WHY FUZZY ANALYTIC HIERARCHY PROCESS APPROACH FOR TRANSPORT PROBLEMS?

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Abstract

The evaluation of transport projects has become increasingly complex. Different aspects have to be taken into account and the consequences of the problems are usually far reaching and the different policy alternatives are numerous and difficult to predict. Various pressure have also emerged causing more complex decision making process. The use of multi criteria analysis for the evaluation of transport projects has increased due to this increasing complexity of the problem situation. Researches on transport issues are generally carried out to provide information to policymakers that have to operate within restrictive parameters (political, economical, social, etc…).

The Analytic Hierarchy Process (AHP) is one of the Fuzzy Multiple Criteria Decision Making methods. Due to its wide range application area, it has been an exciting research subject for many different field researchers. Transportation, logistics, urban planning, public politics, marketing, finance, education, economics are a part of this wide application area. The aim of this paper is, after a brief introduce to AHP method, to offer how to benefit it for the preference of planners in transport problems.

Keywords: Analytic Hierarchy Process, Multi criteria analysis, Transshipment port selection.

1. Introduction

Fuzzy multiple attribute decision-making methods have been developed owing to the imprecision in assessing the relative importance of attributes and the performance ratings of alternatives with respect to attributes. Imprecision may arise from a variety of reasons: unquantifiable information, incomplete information, unobtainable information and partial ignorance. Conventional multiple attribute decision making methods cannot effectively handle problems with such imprecise information.

Basically AHP is a method of breaking down a complex, unstructured situation into its components parts; arranging these parts, or variables, into a hierarchic order; synthesize the judgments to determine which variables have the highest priority and should be acted upon to influence the outcome of the situation. It uses a hierarchical structure to abstract, decompose, organize and control the complexity of decision involving many attributes, and it uses informed judgment or expert opinion to measure the relative value or contribution of these attributes and synthesize a solution.

AHP is one of the most convenient methodologies in order to evaluate transportation issues. First of all, any selection/priority/decision issue consists of various criteria. Frequently these criteria have sub-criteria as well. In this case criteria have to be taken into consideration are quite much. Either objective or subjective considerations or either quantitative or qualitative information might evaluate with AHP technique. Any level of details about the main focus can be listed or structured in this method. By this way the overview of the main focus or the problem can be represented very easily. The aim of this paper is to introduce AHP method and to offer how to benefit it for the preference of urban planners in transport problems. From this point of view, this paper is composed of two main parts. First part consists of the literature survey regarding with the AHP and its application areas. The advantage of methods had been mentioned. Second part focuses on a sample application of AHP technique. AHP is used to decide the convenient project site selection.

2. Brief Overview Of Multi-Criteria Decision Making

Multi Criteria Decision Making (MCDM) is one of the most important fields of operations research and deals with the problems that involve multiple and conflicting objectives. It is obvious that when more than objective exists in the problem, making a decision becomes more complex. MCDM is both an approach and a set of techniques, with the aim of providing an overall ordering of options, from the most preferred to the least preferred option (The London School of Economics and Political Science, 2007). MCDM approaches provide a systematic procedure to help decision makers choose the most desirable and satisfactory alternative under uncertain situation (Cheng, 2000). MCDM provides a framework to evaluate different transport options on several criteria.

MCDM approaches are classified into two groups. This classification makes distinction between Multi Objective Decision Making (MODM) and Multi Attribute Decision Making (MADM). The main distinction between the two methods is based on the number of alternatives under evaluation. In MCDM problems, there exist a relatively small number of alternatives and these alternatives are denoted in terms of attributes. MOD problems have a very large number of feasible alternative and the objectives and the constraints are depend on the decision variables (Mollaghasemi, 1997). MADM methods are designed for selecting discrete alternatives while MODM are more adequate to deal with multi objective planning problems, when a theoretically infinite number of continuous alternatives are defined by a set of constraints on a vector of decision variables (Mendoza, Martins, 2006).

Multi-Attribute Decision Making (MADM)

MADM methods provide simple and intuitive tools for making decisions on problems that involve uncertain and subjective information (Cheng, 2000). These methods have the advantage that they can assess a variety of options according to a variety of criteria that have different units. This is a very important advantage over traditional decision aiding methods where all criteria need to be converted to the same unit. Another significant advantage of most MADM methods is that they have the capacity to analyze both quantitative and qualitative evaluation criteria together. MADM describes each alternative by using multiple attributes. For a given set of alternatives, MADM models try to choose the best alternative among them, rank the alternatives from the best to the worst or classify them into classes. Although the MADM methods are generally used to solve discrete problems, some of them can also be used within the context of continuous decision problems (Doumpos and Zopounidis, 2002). To resolve this difficulty, fuzzy set theory, first introduced by Zadeh, has been used and is adopted herein. Fuzzy set theory attempts to select, prioritize or rank a finite number of courses of action by evaluating a group of predetermined criteria. Solving this problem thus requires constructing an evaluation procedure to rate and rank, in order of preference, the set of alternatives.

Among the MADM methods developed in the literature, AHP, multi-attribute utility theory and outranking methods are more frequently applied to discrete decision problems than all other methods. The following sub-sections give a brief introduction to the main concept and features of them.

3. Analytic Hierarchy Process (AHP)

3.1. AHP Structure

AHP, was proposed by Saaty in 1980, is a multi criteria decision making method for complicated and unstructured problems and also it is an approach that uses a hierarchical model having levels of goal, criteria, possible sub-criteria, and alternatives. The AHP, can be stated, a decision – making and estimation method which gives the percentage distribution of decision points according to factors affecting decision, that is used if there is a defined decision hierarchy. Actually this idea is a result of some former and successive studies or researches on different areas by Saaty. These are solving a specific problem in contingency planning in 1977, design alternative features for a developing country, Sudan, in 1977, energy allocation in 1979, investment in technologies under uncertainty, dealing with terrorism in 1977 and the other smaller applications such as buying a car, choosing a job and selecting a school. Today various applications of AHP have involved the participation of engineers, planners, lawyers, political social scientists and mathematicians or even ordinary citizens. It is easy and useful methodology to be able to provide pair wise comparisons in each area of expertise.

AHP that uses both the linguistic assessments and numerical values for the alternative selection problem having multi-level hierarchical structure will be represented. AHP uses the concepts of fuzzy set theory and hierarchical structure analysis for the selection of the most appropriate alternative among a set of feasible alternatives. The earliest AHP method was proposed by Van Laarhoven and Pedrycz (1983) in which the fuzzy numbers with triangular membership functions describe the fuzzy comparing judgment. Buckley (1985) found out the fuzzy priorities of comparison ratios with trapezoidal membership functions. Boender et al. (1989) extended van Laarhoven and Pedrycz's method and developed a more robust approach to the normalization of the local priorities. Chang (1996) proposed a new method with the use of triangular fuzzy numbers and extent analysis method for the pairwise comparison scale of AHP and the synthetic extent values of the pairwise comparisons, respectively. Furthermore, many AHP methods developed by various authors can be found in literature.

Table 1: The advantages and disadvantages of AHP

Advantages	Disadvantages
• AHP can take into consideration the relative priorities of factors or alternatives and represents the best alternative. • AHP provides a simple and very flexible model for a given problem. • AHP provides an easy applicable decision making methodology that assist the decision maker to precisely decide the judgments. • Either objective or subjective considerations or either quantitative or qualitative information play an important role during the decision process. • Any level of details about the main focus can be listed or structured in this method. By this way the overview of the main focus or the problem can be represented very easily. • AHP has a very wide range of usage like; planning, effectiveness, benefit and risk analysis, choosing any kind of decision among alternatives. • AHP relies on the judgments if experts from different backgrounds; so the main focus or the problem can be evaluated easily from different aspects. • Decision maker can analyze the elasticity of the final decision by applying the sensitivity analyzes. • It is possible to measure the consistency of decision maker‘s judgments. • Computer software help decision makers to apply AHP fast and precisely	• There is not always a solution to the linear equations. • The computational requirement is tremendous even for a small problem. • AHP allows only triangular fuzzy numbers to be used. • AHP is based on both probability and possibility measures. • Rank reversal fact should be considered carefully during the application. It defines the changes of the order of the judgment alternatives when a new judgment alternative is added to the problem. Validity of the rank reversal is still discussed in literature. • AHP has a subjective nature of the modeling process is a constraint of AHP. That means that methodology cannot guarantee the decisions as definitely true. • When the number of the levels in the hierarchy increase, the number of pair comparisons also increase, so that to build the AHP model takes much more time and effort.

AHP Theory has four axioms. It is important to satisfy these axioms in order to successfully apply the AHP technique to a decision making problem (Saaty, 1985). Here is the following:

Axiom 1: Reciprocal Comparison: The intensity of the preferences of the decision maker must satisfy the reciprocal condition: If A is x times more preferred than B, then B is 1/x times more preferred than A.

Axiom 2: Homogeneity: The preferences are represented by means of a bounded scale.

Axiom 3: Independence: In expressing preferences, criteria are assumed independent of the properties of the alternatives.

Axiom 4: Expectations: For the purpose of making a decision, the hierarchic structure is assumed to be complete.

The primary goal of the AHP is to select an alternative that best satisfies a given set of criteria out of a set of alternatives or to determine the weights of criteria in any application. AHP scales the weights of attributes at each level of the hierarchy with respect to a goal using the decision maker's (experts') experience and knowledge in a matrix of pair-wise comparison of attributes. The usual application of AHP is to select the best alternative from a discrete set of alternatives. Table 1 shows the advantages and disadvantages of AHP structure.

3.2. Process of AHP

AHP provides a way to rank the alternatives of a problem by deriving priorities. AHP gives a proven, effective means to deal with complex decision making and can assist with identifying and weighting selection criteria, analyzing the data collected for the criteria and expediting the decision making process. AHP has been shown to be a robust method of eliciting and using multi criteria preference relationships in a range of applications. It is designed for situations in which ideas, feelings, and emotions are quantified based on subjective judgment to provide a numeric scale for prioritizing decision alternatives. The AHP is based on a matrix of pair wise comparisons between criteria, and it can be used to evaluate the relative performance of decision alternatives (for example products and services) with respect to the relevant criteria. The AHP was seen to be a suitable tool for the purpose here, as it is a robust method that is particularly suited to decisions made with limited information (Saaty, 2000).

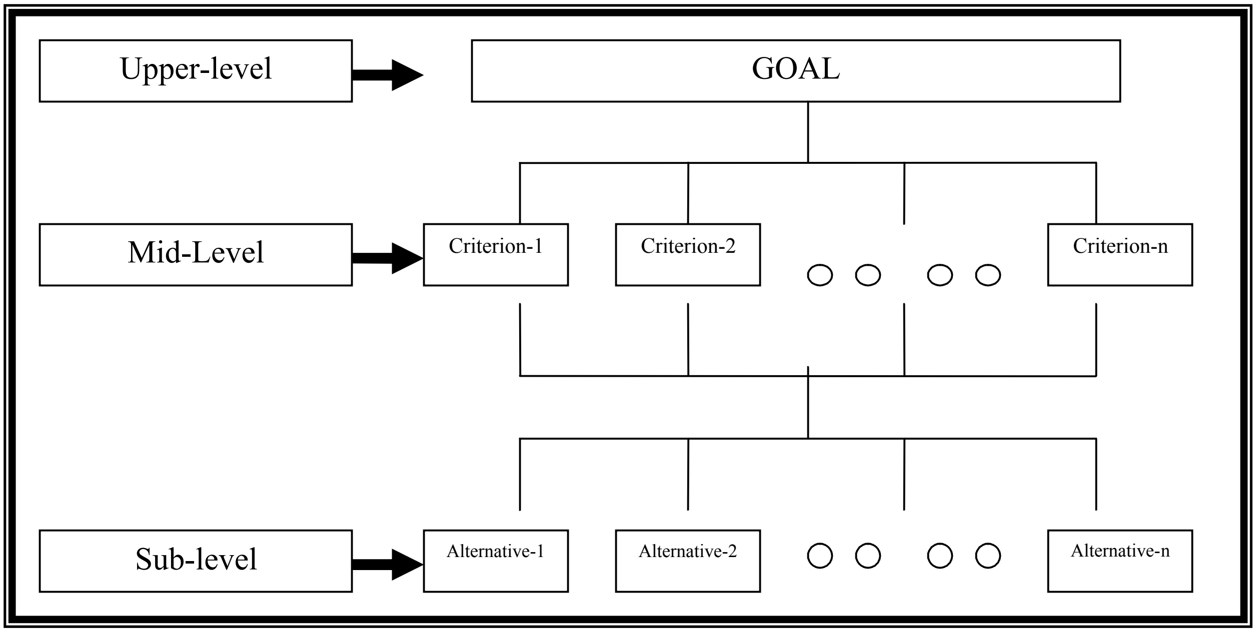

Figure 1: Hierarchical Structure of AHP

Briefly, AHP has three main steps. These are; structuring the hierarchy, pair-wise comparisons (determining the weights) and decision phase (selection of the best alternative among the others). The AHP is a methodology to rank alternative courses of action based on the decision maker's judgments concerning the importance of the criteria and the extent to which they are met by each alternative. To solve a decision problem with AHP, there are some steps which are defined below.

Step 1: Decision – Making Problem Is Defined

At first phase of definition of the decision making problem, decision points are established. In other words, an answer is looked for "The decision will evaluate by how many results?" question. At second phase, factors which are affecting decision points are established. In this study, the numbers of decision points are symbolized with m and the numbers of factors that are affecting these points are symbolized with n; especially, correctly determining the numbers of factors which will affect the result is very important to perform consistent and rational pair wise comparisons.

Step 2: Comparison Matrix Between Factors Is Formed

Comparison matrix between factors is a *nxn* dimensional square matrix. The matrix components on the diagonal of this matrix take 1 value. Comparison matrix is shown below.

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ . & & & . \\ . & & & . \\ . & & & . \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix}$$

When $i = j$, components on the diagonal of the comparison matrix take 1 value; because related factor has been comparing with itself in this situation. Comparing factors is done according to their importance value to each other by one – to – one and reciprocally. One – to – one and reciprocally comparison of the factors importance scale, which is on Table 2 , is used.

Table 2: Importance Scale

Numbers (a_{ij})	Value	Definition
1	Equal	I and j are equally important
3	Moderately more important	I is moderately more important than j
5	Strongly more important	I is strongly more important than j
7	Very strongly more important	I is very strongly more important than j
9	Extremely more important	I is extremely more important than j
2,4,6,8	Intermediate values	Used when a compromise is needed

For example; i seems more important than j by decision maker, first row third column component of the comparison matrix ($i = 1, j = 3$) takes 3 value in this situation. Otherwise, namely the comparison of first factor to third factor; if the more important option is used for third factor, first row third column component of the matrix ($i = 3, j = 1$) will take 1/3 value at this time. In the same comparison, comparison of first and third factors; if the factors have equal importance, first row third column component will take 1 value. Comparisons are done for the values which are above of all the 1 – valued diagonal of comparison matrix. Naturally using the following formula will be enough for the components which are below of the diagonal.

$$aij = \frac{1}{aji}$$

If the example, which is above, is taken into consideration; when first row third column component of the comparison matrix ($i = 1, j = 3$) takes 3 value, third row first column component of the comparison matrix ($i = 3, j = 1$) takes 1/3 value according to the formula.

Step 3: Percentage Importance Distribution of the Criteria Are Determined

Comparison matrix shows importance levels of factors to each other within a certain logic framework. However, the weights of these factors in total, in other words to determine the percentage importance distribution, column vectors, which constitute the comparison matrix are used and column vector *B* which has n units with n components is constituted.

This vector is pointed at below:

$$B_i = \begin{bmatrix} b_{11} \\ b_{21} \\ . \\ . \\ . \\ b_{n1} \end{bmatrix}$$

$$b_{ij} = \frac{aij}{\sum_{i=1}^{n} aij}$$

When the steps, which are told above, are repeated for the other evaluation criteria, column vector B is acquired as the number of criteria. When n units of column vector B are gathered in a matrix format, matrix C that is shown below will be created.

$$C = \begin{bmatrix} c_{11} & c_{12} & \cdots & c_{1n} \\ c_{21} & c_{22} & \cdots & c_{2n} \\ . & & & . \\ . & & & . \\ . & & & . \\ c_{n1} & c_{n2} & \cdots & c_{nn} \end{bmatrix}$$

Using matrix C, percentage importance distributions, which show the criteria importance value according to each other, could be gotten. Therefore, arithmetic average of row components, which is comprised matrix C, is taken and then column vector W which is called priority vector is attained.

$$W_i = \frac{\sum_{j=1}^{n} cij}{n}$$

Vector *W* is shown below.

$$W = \begin{bmatrix} w_1 \\ w_2 \\ . \\ . \\ . \\ w_n \end{bmatrix}$$

Step 4: Consistency in factor comparisons is calculated

Even if AHP has a considerably consistent systematic, naturally the realism of the results will depend on consistency of decision maker's pair wise comparison between criteria. AHP suggests a process to measure the consistency of these comparisons. Eventually, with acquired Consistency Ratio (CR), there has been an opportunity to test the consistency of priority vector and also consistency of pair wise comparisons between criteria. Essence of the CR calculation is based on comparison of number of criteria and a coefficient, which is called Principal Value (λ), by AHP. Principally, from the multiplication of comparison matrix *A* and priority vector *W*, column vector *D* is acquired for the calculation of λ.

$$D = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ . & & & . \\ . & & & . \\ . & & & . \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} x \begin{bmatrix} w_1 \\ w_2 \\ . \\ . \\ . \\ w_n \end{bmatrix}$$

Just like defined below formula, division of the corresponding elements of column vector *D*, which is found above, with column vector *W* constitutes the Principal Value (*E*) for every evaluation criteria. The arithmetic average of these values gives the principal value (λ) according to comparison.

$$Ei = \frac{di}{wi} \qquad (i=1,2,\ldots, n)$$

$$\lambda = \frac{\sum_{i=1}^{n} Ei}{n}$$

After λ is calculated, Consistency Index (CI) can be computed according to the following formula.

$$CI = \frac{\lambda - n}{n - 1}$$

At the last stage, CI divided by Random Index (RI) which is shown as standard correction value in Table 3 and then Consistency Ratio (CR) is obtained. From Table 3 the value that is corresponding to number of criteria is chosen. For example; RI value of 3 criteria comparisons will be 0.58 from Table 3. When the calculated CR value is less than 0.10, comparisons that made by decision maker are consistent. If the CR value is more than 0.10, either there could be a calculation error or there is an inconsistency in the comparisons of decision maker.

Table 3: RI Values

Number of Criteria	RI	Number of Criteria	RI
1	0	8	1,41
2	0	9	1,45
3	0,58	10	1,49
4	0,90	11	1,51
5	1,12	12	1,48
6	1,24	13	1,56

$$CR = \frac{CI}{RI}$$

Step 5: For Every Criterion, Percentage Importance Distributions Are Found At *m* Decision Point

This stage is just like that told above, but this time, for every criterion percentage importance distributions of decision points are determined. In other words, one – to – one comparison and matrix operations are repeated as the number of criteria (n times). However, the dimension of comparison matrices *G*, which will be used at decision points for every criterion, will be *mXm*. After every comparison operations; column vector *S*, which has *mX1* dimensions and shows the percentage distribution according to decision points of evaluated criterion, is acquired. These column vectors are stated below

$$S_i = \begin{bmatrix} s_{11} \\ s_{21} \\ . \\ . \\ . \\ s_{m1} \end{bmatrix}$$

Step 6: Finding the Result Distribution at Decision Points

In this stage principally, *mXn* dimensioned decision matrix *K*, which is consisted of *mX1* dimensioned column vector *S*, is attained. Decision matrix is defined below:

$$K = \begin{bmatrix} s_{11} & s_{12} & \cdots & s_{1n} \\ s_{21} & s_{22} & \cdots & s_{2n} \\ . & & & . \\ . & & & . \\ . & & & . \\ s_{m1} & s_{m2} & \cdots & s_{mn} \end{bmatrix}$$

In conclusion; when decision matrix multiplies by column vector *W* (priority vector), column vector *L* that has m elements is achieved. Column vector *L* gives the percentage distribution of decision points. In other words, the sum of vector's elements is 1. This distribution also shows the importance order of decision points.

$$L = \begin{bmatrix} s_{11} & s_{12} & \cdots & s_{1n} \\ s_{21} & s_{22} & \cdots & s_{2n} \\ . & & & . \\ . & & & . \\ . & & & . \\ s_{m1} & s_{m2} & \cdots & s_{mn} \end{bmatrix} x \begin{bmatrix} w_1 \\ w_2 \\ . \\ . \\ . \\ w_n \end{bmatrix} = \begin{bmatrix} l_{11} \\ l_{21} \\ . \\ . \\ . \\ l_{m1} \end{bmatrix}$$

3.3. The Applications of AHP Methodology and Relevance for Transport Issues

According to Saaty, a hierarchy is an abstraction of the structure of a system to study the functional interactions of its components and their impacts on the entire system. From this definition there are two main question on which the AHP lies. These questions are: How the functions of a system are structured and how the impacts of any element in hierarchy are measured. The strength of the AHP lies in its ability to structure a complex, multi-person, multi-attribute problem hierarchically, and then to investigate each level of the hierarchy separately, combining the results as the analysis progress. AHP incorporates judgments or personal standards in a logical way. It depends on imagination, experience and knowledge to construct the hierarchy of the main focus and on logic, instinct and experience to provide judgment.

Due to its various advantages, AHP has preferred by sort of academic discipline. Planning, priority determination, selection/prioritization/evaluation, resource allocation, demand determination, forecasting the results, designing the system, measuring the performance, optimization, benchmarking, quality management, public policy, health care, strategic planning are some of those.

AHP is one of the most convenient methodologies in order to evaluate transportation issues. First of all, any selection/priority/decision issue consists of various criteria. Frequently these criteria have sub-criteria as well. In this case criteria have to be taken into consideration are quite much. Either objective or subjective considerations or either quantitative or qualitative information might evaluate with AHP technique. Any level of details about the main focus can be listed or structured in this method. By this way the overview of the main focus or the problem can be represented very easily.

Transportation problems are fairly complex due to the affected groups either directly or indirectly. These groups might include public/private sector, pedestrian/motorized people, public transportation, building/infrastructure contractor… Principally AHP provides a simple and very flexible model for a given problem. AHP can help to researcher to analyze each groups' decision or trend. AHP can take into consideration the relative priorities of factors or alternatives and represents the best alternative. At the end of the process evaluated with AHP can allow decision maker can analyze the elasticity of the final decision by applying the sensitivity analyzes. So that researcher/planner can achieve as responsive results as possible. Another advantage of AHP is that progressing computer aided programs make AHP easy, fast and precisely to apply.

Table 4: AHP Application Areas

Academician	AHP Application Area-Various
Ta ve Har, 2000	The selection of the business
Korpela ve Tuominen, 1996	The forecast of demand
Barbarosoğlu ve Yazgaç, 1997	Supplier selection
Boucher vd, 1997	Decision of investment
Korhonen ve Wallenius, 1990	Marketing strategies
Tang and Beynon, 2005	Investment development
Academician	AHP Application Area-Transportation
Tyagi ve Das, 1997	Logistics
Liberatore, 1989, Khalil, 1992	Selection of project
Azis, 1990	Transportation
Liberatore, 1993	Industrial zoning
Olson vd, 1986	Investment decisions of energy corridor
Vreeker, Nijkamp, Welle, 2002	Location of airports
Chang, ve Yeh, 2001	Competition in airways
Tzeng ve Wang, 1994	Efficiency of bus transportation
Frankel, 1992	Maritime Politics
Chou ve Liang, 2001	Performance evaluation of transportation firms
Lirn, Thanopoulou ve Beresford, 2003	Port selection
Song ve Yeo, 2004	Port competition
Fung, 2001	Port comparison
Nir, Lin ve Liang, 2003	Port selection
Kumar, 2002	Maritime route competition
Haralambides ve Yang, 2003	Maritime transportation
Gerçek, Karpak ve Kılınçaslan, 2004	Urban transportation mode selection
Macharis, 2005	Freight transport
Crals et al., 2004	Evaluation of transport policy
Macharis et al., 2004	Evaluation of transport technologies
Zhou Zhijuan, Chen Senfa, 2007	Transportation mode selection
Ferrari, 2003	The selection of highway project
Shang S.J., Tjader y., and Ding Y, 2004	Evaluation of transportation projects
Yelda, S., Shrestha, R.M., 2003	Selection of transport system
Tudela A, Akiki N., Cisternas, R, 2006	Urban transport investments

AHP relies on the judgments if experts from different backgrounds; so the main focus or the problem can be evaluated easily from different aspects. Results and judgments are reliable because it is possible to measure the consistency of decision maker‘s judgments.

4. A Numerical Example

This example intends to demonstrate the deployment of the prototype collaborative decision-making system in a typical decision making scenario. All the steps in the AHP is described - from determining the relative weights of the decision makers to aggregating their preferences and recommending an optimal decision option.

This paper focuses on elements associated with logistics project location selection from the perspective of geographical location, logistics and operational services offered by the logistics center. The other two criteria are assumed as the facility that might need to be get from the urban infrastructure. The management capacity of logistics project team was the last criteria. Hypothetically it is admitted that information and data were collected through a series of surveys on a group of experts (for example logistics company executives, agencies, terminal operators, NGO's, local governments, academics and researchers). Assuming as a brief model, here is not sub criteria. But if there had been, the same procedure would have been followed with criteria level. The alternatives are 4 cities in Middle Anatolia in Turkey. All these cities are strongly industrialized and in competition with each other in order to get more portion from the countries logistical investments. In order to calculate the empirical values of these elements, it is necessary to define the 'identifiable or representative attributes' of each criterion so that measurable or quantitative data can be easily extracted.

As a starting point for empirical analysis, the elements' weights are computed by pair-comparing elements. Experts should be requested to indicate the relative importance of each of four elements (ie pair comparison), ranging from a low '1' to a high '9'. This question might have been asked to experts: "*In comparing between Cargo Volume and Facility, which factor is more important and how important is it relative to the other factor?*" And this question must have been asked for all other pair comparisons as well. The structure of the example is below in figure 2.

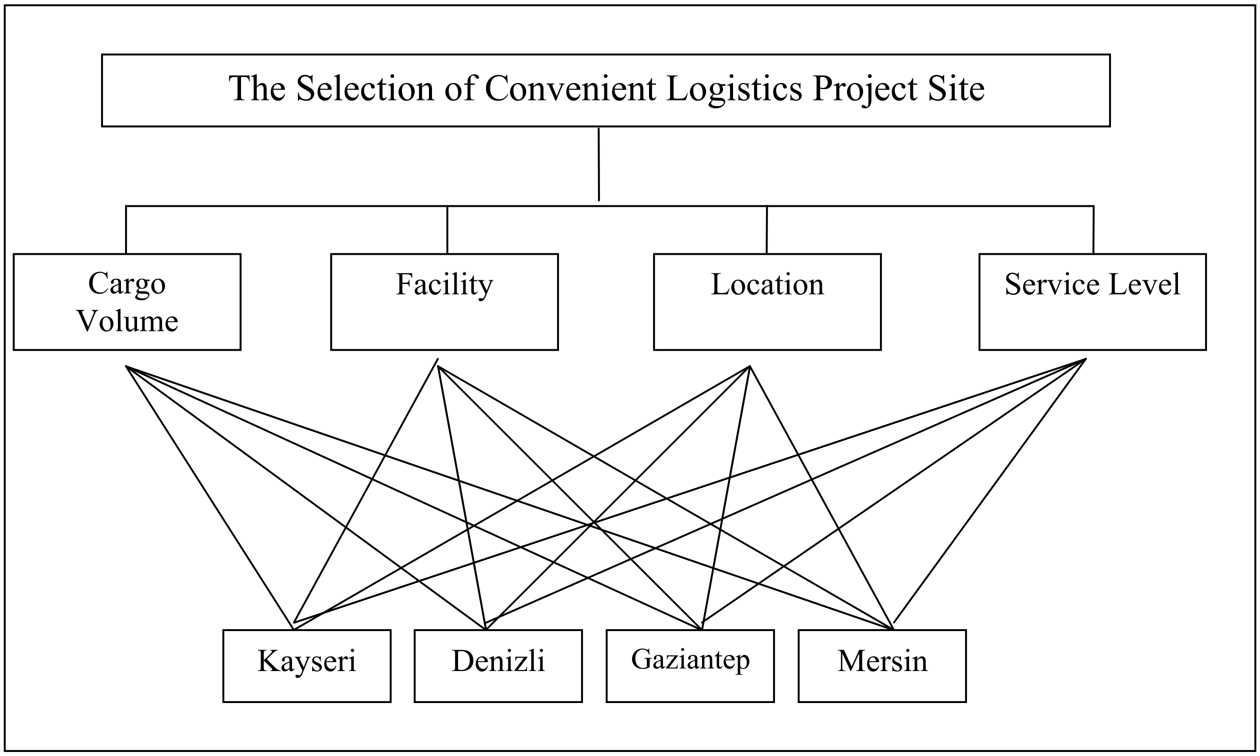

Figure 2: The Hierarchical Structure of AHP Model

The result of process in order to evaluate the criteria is shown in Table 4. It is appeared that logistics project location (0.452) is considered to be the most influential factor to competitiveness, followed by logistics facility (0.198), cargo volume (0.178) and logistics service level (0.174). This result implies that the competitive edge of the industry is still subject to hardware aspects, rather than software; in other words, physical location and facilities play a more vital role than service quality.

Table 5: Pair comparison and element weights of criteria

Elements	Cargo volume	Facility	Location	Service Level	Weight	Priority
Cargo Volume	1	7.20	0.12	0.16	0.178	3
Facility		1	0.22	5.70	0.198	2
Location			1	3.20	0.452	1
Service Level				1	0.174	4
CI=0,024 CR=0.026						

In addition, the consistency ratio is 0.026, which is lower than 0.1 – a critical value. It is therefore confirmed that survey results are effective and consistent. Table 6 shows the attribute values in percentage terms for the sampled cities in Anatolia. As clearly seen, Mersin has the biggest competitive power within others with the weight of 0,550. Gaziantep follows Mersin with the weight of 0,275. Kayseri and Denizli comes respectively.

Table 6: Pair comparison and element weights of alternatives

Sites	Kayseri	Denizli	Gaziantep	Mersin	Weight	Priority
Kayseri	1	3	0.33	0.14	0,118	3
Denizli		1	0.14	0.14	0,052	4
Gaziantep			1	0.33	0,275	2
Mersin				1	0,550	1
CI=0,024 CR=0.026						

After these two preliminary values, an overall evaluation of the logistics project can be made by calculating the weights of elements in Table 4 and attribute values of each logistics center in Table 5. Using the third stage, Table 6 shows the final outputs of values, indicating their relative competitiveness among the sampled logistics projects. Table 6 clearly shows that Mersin is the most competitive – that is, the overall value is 0.551. Kayseri is the second powerful candidate for being a logistics project site. Denizli and Gaziantep are respectively third and fourth.

Table 7: Attribute Values for Logistics Site Selection

		Cargo Volume	Facility	Location	Service Level	Overall Values	Ranking
		(0,178)	(0,198)	(0,452)	(0,174)		
Kayseri	0,118	0,021	0,023	0,053	0,021	0,118	2
Denizli	0,053	0,009	0,010	0,024	0,009	0,053	3
Gaziantep	0,028	0,005	0,005	0,012	0,005	0,028	4
Mersin	0,550	0,098	0,109	0,249	0,096	0,551	1

5. Conclusions

In this paper, the evaluation of Logistics Site Selection is handled. AHP methodology is structured here that AHP result weights as input weights. Then a numerical example is presented to show applicability and performance of the methodology. Also, a sensitivity analysis is hold to discuss and explain the methodology results. AHP is one of the most convenient methodologies in order to evaluate transportation issues. It can be said that using linguistic variables makes the evaluation process more realistic. Because evaluation is not an exact process and has fuzziness in its body. Here, the usage of fAHP weights makes the application more realistic and reliable.

As a future direction, other decision-making methods can be included in the methodology to ensure more integrated and/or comparative study.

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