

Fuzzy Analytical Approach to Industrial Cluster Selection

Seyed Mostafa Mousavi

Specialty of Economics-Mathematical Methods and Modeling, Yerevan State University, Armenia

ABSTRACT

In this article, by using fuzzy AHP technique we propose a new method for industrial cluster selection between clusters that identified in food industries. After reviewing some criteria that use four comparing in this paper we use them as criteria in AHP tree. In this methodology by utilizing improved Analytical Hierarchy Process by Fuzzy set theory, first we try to calculate weight of each criterion. Then, assessment of industrial cluster has been done and finally Obtained results have been tested in a numerical example.

Keywords: Analytical Hierarchy Process (AHP), industrial cluster, Fuzzy set theory, criteria.

1. INTRODUCTION

The competitive environment in industry started to change, especially in manufacturing industry. Before the late 1970, the firms of manufacturing semiconductors and electronics employed technology to create modern markets. Semiconductor technology was modern, too complicated and very significant to be developed and commercialized sufficiently within a single organization. Companies at first relied on time-to-market advantages to retain competitive advantages. Besides, the complexity of technology was increasing and so encouraged the business risks.

Industries can open out operations all over the world in a global market. Carrie (2000) orgues the emergence of a new form of competition, namely, competition between regional clusters, which could contribute to multinationals' global activities. Furthermore, a consensus reached at the international working conference on strategic management of manufacturing value chain that distinguished the implications of shifting basis of competition. In the modern definition, competition is between clusters of companies, customers, suppliers and other private and public stakeholders rather than individual companies.

Technological innovation is essential for competitive interest and development and application of new technology and selecting new organizational forms make a competitive private enterprise system. It is obvious that the technological innovation and progress result from many interactions between industries and technologies. The technological interaction among firms can be boosted through the geographical concentration of an industry.

Peter has considered the development of the concept of 'Industrial Cluster' in the 1980s as an important factor in innovation, enterprenuership and technology industries [4]. Most governments have considered the clusters central to their economic development strategies; however, many factors have impacts on industrial clusters.

This article employs the Fuzzy AHP method to study the factors affecting on industrial clusters. New industrial environments have specially included particular division of labor and the best way to create competitive ability for enterprises is to get support from supply chain partnerships and describing the relation of the supply chain. The primary contributions of this research are to apply System Dynamics (SD) approach to explore the factors that have influence on industrial cluster and to establish the dynamic model of various factors of industrial cluster effect through causal loop diagram (or cause-and-effect chain)

The focus of intensive research efforts are the design and implementation of the systems of decision support which can introduce automation and intelligence to online negations. Various models of negotiation and automated trading systems have been produced, meeting different market requirements. Among them, the services negotiation model seems the most complicated because it needs the evaluation and decision-making under the uncertainly, which are based on multiple attributes (criteria) of the quantitative and qualitative nature, includes temporal and resource constrains, risk and commitment problems, differing tactics and strategies, domain specific knowledge and information asymmetries, etc.

The cycle of negotiation usually includes a series of interdependent activities (decision-making and actions) from preparation till entrance into negotiation, through the negotiation per se the execution of the agreed deal. The pre-negotiation phase is a special importance since the actions and outcomes in one stage may have strong effect on the next and can constrain it [5, 6]. It some authors [7] find that in a simulated competitive market, the specific composition of the initial offers affect on the final agreements beyond the effect predicted by their overall value.

^{*}Corresponding Author: Seyed Mostafa Mousavi, Specialty of Economics-Mathematical Methods and Modeling, Yerevan State University, Armenia.

While the computational complexities of automating negotiations over multidimensional goods as services have been identified, the concept of some of decision-making problems and changing part of reasoning to prenegotiation phase has not yet been clearly formulated.

This article addresses the problem of uncertainty related to some of main assessment methods used in negotiations over services. The proposed approach is going to solve the problems in ranking service offers, by applying a modification of the analytic hierarchy process (AHP) as evaluation tool.

The AHP is used widely for multi-criteria decision-making and has successfully have applied to many practical problems of decision making [13]. This method is often criticized for its inability to handle the inherent uncertainty and imprecision associated with the mapping of decision-makers perception to exact numbers.

In the traditional formulation of the AHP, human's judgments are represented as exact (or crisp, according to the fuzzy logic terminology) numbers. However, in many practical cases the human preference model is uncertain and decision-makers might be reluctant or unable to assign exact numerical values to the comparison judgments. For instance, when evaluating different services, the decision-makers are usually unsure in their level of preference due to incomplete and uncertain information about possible service providers and their performance. Since some of the service evaluation criteria are subjective and qualitative, it is very difficult for the decision-maker to express the strength of his preferences and to provide exact pair wise comparison judgments.

The main objective of this paper is to propose a new approach within the AHP framework for industrial cluster selection between clusters that identified in food industries, where the decision-makers comparison judgements are represented as fuzzy triangular numbers. A new fuzzy prioritization method, which derives crisp priorities (criteria weights and scores of alternatives) from consistent and inconsistent fuzzy comparison matrices is described.

2. Statement of the cluster selection Problem

As previously mentioned the main issue in this study developed an algorithm to select good clusters deserves appropriate business development projects are in the cluster. After determining the problem and purpose, criteria and determine the next step to identify the type of relationship between them. This issue is influenced by different criteria. These criteria in two ways have been identified.

Beginning with a literature study discussed the resources to talk about such projects have paid, then interviews with experts in the field of business projects, cluster size to determine the exact problem and information about the criteria influencing the issue was completed.

Factors in the prioritization and selection of top clusters, focusing on six criteria of geographical clusters, the potential market access, strategic role for the regional level, potential access to raw materials, the existence of institutions and development support and complement susceptibility clusters are summarized.

Criterion "level strategic role for the region" following three criteria units, the share of regional employment and investment can be divided into shares. Cluster quality criteria developed under the criteria of both the process and increase the process of increasing production unit has been formed.

2.1 Evaluation criteria clusters

Clusters identified for evaluation with regard to theories of experts and scholars on five main criteria were the following referred to.

2.1.1Role in the regional economy:

This benchmark consists of three sub-criteria which are as follows:

- Number of firms: one of the most important indicators to determine the number of clusters and identify the active agent or agent-related business cluster, which is considered the minimum number of 25 firms are in the project.
- Share of employment in the region: as the following criteria for the role of the regional economy is considered. Each cluster that a greater share of employment in the region is more important is specifically.
- Investment share: share of exports in the fourth as the following criteria are considered.

2.1.2 Cluster Geographic focus

The initial investigation to determine clusters according to the criteria focus on the province's cities and regions (East and West and Centre) intended. The criteria in determining the initial cluster was used and discussed. Clusters in the assessment of each cluster that was more focused than the more points will be more.

2.1.3 Potential market access

the cluster potential is greater market access phase of development will enjoy greater success.

2.1.4 Extensible cluster

- Trend increase in the number of units
- Trend of increasing production

2.1.5 Potential availability of raw materials

Cluster potential access to material that is more in phase of development will enjoy greater success.

2.1.6 Despite support and complement institutions

Supporting institutions such as unions exist if the activity, the success of cluster development will be effective the same reason as the main criteria were considered.

Finally in this step using the classical background investigation and assessment criteria as well as clusters of expert opinions (which are collected through a questionnaire) measures affecting the success of business clusters and determining the hierarchical structure was formed.



Fig. 1. Decision hierarchy

3. Fuzzy Analytic Hierarchy Process

AHP divides the decision problem into the following major steps (Saaty 1988):

- 1. Problem structuring
- 2. Assessment of local priorities
- 3. Calculation of global priorities

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The AHP decision problem is structured hierarchically at different levels that each level consists of a definite number of decision elements. The top levels of the hierarchy represent the overall aim, while the lowest level is composed of all possible options. The relative importance of the elements of decision making is evaluated indirectly from the comparison during the second step of process of decision-making. The values of weights and scores are resulted from these comparisons. The last step of AHP aggregates all local priorities from the decision table through a simple weighted sum.

The assessment of local priorities based on pair wise comparisons needs some prioritization method to be applied while the first and last steps of AHP are simple. However, the standard AHP eigenvalue prioritization approach can not be used, when the decision maker faces a complex problem and discusses the comparison as uncertain ratios. A natural way to cope with such uncertainty is to express the comparison ratios as fuzzy sets or fuzzy numbers, which reflects the vagueness of human thinking. When comparing any two factors at the same level of decision hierarchy, an uncertain comparison can be represented by a fuzzy number. In this study we use triangular

fuzzy numbers, which are a special class of LR fuzzy sets. A triangular fuzzy number N is defined by there read numbers $a \le b \le c$, and characterized by a linear piecewise continuous membership function $\mu_N(X)$ of the type:

$$\mu_{\widetilde{N}}(x) = \begin{cases} (x-a)/(b-a) & a \le x \le b\\ (c-x)/(c-b) & b \le x \le c\\ 0 & otherwise \end{cases}$$
(1)

4. Deriving Priorities from Fuzzy Comparison Matrices

All weights and scores by these methods are fuzzy sets and their aggregation over the last step of AHP creates the final scores of alternatives that are represented as fuzzy sets. The resulting fuzzy scores have widespread supports, because the numbers of multiplication and addition operations are high. The fuzzy prioritization methods mentioned requires an additional fuzzy ranking procedure to compare the final fuzzy scores and ranking alternatives. To overcome some drawbacks of the existing fuzzy prioritization methods, a new approach is proposed in Mikhailov (2003), based on a cuts decomposition of fuzzy judgments into a series of interval comparisons. The method of fuzzy preference programming (FPP) is applied to derive optimal crisp priorities which change the task of prioritization task into a fuzzy linear programming problem. A non-linear modification of FPP method is described in the next section; but without transforming the judgments into interval series and further aggregation of priorities. The proposed method does not need a fuzzy ranking procedure.

Let us consider a prioritization problem at a level with *n* elements, where pairwise comparison ratios are represented by fuzzy triangular numbers $\tilde{a}_{ij} = (l_{ij}, m_{ij}, u_{ij})$ the traditional AHP method, a fuzzy reciprocal matrix $\tilde{A} = \tilde{a}_{ii} \in \mathbb{R}^{M \times M}$.

 $\widetilde{A} = \begin{bmatrix} 1 & \widetilde{a}_{12} & \cdots & \widetilde{a}_{1n} \\ \widetilde{a}_{21} & 1 & \cdots & \widetilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \widetilde{a}_{n1} & \widetilde{a}_{n2} & \cdots & 1 \end{bmatrix}$ (2)

The known fuzzy prioritization methods derive *fuzzy* priorities \widetilde{w}_i , i = 1, 2, ..., n which approximate the fuzzy ratios \widetilde{a}_{ij} so that $\widetilde{a}_{ij} \approx \widetilde{w}_i / \widetilde{w}_j$

5. Fuzzy Prioritization Approach

Consider a prioritization problem with n elements, where the pairwise comparison judgements are represented by normal fuzzy sets or fuzzy numbers. Suppose that the decision maker can provide a set $\mathbf{F} = \tilde{\mathbf{a}}_{ij}$ of $m \le n(n-1)/2$ fuzzy comparison judgments, $\mathbf{i} = 1, 2, ..., n-1$, $\mathbf{j} = 1, 2, ..., n, j > i$ represented as triangular fuzzy numbers $\tilde{a}_{ij} = (l_{ij}, m_{ij}, u_{ij})$ The problem is to derive a crisp priority vector $w = (w_1, w_2..., w_n)^T$, such that the priority ratios wi/wj are approximately within the scopes of the initial fuzzy judgments, or

$$l_{ij} \tilde{\le} \frac{w_i}{w_i} \tilde{\le} u_{ij},\tag{3}$$

Where the symbol \leq denotes the statement 'fuzzy less or equal to'.

6. Solving the fuzzy prioritisation problems

The solution procedure of this method is based on the rule of maxim in decision, is known from the game theory. The maximin rule was applied by Bellman and Zadeh [1] to solve the problem of decision-making in uncertain environment. Zimmerman [23] was the same decision rule for fuzzy linear problems with soft constraints and shows, the maximin problem can be transformed into a linear programming problem. Similar linear formulations of prioritization problem are given in [12, 13].

In the next step of process of decision-making, weights of all criteria and scores of alternative providers are to be derived from fuzzy pair wise comparison matrices of the type (2). In this example, we suppose that all pair wise ∞

comparison judgments are represented as fuzzy triangular numbers $\hat{a}_{ij}=(l_{ij}, m_{ij}, u_{ij})$. Such that $u_{ij} \ge m_{ij} \ge l_{ij}$.

The maximin prioritisation problem (7) can be represented in the following way:

Maximize
$$\lambda$$

Subject to
 $\lambda \leq \mu_{ij}(w),$
 $i = 1, 2, ..., n - 1, j = 2, 3, ..., n, j > i,$
 $\sum_{l=1}^{n} w_l = 1, w_l > 0, l = 1, 2, ..., n.$
(4)

Taking into consideration the specific form of the membership functions (4), the problem (8) can be further transformed into a bilinear program of the type

Maximize
$$\lambda$$

Subject to
 $(m_{ij} - l_{ij})\lambda w_j - w_i + l_{ij}w_j \le 0,$
 $(u_{ij} - m_{ij})\lambda w_j + w_i - u_{ij}w_j \le 0,$
 $\sum_{k=1}^{n} w_k = 1, \ w_k > 0, \ k = 1, \ 2, \ \dots, \ n,$
 $i = 1, \ 2, \ \dots, \ n - 1, \ j = 2, \ 3, \ \dots, \ n, \ j > i.$
(5)

The optimal solution to the above non-linear problem (λ^*, w^*) might be obtained by employing some appropriate numerical method for non-linear optimisation. The results shown in the next section are obtained by the Excel Solver tool, which is based on a gradient search numerical algorithm. The optimal value λ^* , if it is positive, indicates that all solution ratios completely satisfy the fuzzy judgements, i.e. $l_{ij} \leq (w_i^* / w_j^*) \leq u_{ij}$, which means that the

initial set of fuzzy judgements is rather consistent. A negative value of λ^* shows that the solutions ratios approximately satisfy all double-side inequalities (3), i.e. the fuzzy judgements are strongly inconsistent. Therefore, the optimal value λ^* can be used for measuring the consistency of the initial set of fuzzy judgements.

The existence of a consistency index is a very attractive feature of the proposed fuzzy prioritization method, which is illustrated in the next section. It can also be observed, that the non-linear program (9) does not necessarily need a full set of all fuzzy judgements from the upper triangular part of the comparison matrix (2). Therefore, the proposed method can derive priorities from incomplete set of judgements, which is another appealing feature of our approach.

7. Choose the best business clusters using Fuzzy AHP

Regarding the issue raised in the second part of this process in this paper using fuzzy AHP solution is done. The solution process is based on the proposed fuzzy modification of the AHP method. The first step in applying the fuzzy AHP is to construct a (three level) hierarchy of alternative providers and criteria for choice, as shown in Fig. 1.

In the next step of the decision-making process, weights of all criteria and scores of alternative providers are to be derived from fuzzy pairwise comparison matrices of the type (2). In this example, we suppose that all pairwise comparison judgements are represented as fuzzy triangular numbers $\widetilde{\mathbf{a}}_{i1} = (l_{ij}, m_{ij}, u_{ij})$, such that $u_{ij} > n_{ij} > l_{ij}$.

By solving a number of optimization problems of the type (5), similar to the first one, we can find the scores of the alternative cluster with respect to all criteria, which are shown in Table 1. The local weights of all sub-criteria, shown in the second column of Table 4 are obtained by multiplying their relative weights by the weights of the main criteria.

From this column we can see, that the fuzzy comparison matrices with respect to Demand-based Pricing and Negotiable Delivery are absolutely consistent.

		Criteria weights		Cluster bread and muffins	Beverage manufacturing clusters	Meat production clusters	Rice Cluster	Dairy Cluster	Fish Cluster
Cluster Geographic focus		0.067662		0.125	0.125	0.125	0.25	0.125	0.25
Potential market access		0.229244		0.135688	0.181766	0.181766	0.162158	0.13602	0.13602
Potential availability of raw materials		0.215546		0.285714	0.142857	0.071429	0.071429	0.14285	0.28571
Despite support and complement institutions		0.040423	1	0.110206	0.110206	0.110206	0.177275	0.14866	0.34343
Extensible cluster	Trend increase in the number of firms	0.3845	0.5	0.153846	0.153846	0.153846	0.076923	0.15384	0.30769
	Trend of increasing production		0.5	1.08333	1.08333	1.08333	0.541667	1.08333	2.16667
Role in the	Number of firms	0.0625	0.2	0.083333	0.083333	0.083333	0.333333	0.08333	0.33333
regional economy	Share of employment in the		0.4	0.172631	0.121797	0.062674	0.173973	0.15323	0.31568
	region								
	Investment share		0.4	0.130282	0.062097	0.064423	0.344301	0.11822	0.28067
Goal weights				0.17338	0.15018	0.132322	0.10797	0.1434	0.276

Table 1. Results from the fuzzy AHP method

The global weights of clusters, calculated by the AHP aggregation rule (weighted arithmetic mean), are represented in the last row of Table 1. The aggregated weights show that the fish cluster is slightly better than the other one, while the rice cluster is last.

8. Conclusions

In this paper we have studied the process of selection of cluster to improve. It is shown that the business cluster selection is a critical factor in the formation of such enterprises and there is a need of formalized decision-making support. The business cluster selection process is formulated as a multiple criteria decision-making problem under uncertainty and an AHP-based model is proposed to derive global priorities of all possible alternatives. A new Fuzzy Preference Programming method based on interval pair-wise comparison judgements and approximate reasoning is applied for assessment of the uncertain weights of selection criteria and scores of alternative partners. Contrary to the existing interval prioritisation methods, the proposed fuzzy method can derive crisp priorities from inconsistent interval pairwise comparison matrices. These features make the proposed approach a suitable alternative for resolving uncertain business cluster selection problems and developing of appropriate decision-making support tools.

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