for some US industries. They concluded that there was no correct answer to choosing the best outsourcing strategies and that many criteria/factors should be considered in the process. Lee and Kim (2005) analyzed the structural relationship among the determinants of an outsourcing partnership and identified the relationship between partnership-related variables and outsourcing success. They identified six key factors for a successful partnership in areas of outsourcing, working partnerships in marketing and strategic alliances in management. Their proposed six inter-related key factors are: shared knowledge, organizational linkage, mutual dependency, benefits, commitment and predisposition. Some other researchers (Yang *et al*., 2007; Wang and Yang, 2007) have used different MCDM models to investigate information systems outsourcing. However, they did not consider the inter-relationship between various criteria.

Supplier selection criteria: Supplier selection has been a focus of academicians and purchasing practitioners since the 1960s (Dickson, 1966; Weber *et al*., 1991). During recent years supply chain management and supplier selection process have received considerable attention in the literature. A supply chain is a network of suppliers, manufacturing plants, warehouses and distribution channels organized to acquire raw materials, convert these raw materials to finished products and distribute these products to customers (Bidhandi *et al*., 2009). Supplier selection is one of the most critical activities of purchasing management in supply chain and in this process suppliers are reviewed, evaluated and chosen to become a part of the company's supply chain (Sanayei *et al*., 2008; Guo, 2009). The evolution of the competitive environment has made company competitiveness and survival depend more and more on their suppliers (De Boer *et al*., 2001).

Periodic evaluation of supplier quality is carried out to ensure the meeting of relevant quality standards for all incoming items (Jain *et al*., 2004). Researchers have applied both qualitative and quantitative approaches in considering supplier selection and there are many studies that discussed the issue of supplier selection (Bhutta and Huq, 2002; Chou and Chang, 2008; Garfamy, 2006; Ramanathan, 2007; Teng and Jaramillo, 2005), most of them focus on price, quality, services, delivery time, supplier location, supplier financial statues and performance.

Yang and Chen (2006) performed a literature review and an interview with three business executives that concluded to six qualitative criteria including quality, finances, service, production capacity, design, technological capability and IT infrastructure and to four quantitative criteria including turnover, cost, delivery and distance. Kahraman *et al*. (2003) mentioned that selection criteria typically fall into one of four categories: supplier criteria, product performance criteria, service performance criteria and cost criteria.

Gill and Ramaseshan (2007) indicated that few scholars discuss the performance during the purchasing processes or consider it as a significant factor in supplier selection. They divided this performance into five parts:

- Relationship commitment
- Product quality
- Price
- Payment facilities
- Brand recognition

Hong *et al*. (2005) defined important criteria of both supply risk and supply profit. In terms of supply risk, they defined the criteria which can be used to evaluate whether or not a supplier is capable of delivering the desired product, in the desired quantity and at the desired time. On the other hand, they defined the criteria that can be used to evaluate profit as price, quality and quantity. Bottani and Rizzi (2006) presented a multi-attribute approach for selection and ranking of the most suitable 3PL service provider. They applied service criteria such as breath of service, business experience, characterization of service, compatibility, financial stability, flexibility of service, performance, price, physical equipment and information, quality, strategic attitude, trust and fairness.

Supplier selection techniques: Since supplier selection problems usually have several objectives such as maximization of quality or maximization of profit or minimization of cost, the problem can be modeled using mathematical programming. There are exist plethora of research on the supplier selection process. Traditional methodologies of the supplier selection process in the extant literature range from single objective techniques such as the cost-ratio method, linear or mixed integer programming to goal and multi-objective linear programming models (Yan *et al*., 2003; Oliveria and Lourenço, 2002). While several supplier selection methods have been identified and widely applied in the industry, industrialists and academics differ in their approach to the study of methods for supplier selection. Industrialists take a relatively more practical approach than academics.

Lee *et al*. (2001) used only AHP for supplier selection. They determined the supplier selection criteria based on the purchasing strategy and criteria weights by using AHP. Xia and Wu (2007) used an integrated approach of AHP improved by rough sets theory and multi-objective mixed integer programming, which was proposed to simultaneously determine the number of suppliers to employ and the order quantity allocated to these suppliers in the case of multiple sourcing and multiple products, with multiple criteria and with the supplier's capacity constraints.

Haq and Kannan (2006) developed an integrated supplier selection and multi-echelon distribution inventory model for the original equipment manufacturing company in a built-to-order supply chain environment using fuzzy AHP and a genetic algorithm. Chen *et al*. (2006) developed a hierarchy multiple criteria decision-making model based on fuzzy sets theory to deal with the supplier selection problems. Their model uses the concept of TOPSIS to determine the ranking order of all suppliers. There are exists a plethora of research on the supplier selection process.

Wang and Hu (2005) have developed a decision-based methodology for supply chain design that a plant manager can use to select suppliers. This methodology derived from the techniques of Analytical Hierarchy Process (AHP) and pre-emptive goal programming.

The researches and applications in recent years are: applied analytical hierarchy process (Kokangul and Susuz, 2009), used analytic network process (Hsu and Hsu, 2008; Wu *et al*., 2009), proposed neural network (Lee and Ou-Yang, 2009), proposed a fuzzy model (Lee *et al*., 2009), proposed a hybrid method (Ha and Krishnan, 2008) and proposed fuzzy hierarchical and TOPSIS for the supplier selection problem (Wang *et al*., 2009).

Feng *et al*. (2005) proposed a comprehensive evaluation method based on fuzzy decision theory and characteristics of supply chain management for optimal combination and selection among candidate suppliers and outsourced parts. Chan *et al*. (2008) propose a fuzzy AHP approach for global supplier selection. Chamodrakas *et al*. (2009) use fuzzy AHP to select supplier in electronic sector.

Shemshadi *et al*. (2011) extended the VIKOR method with a mechanism to extract and deploy objective weights based on Shannon entropy concept for supplier selection. Chen and Wang (2009) provided a more efficient delivery approach for evaluating and assessing possible suppliers/vendors using the fuzzy VIKOR method. Sanayei *et al*. (2010) proposed a hierarchy MCDM model based on fuzzy sets theory and VIKOR method is proposed to deal with the supplier selection problems in the supply chain system.

METHODOLOGY

Research done in terms of categories based on objective research, applied research is intended to transfer the scientific findings of fundamental research to technology field. But in terms of how to collect data and descriptive type of research is a case study of the branches. This study developed three questionnaire. Sampling in this study is simple random and the formula (1) for the experts to follow:

$$n = \frac{N*\left(Z\frac{\propto}{2}\right)^2*pq}{(\varepsilon)^2*(N-1)+\left(Z\frac{\propto}{2}\right)^2*pq} \quad (1)$$

So the sample size required for 26 experts.To increase the validity of Bartlett's test and KMO index is used. KMO value in this study equal 0.83 and 0.00 times the amount of sig has been indicating that factor analysis is to identify the appropriate structure. also on the reliability coefficient Kronbakh's alpha used in this study, alpha coefficients equal to 0.8737 is obtained, the data of the questionnaire has acceptable reliability.

Fuzzy analytic hierarchy process: Laarhoven and Pedrycz (1983) proposed the Fuzzy Analytic Hierarchy Process in 1983, which was an application of the combination of Analytic Hierarchy Process (AHP) and Fuzzy Theory. The linguistic scale (Table 1) of traditional AHP method could express the fuzzy uncertainty when a decision maker is making a decision. Therefore, FAHP converts the opinions of experts from previous definite values to fuzzy numbers and membership functions, presents triangular fuzzy numbers in paired comparison of matrices to develop FAHP, thus the opinions of experts approach human thinking model, so as to achieve more reasonable evaluation criteria. Laarhoven and Pedrycz (1983) proposed the FAHP, which is to show that many concepts in the real world have fuzziness. Therefore,

Table 1: Linguistic variables for weight of each criterion

Extremely strong	(9, 9, 9)
Intermediate	(7, 8, 9)
Very strong	(6, 7, 8)
Intermediate	(5, 6, 7)
Strong	(4, 5, 6)
Intermediate	(3, 4, 5)
Moderately strong	(2, 3, 4)
Intermediate	(1, 2, 3)
Equally strong	(1, 1, 1)

the opinions of decision makers are converted from previous definite values to fuzzy numbers and membership numbers in FAHP, so as to present in FAHP matrix.

The steps of this study based on FAHP method are as follows:

- **Determine problems:** Determine the current decision problems to be solved, so as to ensure future analyses correct; this study discussed the ‘‘evaluation criteria for verification of supplier selection criteria”.
- **Set up hierarchy architecture:** Determine the evaluation criteria having indexes to be the criteria layer of FAHP, for the selection of evaluation criteria, relevant criteria and feasible schemes can be found out through reading literatures. This study screened the important factors conforming to target problems through FDM investigating experts' opinions, to set up the hierarchy architecture.
- Construct pair wise comparison matrices among all the elements/criteria in the dimensions of the hierarchy system. Assign linguistic terms to the pair wise comparisons by asking which is the more important of each two dimensions, as following matrix $\tilde{A}$:

$$\tilde{A}=\begin{bmatrix} 1 & \tilde{a}_{21} & \cdots. & \tilde{a}_{21} \\ \tilde{a}_{21} & 1 & \cdots & \tilde{a}_{21} \\ & & & \\ \tilde{a}_{21} & \tilde{a}_{21} & \cdots & 1 \end{bmatrix}=\begin{bmatrix} 1 & \tilde{a}_{21} & \cdots. & \tilde{a}_{21} \\ \frac{1}{\tilde{a}_{21}} & 1 & \cdots & \tilde{a}_{21} \\ & & & \\ \frac{1}{\tilde{a}_{21}} & \frac{1}{\tilde{a}_{21}} & \cdots & 1 \end{bmatrix}$$

where,

$$\tilde{a}_{ij}\begin{cases}\tilde{9}^{-1},\tilde{8}^{-1},\tilde{7}^{-1},\tilde{6}^{-1},\tilde{5}^{-1},\tilde{4}^{-1},\tilde{3}^{-1},\tilde{2}^{-1},\tilde{1}^{-1},\tilde{1},\tilde{2},\tilde{3},\tilde{4},\tilde{5},\tilde{6},\tilde{7},\tilde{8},\tilde{9} & i \neq j \\ 1 & i = j\end{cases}$$

- To use geometric mean technique to define the fuzzy geometric mean and fuzzy weights of each criterion by Hsieh *et al*. (2004):

$$\tilde{r}_i = \left(\tilde{a}_{i1} \otimes \tilde{a}_{i2} \otimes .... \otimes \tilde{a}_{in}\right) \quad (3)$$

$$\tilde{w}_i = \tilde{r}_i \otimes \left(\tilde{r}_1 \oplus \tilde{r}_2 \oplus .... \oplus \tilde{r}_n\right)^{-1} \quad (4)$$

where, a_{ij} is fuzzy comparison value of dimension i to criterion j, thus, $\tilde{r}_i$ is a geometric mean of fuzzy comparison value of criterion i to each criterion, $\tilde{w}_i$ is the fuzzy weight of the ith criterion, can be indicated by a TFN, $\tilde{w}_i = \left(lw_i, mw_i, uw_i\right)$. The lw_i, mw_i and uw_i stand for the lower, middle and upper values of the fuzzy weight of the ith dimension.

DATA ANALYSIS

In this section, an empirical study of the selection of outsourcing providers in the Shima Film is used to illustrate the feasibility of the proposed method.

Problem descriptions: Globalization has resulted in a closely integrated labor and capital market, where firms have greater access to human capital scattered around the world. The CD/DVD production is a highly complex business encompassing a variety of professional skills. In order to provide total and effective services, producers must overcome the challenges of rapid change, rising competition, rising complexity and radically-changing environments. As a result, many major companies are going through deintegration processes as they contract out large parts of their business to networks of suppliers in search of greater efficiency and competitiveness. Therefore, we have proposed a hybrid processing model for Shima Film that can efficiently select strategic partners for outsourcing activities.

The model is developed and then validated using data from Shima Film, a Iranian company that produces CD/DVD. In order to reduce manpower costs and provide more efficient services, the company has sought to contract out its ground services in foreign destinations. The decision is strategic because the development's success will have great bearing on the company's competitive abilities.

Supplier selection criteria: In any outsourcing activity, there are risks, such as potential structural and cultural incompatibilities. To ensure success, it is crucial that both users and providers (partners) have a clear understanding of their similarities and differences and recognize opportunities for mutual benefits under cooperative arrangements. Since partner selection is crucial, it is imperative for decision-makers to devise, identify and recognize effective partner selection criteria, as well as evaluate questions of compatibility and feasibility prior to outsourcing activities. Several issues are important for determining the optimal

collaborator in this partner selection process, including: whether there has been favorable past association between the partners; whether the national and corporate cultures of the partners are compatible; and whether trust exists between the partners' management teams. The partner selection criteria were developed on the basis of a literature review and a series of discussions with Shima Film's managers. This discussion with the industry helped us to classify the various criteria of decision-making into four dimensions: compatibility, risk, quality and cost. These dimensions were then divided into various criteria, as indicated in Table 2. By examining these dimensions, we can avoid the pitfalls of classic outsourcing decisions where cost alone is used as the deciding factor.

Measuring the relationships between dimensions: Since the partner selection systems are complex, it is not appropriate to assume the elements within systems are independent. Therefore, we sought to find the important criteria for the various evaluation systems and measure the relationships among these dimensions (Table 3).

To calculate the fuzzy weights of criteria, the computational procedures are displayed as following parts:

$$\tilde{r}_1 = \left(\tilde{a}_{11} \otimes \tilde{a}_{12} \otimes .\tilde{a}_{13} \otimes \tilde{a}_{14} \otimes \tilde{a}_{15} \otimes \tilde{a}_{16} \otimes \tilde{a}_{18} \otimes \tilde{a}_{19}\right)^{\frac{1}{9}}$$

$$\tilde{r}_1 = \begin{pmatrix} (1,1,1) \otimes (1.718,2.595,3.489) \otimes .(1.571,2.301,3.025) \\ \otimes (2.097,3.157,4.186) \otimes \\ (5.23,6.25,7.23) \otimes (3.616,4.708,5.753) \\ \otimes (3.933,5.037,6.058) \otimes (5.95,6.854,7.726) \end{pmatrix}^{\frac{1}{9}}$$
$$= (2.76,3.556,4.294)$$

$$\tilde{r}_2 = (1.385,1.839,2.343)$$
$$\tilde{r}_3 = (1.175,1.941,2.434)$$
$$\tilde{r}_4 = (1.148,1.488,1.915)$$
$$\tilde{r}_5 = (0.357,0.438,0.553)$$
$$\tilde{r}_6 = (0.602,0.757,0.973)$$
$$\tilde{r}_7 = (0.473,0.603,0.784)$$
$$\tilde{r}_8 = (0.635,0.801,1.03)$$
$$\tilde{r}_9 = ((0.276,0.333,0.421)$$

For the weight of each criterion, they can be done as follows (Table 4):

$$\tilde{w}_i = \tilde{r}_i \otimes \left(\tilde{r}_1 \oplus \tilde{r}_2 \oplus .\tilde{r}_3 \oplus \tilde{r}_4 \oplus \tilde{r}_5 \oplus \tilde{r}_6 \oplus \tilde{r}_7 \oplus \tilde{r}_8 \oplus \tilde{r}_9\right)^{-1}$$
$$\tilde{w}_1 = \tilde{r}_1 \otimes \left(\tilde{r}_1 \oplus \tilde{r}_2 \oplus .\tilde{r}_3 \oplus \tilde{r}_4 \oplus \tilde{r}_5 \oplus \tilde{r}_6 \oplus \tilde{r}_7 \oplus \tilde{r}_8 \oplus \tilde{r}_9\right)^{-1}$$
$$\tilde{w}_1 = (2.76,3.556,4.294) \otimes \begin{pmatrix} 1\Big/\begin{pmatrix} 4.294 + 2.343 + 2.434 + 1.915 + 0.553 \\ + 0.973 + 0.784 + 1.03 + 0.421 \end{pmatrix}, \\ 1\Big/\begin{pmatrix} 3.556 + 1.839 + 1.941 + 1.488 + 0.438 \\ + 0.757 + 0.603 + 0.801 + 0.333 \end{pmatrix}, \\ 1\Big/\begin{pmatrix} 2.76 + 1.385 + 1.175 + 1.148 + 0.357 \\ + 0.602 + 0.473 + 0.635 + 0.276 \end{pmatrix} \end{pmatrix}$$
$$= (0.187,0.302,0.487)$$

We also can calculate the remaining $\tilde{w}_i$, there are:

$$\tilde{w}_2 = (0.094,0.156,0.226)$$
$$\tilde{w}_3 = (0.08,0.165,0.276)$$
$$\tilde{w}_4 = (0.078,0.126,0.217)$$

DISCUSSION AND CONCLUSION

This study develops a hybrid decision model for outsourcing that considers interdependencies between criteria and shows how the model may be applied in real-world decision processes. Factors affecting outsourcing partner selection were investigated under multiple criteria (including compatibility, quality, cost and risk) in order to avoid the mistakes made by traditional outsourcing decisions. These traditional decisions generally only consider cost as a criterion, or assume that the criteria are independent. Also, our hybrid model considers the decision-makers' vague judgment during pair wise comparisons. Moreover, through the impact relationship map, the alternatives (outsourcing providers) can easily develop their improving strategies and increase their competitiveness.

Our results have several implications for the outsourcing partner selection process. First, managers considering outsourcing should identify its selection criteria and weights very carefully. Various criteria and weights may result in different solutions. In addition, since it is up to managers to assess the criteria and their relative impact on provider selection, they need to have

Table 2: List of criteria and definition

Criteria	Definition
C_1: Quality	To provide a high-quality product, supplier should have a quality system including quality assurance, quality control procedures, quality control charts, documentation, continuously quality improvement, etc.
C_2: Cost	Cost of product is a high percentage of in total cost of purchasing. Therefore purchasing department wants to purchase the product with minimum price to decrease the total cost
C_3: Risk	Supplier's production facilities should meet customer's specific requirements. When the customer develops new product or improves current product according to market demand the supplier's facilities should be available to produce it
C_4: Compatibility	Compatibility of computer systems and information-sharing, such as new information/regulations

Table 3: Fuzzy comparison matrix for the relative importance of criteria

	C1	C2	C3	C4
C1	(1, 1, 1)	(1.71, 2.5, 3.4)	(1.5, 2.3, 3.2)	(2.09, 3.1, 4.1)
C2	(0.2, 0.3, 0.5)	(1, 1, 1)	(0.6, 0.8, 1.1)	(0.9, 1.3, 1.8)
C3	(0.3, 0.4, 0.6)	(0.8, 1.1, 1.5)	(1, 1, 1)	(1.02, 1.4, 1.8)
C4	(0.2, 0.3, 0.4)	(0.5, 0.7, 1.6)	(0.5, 0.7, 0.9)	(1, 1, 1)

Table 4: The weights and rank of criteria

$\widetilde{W}_i$	Fuzzy weight	Crisp weight	Rank
$\widetilde{w}_1$	(0.187, 0.302, 0.487)	0.314	1
$\widetilde{w}_2$	(0.094, 0.156, 0.226)	0.165	3
$\widetilde{w}_3$	(0.08, 0.165, 0.276)	0.169	2
$\widetilde{w}_4$	(0.078, 0.126, 0.217)	0.127	4

Table 5: Performance matrix of service providers for each criterion

Outsourcing provider selection criteria	Weights	A1	A2	A3	A4
C1	0.314	0.685	0.752	0.821	0.772
C2	0.165	0.743	0.724	0.652	0.752
C3	0.169	0.772	0.757	0.742	0.763
C4	0.127	0.681	0.750	0.860	0.784

a clear picture of their evaluating systems. In addition, managers of outsourcing providers should understand which factors can affect the outsourcing partner selection. In our results, managers must make special effort to enhance their compatibility with the users, because a provider's compatibility plays a significant role in the decision model for outsourcing activities. In summary, the case study helps to verify that the proposed hybrid model is an effective and efficient decision-making tool which can be easily extended.

The proposed hybrid model provides a systemic analytical model for the selection of outsourcing providers. Besides including multiple criteria, interdependencies among dimensions are also considered through the fuzzy method. Because of the diversity of judgments from decision-makers, we combined fuzzy preference programming and ANP to decide the relative weights of each criterion given dependence and feedback. The integrated score of each provider was aggregated by the simple additive weight method. In our case study if A>B means A outranks B, then the ranking of service providers for the Shima Film are as follows: A3>A4>A2>A1. In other words, A3 is the best service provider because it has the highest integrated score compared to the other alternatives. Looking at the performance matrix (Table 5) in more detail, we find that A3 has the highest score in terms of compatibility, which also causes the other criteria to have superior performance.

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