



## A fuzzy ANP approach to shipyard location selection

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### ABSTRACT

It is the first duty of investors to transform financial resources into investments in the right places at the right times and earn benefits. However, where to invest and how to invest is always a risky and complicated problem. The decision which will be made under a variety of factors might result in a terrible mistake if it is not felicitous. It is necessary to utilize scientific methods when deciding to make these types of complicated investments which can cause large financial losses. Analytical network process (ANP) can show us the best alternative based on different criteria from a variety of alternatives. However, the network structure should model the actual in a very good way. Analytical network process will give us the best result in span after the correctly built network structure's comparisons are made correctly. It is important to design the structure flexibly in this work in order for it to lead to improvements. Shipyard location is selected in this work which provides reference to investors based on numerical and solid essences. At the end, the study has received a successful application with the help of expert people and the correct fuzzy analytical network process's success over the criteria which have a close relationship with each other.

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### 1. Introduction

Nowadays countries are focusing on heavy industry in order to develop and bloom. Although its importance is known in Turkey, the shipbuilding industry, which is a heavy industry branch, hasn't made a thrust yet. But the private sector has recognized the financial benefit of this area and has started making the necessary investments. On this, the sudden development of the market, inexpensive labour in Turkey, closeness to the market, geographical practicability and incentives from the government for the development of the region has effects. The analysis of the inner and outer environment is very important in order to compete with the current market conditions. A firm will be able to take make successful decisions based on its ability to analyze the current situation and forecast for future situations. Enterprises want to utilize their resources efficiently and this is only possible if experience is supported with scientific works. During the stage of making a decision, a lot of criteria should be considered and a decision should be made based on these criteria. As criteria and alternatives increase, it becomes very hard and almost impossible for a human brain to analyze the relation between all the criteria and alternatives and make a decision. At this point it is necessary to use a technique of making a decision with a lot of criteria. Saaty has developed analytic network process (ANP) management and brought it into the literature. By using ANP, it can consider objec-

tive and subjective evaluation criteria. ANP has been used in tens of different decision making stages and its success has been accepted. It has found different areas of application which includes recruiting, forecasting of NBA results, the decision of building a barrage and the decision made by the United States to build a global missile defence system. During their study Meade and Presley (2002) argued about using ANP as a model in selecting the suggestions for R&D. In addition to this, Mohanty, Agarwal, Choudhury, and Tiwari (2005) study an application of fuzzy ANP along with fuzzy cost analysis in selecting R&D projects. As ANP makes comparisons to get us the needed results, the quality of the information being used and the built structure has a very critical importance. Although ANP is a fine technique, it is weak in eliminating ambiguities. Even though people who make the comparisons are aware of the subject, their different perspectives may result in discrepancies on information. In order to eliminate this ambiguity, it is possible to utilize fuzzy logic methods. Fuzzy logic provides numerical information on the situation where there is no certainty and it helps to get a more realistic result on defining the existence of a relation in between. Some researchers have applied the fuzzy ANP based approach to solve complex decision making problems (Chung, Lee, & Pearn, 2005; Kahraman, Cebeci, & Ruan, 2004; Karsak, Sozer, & Alpteki, 2002). In our study, a network has been formed by using the effective criteria of selecting a location from one of four different shipyard location alternatives in Turkey and a survey has been made by the experts with different experiences, education and who possess work area and information about existent subject. The gathered information's blur has been cleared with

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the help of Microsoft EXCEL and the results have been gathered after the transfer of information to the formed network which is called Super Decisions. With this study, the usage of the analytical network process together with fuzzy logic and its success in selecting a shipyard location which is a complex and important problem has been shown. This study can be a guide for investors in using their financial resources in the best way and a reference for the critical decisions that will be made. A new addition to the variety of usage areas in literature has been made and the reliability of the fuzzy analytic network process has increased because of the successful result.

## 2. Literature review

Studies show that human beings do not have enough capacity to perform effective and intuitive synthesis for complex decisions. With the awareness of this kind of approach from humans, the analytic hierarchy method suggestion of Saaty is that, instead of making people obligated to use a method on how to make decisions; provide them the opportunity to recognize their own decision making mechanisms; this way, the goal is to make them able to make better decisions.

A lot of decision making and problem solving duties are convoluted as it cannot be cleared by quantitative control. Most of the researchers [Levary and Wan \(1998\)](#), [Ribeiro \(1996\)](#), [Ruoning and ve Xiaoyan \(1992\)](#), [Zimmermann \(1987\)](#) have pointed out that fuzziness and ambiguity are the base characteristics of decision making problems. Decision making models and the decision makers' success depends on their tolerance towards ambiguity.

Since the calculation of qualitative choices is hard, it is possible to express a portion or a whole of double comparison values of AHP problems with an ambiguity level. This type of prioritization vector that is formed in double comparison environment is called fuzzy AHP problem. The earliest work in the FAHP appeared in [Laarhoven and Pedrycz \(1983\)](#), which utilised triangular fuzzy numbers to model the pair wise comparisons made in order to elicit weights of preference of the decision alternatives considered. Since then, the FAHP related developments have been consistently reported in the concomitant literature ([Tang & Beynon, 2005](#)). In the frame of this study, one of the most common AHP approaches in literature by Chang has been used.

[Saaty \(1999\)](#) has brought analytic network process (ANP) into literature which covers AHP but differs by using net structure in his book "The analytic network process" with comprehensive details. A decision making problem in ANP technique is modelled through a net structure and the interactions between factors during the modelling process, feedbacks between factor clusters and inside dependencies in factor clusters are being considered. With this kind of framing, ANP technique provides decision making problems to be solved more actively and realistically.

Analytic network process has been used in solving many complicated decision-making problems because it is a comprehensive multi-purpose decision method. There are many studies and appli-

cations on ANP. [Tesfamariam and Lindberg \(2005\)](#) developed an approach and sampled a case to select the best among the competing system configurations. [Wua and Lee \(2007\)](#) developed a method based on the ANP to help companies that need to select knowledge management strategies. [Fariborz and Partovi \(2006\)](#) studied the facility location problem which incorporates both external and internal criteria in the decision-making process. [Chung et al. \(2005\)](#) dealt with an application for the selection of product mix for efficient manufacturing in a semiconductor fabricator. Also, [Lee and Kim \(2000, 2001\)](#) performed in two separate studies, ANP was used in the interdependent information system project selection process, and project priorities found in these two studies. In addition to these studies, other studies where ANP was used are; [Yurdakul \(2003\)](#) evaluated long-term performances of production systems; [Meade and Presley \(2002\)](#) evaluated alternative research-development projects; [Mikhailov and Singh \(2003\)](#) studied the development process of a decision support system; [Momoh and Zhu \(2003\)](#) specified optimal production schedules; [Sarkis \(2002\)](#) developed a model for the purpose of strategic supplier selection.

## 3. Discussion of location selection with ANP

In ANP, the relative importance or strength of the impacts on a given element is determined, similar to AHP, by using pairwise comparisons with a scale of 1–9. The scale can be seen in [Table 1 \(Saaty, 1994\)](#). However, ANP must evaluate interdependencies within levels of clusters and mutually dependent elements in a cluster. To complete this evaluation, Saaty has developed a square matrix 'supermatrix' whose size is the number of all elements in the network.

The final analysis of ANP is to derive the overall weight of each element. These overall weights are usually calculated by raising the supermatrix to a sufficiently large power until the weights have converged and can remain stable. If the weights have not converged and remain unstable, Saaty and Vargas have developed the following three steps:

1. The supermatrix is decomposed into network portions and hierarchical portions.
2. The sub-supermatrix corresponding to the network portions is raised to a sufficiently large power.
3. A cross-product of the converged network data supermatrix and the hierarchical network data ([Nakagawa & Sekitani, 2004](#)).

Turkey has advantageous coasts to build shipyards because of its strategic position and geological structure. It is very important to develop by doing sea business in a country which is surrounded by seas. The presence of harbours is very important in order to do this business.

An important portion of the world's business is done via sea ways. In order to get its share from this business, our country has done investments to build new harbours and has partially

**Table 1**  
Saaty's 1–9 scale for AHP preference.

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgement slightly favour one over another
5	Strong importance	Experience and judgment strongly favour one over another
7	Very strong importance	Activity is strongly favoured and its dominance is demonstrated in practice
9	Absolute importance	Importance of one over another affirmed on the highest possible order
2, 4, 6, 8	Intermediate values	Used to represent compromise between the priorities listed above

Reciprocal of above If activity  $i$  has one of the above non zero numbers assigned to it when non zero numbers compared with activity  $j$ , then  $j$  has the reciprocal value when compared with  $i$ .

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