# FUZZY LOGIC METHOD DETERMINATION OF VARIABLES AFFECTING REAL ESTATE PRICES IN TURKEY

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## PREFACE

In 2023, my advisor Prof. Dr. Novruz Allahverdi passed away. I dedicate this book to my dear teacher. May his grave be heaven.

**CONTENTS**

## 1. INTRODUCTION

In developed countries, economies are determined by immovable values. The fact that these values are the subject of all transactions is an indicator of development. There is no definitive model for determining the real estate value in our country. In this book, it has been created on the basis of real estate value determination with fuzzy logic method by making use of computer technologies.

The aim of this study is to develop a model that will allow the processing of both numerical and non-numerical criteria affecting the value in order to solve the problem of determining the real estate value. It is thought that the created model will provide valuation with alternative criteria as well as being used in wide areas.

For this purpose, a survey was conducted to determine the views in the first value section. In the second section, there are data packages for real estate in two different regions, where construction is low and construction is intense.

In fuzzy logic, the Mamdani system is a fuzzy structure and is unstructured. In built-up areas, scenarios were produced with other criteria. With the test results obtained in both regions and according to both structures, the approximation rates of 85% in the unstructured area and 90% in the built area were obtained on average.

Fuzzy logic is a good method used in real estate evaluation. Fuzzy Logic is used in every field. It is extremely widely used in the real estate field.

The scope of fuzzy logic application areas is wide. These apps affect our lives. This Fuzzy Logic method provides an advantage by finding the estimated value of the real estates. It prevents the price increase in the markets and provides to find the real value of the real estate.

### 1.1. The Aim of the Study

Real estate valuation is very important today. It has become very important nowadays. Different methods have been used in this area so far. In each country, it determines the value by choosing a method suitable for its own local characteristics and market conditions.

The fact that there are legal gaps in real estate valuation in our country and that this issue cannot be placed in a certain system makes valuation more difficult. Valuation is required for different applications such as expropriation, property tax, determination of purchase and sale value, mortgage or credit in banks, land and land arrangement, land consolidation and privatization. The real estate values determined in the applications do not match the values formed in the market conditions, and even different values are encountered for the same real estate whose value is determined in the name of different applications (Arıcı et al. 2002).

### 1.2. Importance of the Study

Today, the search for new approaches for valuation continues. Every day, a new ring is added to its use in a wide range of fields, starting from the computer field, professional applications and extending to every field. Artificial intelligence techniques, which are the latest work of computer technologies in this wide range, are coming to fruition. Artificial intelligence techniques are methods created to imitate human thought. Although the way each of these methods works is different, the purpose of each is to introduce the concept of logic to the computer.

Machine systems, medicine, economics, etc. with the Fuzzy logic method as artificial intelligence techniques. Application examples are frequently encountered in many fields, especially in fields.

The country's economic data is not regular, structure, etc. Difficulties such as the inadequacy of costs for different areas and the difficulty of finding real estate with similar characteristics are expressed as frequently encountered problems.

The aim of the study is to think that the necessity of linguistic expression of the criteria affecting the value, as well as the effect of subjective approaches in the valuation of real estate, can be used by taking advantage of the features of fuzzy logic, one of the artificial intelligence methods, and that the model that will be created by taking into account local preferences in valuation will contribute to a fast and accurate result. In the first part of the study, in this book, which is used in the determination of real estate value with the fuzzy logic method, which is one of the artificial intelligence techniques; resource research, in the second part, the conceptual framework about the real estate market and real estate demand is given, and the determinants of real estate demand are discussed in detail. In the third part; fuzzy logic concept and membership functions in fuzzy set theory are given. In addition, the emergence of fuzzy regression analysis, which is an alternative method to classical regression analysis, and the methods developed for fuzzy regression analysis are explained. In the fourth part of the study; a brief summary of the relevant records is presented, both the real estate claims records and the aggregate regression analyses. In the last part of the study; A comprehensive regression analysis was conducted for the prediction of house prices in Turkey and the study was completed with the conclusion part.

## 1.3. Source Research

Various articles have been published on real estate valuation. It can be defined as the real estimation of the value in real estate valuation (Açlar and Çağdaş, 2002).

There are also different definitions for real estate valuation. Brown (1967) defines value as the process of determining the seller's provision for investment or long-term use according to the properties of the real estate, while in Ring (1972) it is based on real estate valuation, needs, desires and financial capacity for trading or corporate transactions.

It defines a variable response.

In order to know the value of the real estate, Yomralıoğlu grouped it as follows.

1- Purpose of Use of the Immovable: Land, land, residential, commercial, industrial,

like agriculture

2- Properties of the Immovable Location:

a- Legal Features:

b- Personal Characteristics of the Owners of the Real Estate:

3- Location of the Immovable: Especially for economic facilities and social facilities.

Location and transportation status are taken into account.

4- Location Characteristics: The geometric and physical structure of the immovable as of its location and the usage depending on these changes in the size of the real estate from an economic point of view they are capable of affecting (Yomralıoğlu 1997).

After determining the effective criteria to determine the value of the real estate, the valuation method is selected. The most used approaches in the literature on methods of real estate valuation:

• Valuation method according to the arm's length

• Income valuation method

• It is a cost-based valuation method (Yomralıoğlu 1997, Ertaş 2000, Açlar ve Çağdaş 2002).

However, the difficulties in the application of these methods with the developing technology necessitated new searches.

In the study conducted by Pagourtzi and Assimakopoulos (2003), real estate valuation methods are grouped as traditional and advanced valuation methods as follows.

Traditional valuation methods include:

• Comparison method ;
• Income method;
• Cost method;
• Multiple regression method;
• Hedonic price method;
• Benefit method.

The methods of advanced valuation methods are as follows.

• Artificial Neural Networks (ANNs);
• Fuzzy Logic;
• Spatial Analysis;
• Self Declining Integrated Average Motion Method (ARIMA)(Pagourtzi et al. 2003).
• Artificial Neural Networks (ANNs);
• Fuzzy Logic;
• Spatial Analysis;
• Self Declining Integrated Average Motion Method (ARIMA) (Pagourtzi et al. 2003).

Artificial neural networks and fuzzy logic are methods of artificial intelligence and have wide application areas.

Today, there are many occupational groups that use artificial intelligence methods, which are frequently encountered, effectively. Cartographers and city-regional planners, who are in search of new ones, have also started to find a place in this group.

There are many cartography problems suitable for artificial intelligence solutions. Apart from these, artificial intelligence offers new research areas to cartographers (Heine 2001, Ölgen 2003).

The artificial intelligence method is as follows according to its application areas.

- Spoken language processing
- Intuitive search
- Knowledge-based systems
- Expert systems
- Fuzzy logic
- Pattern recognition
- Robotics and artificial life
- Computer vision
- Machine learning
- Artificial neural networks (Neurocomputer)
- Evolutionary programming

The mentioned methods differ according to the application area. Other topics of artificial intelligence, especially artificial neural networks, which are used as an alternative method in the classification of satellite images, have also found application in cartography. In this regard, Ölgen (2003) explains the solutions according to each technique.

Fuzzy logic method is used in cartography (Worzala 1995, Heine 2001, Hansen2003).

Fuzzy logic is a kind of machine intelligence. Thanks to this intelligence, the computer sorts and controls the systems that are not fully defined with a common sense approach.

Fuzzy logic is based on thought, concept, term, proposition and inference. Differentiating points of fuzzy logic from other logic types;

a) there are verbal ambiguities,
b) it is a multiple logic,
c) the absence of equations of the phenomena under study,
d) In fuzzy logic, all models are in the form of a bundle of propositions.

To model an event by examining it in fuzzy logic

1) Variables representing the event are decided verbally. This is verbal criteria are called fuzzy logic variables.

2) Then, which of these words are precedent and which are final.

the decision is made. This is similar to the distinction between dependent and independent variables in mathematics.

3) The third stage of modeling in fuzzy logic is the question of how many propositions will emerge from these premises. In a way, the number of propositions is the number of options for combining the premises in different ways (Şen 2002).

Real estate valuation studies using fuzzy logic have become common in recent years. For example, in the study conducted by Büyükkaracığan (2021), advanced valuation methods were emphasized. He compared fuzzy logic modeling outputs with sample applications and traditional methods. As a result, he saw that fuzzy logic modeling gave successful results in real estate valuation.

In their study, Ödük and Büyükkaracığan (2022) applied the Fuzzy Logic model to real estate data in Konya province. The results of the created model and the current values were approximately the same. Accordingly, fuzzy logic method can be used in modeling in real estate valuation.

# 2. REAL ESTATE MARKET AND DETERMINANTS OF REAL ESTATE DEMAND

## 2.1. Real estate Concept

Real estate is structures produced and supplied to meet the shelter needs of individuals. Where people live. place, residence, settlement (Turkish Language Association, 2019).

In addition to meeting the real estate needs of households, houses also have functions such as being an investment tool and helping economic security (Özmen, 2016: 12).

Recently, more than one research has been done on the concept of real estate and different methods have been applied. Therefore, many comments have emerged. He stated that the concept of real estate includes more meanings around the real estate area than just a shelter. They stated that a good house will contribute to the welfare and happiness of its users, and that besides meeting the accommodation needs of the people, their social place and status in the society are also revealed. Homes; It is also related to economic, physical and aesthetic values. All these are related to the basic criteria that its users seek in a house and make them happy. Real estate today; It has become a complex, multidimensional process that includes meeting different personal needs. Today, rapidly developing residence structures, more complex real estate systems including sports, shopping, education and entertainment centers are good examples of changing expectations for the concept of real estate (Öztürk and Fitöz, 2009: 23).

One of the biggest problems in the real estate sector is public interventions. In particular, inadequate control intervals lead to the formation of unhealthy real estate. For this reason, the preparation of plans submitted to the Ministry of Environment and Urbanization, the issuance of licenses and similar zoning applications should be carried out in coordination with the relevant municipalities (Ödük and Büyükkaracığan, 2022).

Houses in essence; These are the structures produced to meet the real estate needs of the households. Whether individuals own the house or just rent the right of use, the reason behind the demand for real estate in general is shelter, security, health, peace and well-functioning social relations. The demand for real estate is also affected by the disposable income level of the households, real estate prices, expectations from the real estate, the tastes and preferences of those who demand real estate, and the prices of complementary and substitute goods, just like the demand for other normal or luxury goods and services (Durkaya, 2002: 10).

Expropriation decisions are very effective in the real estate sector in our country. Valuation studies are very important in areas where expropriation is carried out. Expropriation methods of public institutions are purchase, complete or expropriation, easement with expropriation, emergency expropriation, exchange, etc. (Ödük and Büyükkaracığan, 2023).

Especially in areas undergoing urban transformation, practices cause significant ups and downs in real estate prices. In preventing disputes between rights holders, correctly made valuation prevents loss of rights (Ödük and Büyükkaracığan, 2023).

Berberoğlu and Teker (2005), considering the concept of real estate more comprehensively, He stated that in addition to its functions such as being a shelter, an investment tool, contributing to economic development, and being a guarantee for the future of individuals, it is also an important indicator of the economic and social development level of societies.

According to the Turkish Statistical Institute (TÜİK), the definition of real estate is; It is a place with its own door, which is closed, whose ceiling is covered and which opens directly to the street, corridor or general place (TÜİK, 2008). Today, apart from the need for shelter, real estate has also become a status indicator in the social structure. Shelter has been determined as the basic need for human life and has been accepted by the Universal Declaration of Human Rights, which is recognized by the whole world. In

the declaration proclaimed by the United Nations General Assembly's Resolution 217 A (III) of 10 December 1948, this article was explained as follows: All people have the right to food, clothing, real estate and medical care so that they and their families can live in good health and well-being. OHCR, 2013: 5).

The real estate sector's contribution to the Gross Domestic Product is in the construction sector (Öztürk and Fitoz, 2009: 22).

In addition, with the real estate sales made to foreigners in recent years, foreign direct investment (FDI) has started to enter the country to a significant extent, and these incomes have a great place and importance especially in closing the current account deficit (Göçer, 2013: 222).

There was an increase of 8% in 2008 and 2009 on a per square meter basis in building permits obtained throughout Turkey. The 18% contraction in 2018 can be shown as the best example of this. Sector 2011 started to recover from the beginning and by 2015, a remarkable has achieved growth. However, the global economic crisis in 2015 caused a political crisis in the world and in Turkey. In the real estate sector, due to developments and especially the excess supply in real estate, There was a significant recession (Büyükkaracığan ve Ertaş 2015)

When writing a real estate valuation report, first of all, due diligence should be done needs to be realised. For this purpose, title deed examination, official institution examination and on-site three basic studies should be carried out (Altınışık, Büyükkaracığan ve Uzun, 2017).

## 2.2. Real estate Shortage and Real estate Problem

Real estate shortage; It means that the real estate supply is less than the real estate demand (IMO, 2017).

Increasing urbanization and population growth problems in developing countries bring along the problem of real estate deficit. Illegal methods are used in order to meet the need for accommodation at low cost in

migrations to the cities, and this creates the problem of unplanned urbanization. In Turkey, especially since the 1950s, when urbanization began, the problem of real estate deficit has emerged. Urbanization and the rapid increase in population have caused concentration in metropolitan cities and an increase in real estate demand. Due to the lack of sufficient number of houses and the lack of adequate lands with suitable infrastructure, slum structures have been formed. Real estate problem in a narrow sense; It is the situation in which individuals living in a country cannot be provided with real estate in a way that can meet their needs for sheltering in a healthy and safe manner. Real estate of some people in unqualified (without electricity, clean water, sewerage, clean air, etc.) houses is also a part of the real estate problem. Insufficient number of qualified houses increases the value of these houses, which makes it impossible to solve the real estate problem of low-income households. When the real estate problem is examined in more detail, it is seen that the main problem also includes quality, space and infrastructure (Emekçi and Tanyer, 2019: 55).

The most important reason for the real estate problem is the rapid increase in population and urbanization. This problem is not only the problem of developing and underdeveloped countries, but also one of the problems that developed countries are seeking solutions for. The increase in the world population and the rate of urbanization has increased the need for real estate significantly (Çakır, 2014).

Population growth; While it is experienced with high birth rates in underdeveloped and developing countries, it occurs due to migration in some developing countries such as Turkey and developed countries such as the USA, Canada and European Countries (Lin, et al. 2018: 1 - 2).

Real estate is an important indicator for countries as it contains many variables. It is necessary to provide the supply-demand balance in the real estate market, to carry out the necessary quality controls in the real estate production strictly by the competent authorities, and to make the real estate investments in a balanced way.

## 2.3. Real estate Demand

Real estate demand; It refers to the situation in which individuals are willing to pay the ownership of the house or the rent and have the financial power to meet it, and it emerges as a different concept from the need for real estate. Because while the need for real estate shows a necessity, , it also includes real estate demands for investment purposes (Fingleton, 2008: 1546 - 1547). Ertürk (1996) handled the real estate demand from two different aspects: First; personal needs, the latter; social texture. Factors affecting the demand for real estate in terms of personal; Individuals' tastes and preferences, economic conditions, social status, real estate prices, real estate-related replacement and complementary goods prices and alternative costs of buying a house.

Demand for real estate in terms of individuals can be shaped as more or less than real estate need, depending on the factors mentioned above. Long-term social and economic factors will be an important parameter in estimatimating the real estate demand that will occur throughout the country. Among these factors, the population growth rate, the age distribution in the society (7 shapes of the age pyramid) and the changes in the family structure (extended family, nuclear family) are effective in shaping the demand for real estate. These factors can cause reshaping of individual and social real estate demand. Real estate demand can be broadly divided into two sub-sections as consumption real estate demand and investment real estate demand. Consumptive real estate demand; While loan and interest rates are determined by household income and real estate prices, the wealth of the household is the main determinant, along with other factors, in the demand for investment real estate (Öztürk and Fitöz, 2009).

### 2.3.1. Determinants of Real estate Demand

The most important determinants of real estate demand are; real estate prices, household income, credit facilities, social demand and demographic factors (population), the details of which are discussed below.

### 2.3.1.1 Real estate Prices

The factor that triggers the demand for real estate is the price of real estate. The law of demand works in real estate. Price is the main factor in ensuring the supply-demand balance.

Changes in real estate prices are also effective on real estate demand. While the increase in real estate prices affects the real estate demand negatively, the decrease in real estate prices has a positive impact. This situation shows that there is an inverse relationship between real estate demand and real estate prices (Siso, 2009: 55).

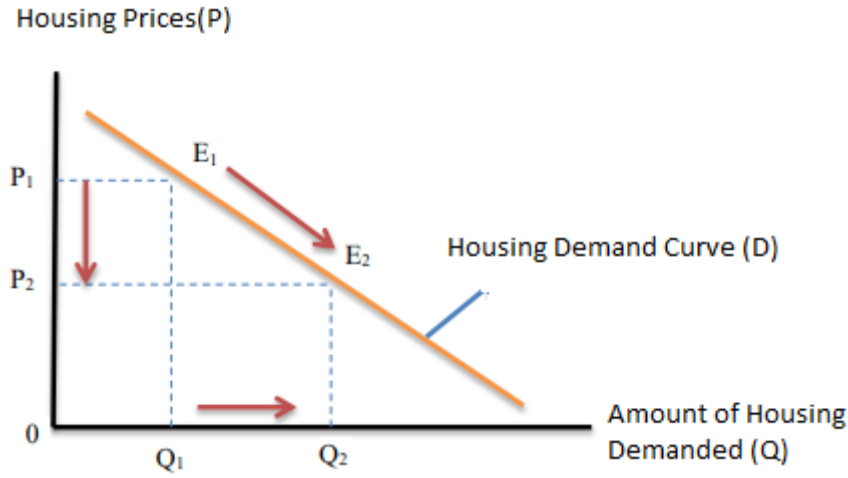


**Figure 2.1.** Real estate Prices and Real estate Demand

As can be seen from Table 2, when house prices fall from P1 to P2, the quantity of real estate demanded increases from Q1 to Q2. The opposite is also possible. That is, if house prices rise from P2 to P1, the quantity of houses demanded will also fall from Q2 to Q1. The quality of the material used in the construction of the house, the size of the house, the environment in which it is located and the quality of workmanship are also effective in

house prices. The fluctuation in real estate prices is due to the differences in these factors (Büyükkaracığan, 2022).

### 2.3.1.2. Change in Income

Change in income is another factor affecting real estate demand. The change in income indirectly affects the demand for real estate. Blumenfeld (1944) argues that an increase in income leads to an increase in marriage rates, which in turn will lead to an increase in real estate demand. Increases in household income significantly determine the demand for real estate. This situation can be examined with the help of Table 2.2.

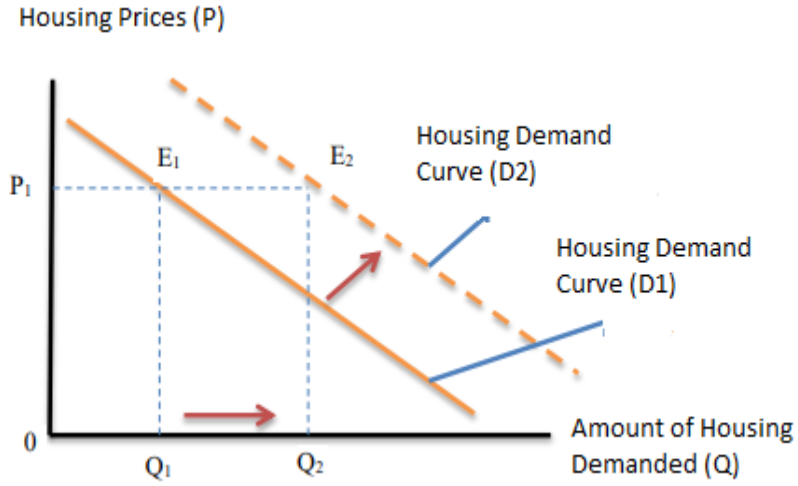


**Figure 2.2.** Effects of Change in Household Income on Real estate Demand

As can be seen from Table 2.2, an increase in household income will increase the demand for real estate from Q1 to Q2, by enabling the real estate demand to expand to the upper right. The opposite may also be the case. That is, when household income decreases, demand for real estate shifts left-down and the amount of real estate demanded may fall from Q2 to Q1. In this case, income and real estate demand are positive.

$$Y \uparrow \rightarrow D \uparrow \textbf{ (1)}$$

The inequality of income distribution experienced in Turkey has a different dimension in terms of real estate demand. In the country where people in the low-income group are in the majority, it causes the demand for real estate to shift to low-standard real estate. The increase in national income per capita will contribute to the increase in individual savings, which in turn will contribute to the increase in real estate demand and the construction of more qualified houses (Siso, 2009: 57).

The choice of income measure plays an important role in real estate demand analysis. The most accurate measure frequently encountered in empirical analysis is real income per capita. Since permanent income measurements and the average income expectation that individuals hope to achieve (anticipate) in the long term can be a more meaningful criterion in this field, real estate demand can be frequently used in real estate demand analyzes and can produce quite meaningful results in this field. Demand for real estate for investment or consumption purposes is shaped according to the income people plan to earn throughout their lives (Durkaya, 2002: 12).

In order to meet the needs, there is a need for economic support, and the demand will arise to the extent that this support (income stream) is provided. This is also true for the real estate market. The need for real estate is not the only indicator of real estate demand. In order for the demand to be realized, it is also necessary to obtain the purchasing power. If the need for real estate is supported by purchasing power, it becomes an indicator of real estate demand (Määttänen and Terviö, 2010).

#### 2.3.1.3. Loan Opportunities and Loan Interest Rates

Access to loans and real estate loan interest rates are another important variable that determines real estate demand. Similarly, interest rates applied to real estate loans and deposit interest rates; It is an important determinant of real estate demand. When the interest rates applied to real estate loans decrease, the maturities of these loans are extended, the file costs and collateral required from individuals in return for loans are reduced, individuals will be able to access real estate loans more easily and this will

increase the demand for real estate. On the other hand, in terms of savers; Real estate purchases and time deposits are substitutes for each other (opportunity cost). When the interest rates applied to time deposits increase, people may prefer to obtain higher returns by investing their funds (savings) in time deposits instead of real estate acquisition (Durkaya, 2002:29).

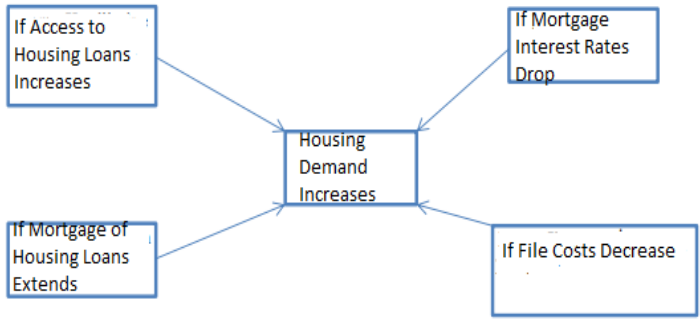


**Figure 2.3.** Relationship Between Interest Rates and Real estate Demand

The relationship in Table 2.3 can also be examined from Table 2.4 with the help of the demand function.

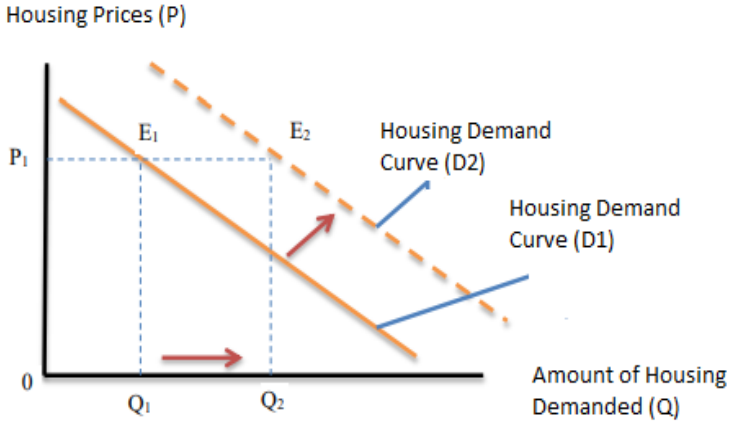


**Figure 2.4.** The Effects of Increasing Real estate Loan Opportunities and Decreasing Loan Interest Rates on Real estate Demand

As can be seen from figure 2.3 and figure; Facilitating households' access to real estate loans, lowering real estate loan rates, extending the maturity of real estate loans or reducing the file and transaction costs demanded from real estate loans and the amount of collateral demanded in return for these loans will increase the real estate demand of individuals. In this case, the real estate demand curve will shift to the right-upper position and become D2, and the amount of demanded real estate will increase to Q2. If Real estate Loan Interest Rates Decrease, Real estate Demand Increases, If Access to Real estate Loans Increases, If the Maturity of Real estate Loans is Extended, If File Costs and Collaterals Requested for Real estate Loans are Decreased Q1 Real estate Prices (P) Real estate Demand (Q) P1 Q2 0 E1 E2 Real estate Demand Curve (D1) Real estate Demand Curve (D2)

In particular, the interest rate is an important variable among the determinants of real estate demand. It is observed that long-term interest rates lead to an increase in real estate demand. While the decrease in long-term interest rates ($i$) causes an increase in real estate loans ($CRD$) and real estate demand ($D$), real estate demand decreases when interest rates increase. In this respect, it is expected that there will be a negative relationship between the real estate demand and the interest rate (Aktürk and Tekman, 2016).

This can be expressed by the following arrow diagram:

$$\boldsymbol{i \downarrow \rightarrow CRD \uparrow \rightarrow D \uparrow} \quad \textbf{(2)}$$

On the other hand, an increase in interest rates applied to time deposits will decrease the demand for real estate and increase the utilization of savings in time deposits. This situation can be examined with the help of figure 2.5.

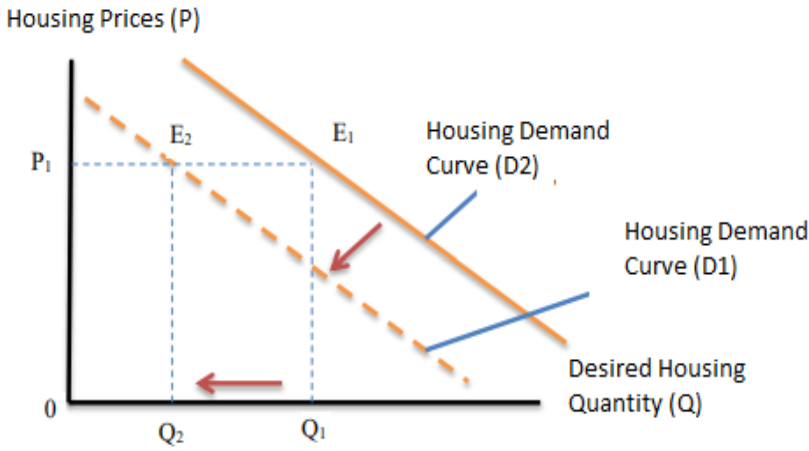


**Figure 2.5.** Effects of Increase in Time Deposit Interest Rates on Real estate Demand

As can be seen from Table 2.5; Increases in interest rates on time deposits will shift the direction of use of savings from real estate demand to time deposits, causing the real estate demand curve to shift to the left-downward and the real estate demand to come from Q1 to Q2. In the continuation of the deregulation period experienced in Turkey and throughout the world in the post-1980 period, product and customer diversity has been introduced in the banking sector. It was observed that there was an increase in real estate loans in this period (Snyder, 2010: 3).

### 2.3.1.4. Social Demand

Social demand is another variable that affects real estate demand. Owning a home is also seen as a security tool in developing countries. In addition to the need for shelter, real estate also has the characteristics of being a security for the households to live comfortably in the future and being an investment tool.

People use technology more and more every day. Their basic needs such as shelter, heating and nutrition are at an extreme level. In addition, communication, means of transportation and the natural environment are

constantly changing. The changing environment also directly affects the real estate market(Ödük and Büyükkaracığan, 2023).

Therefore, households may, in some cases, demand real estate in excess of their families' probable real estate needs in the current and future periods. This situation may lead to the concentration of real estate investments from time to time, independent of and exceeding the current needs and demand, and excessive production, and may cause inefficient distribution of scarce resources in the economy and speculations that can be made in this area (Bayat, 2001: 26).

Especially in the USA in the process leading up to the 2008 global economic crisis, the extreme fall of mortgage loans and the misperception (speculation) that real estate prices will constantly increase, caused thousands of people to buy additional houses for investment purposes by using new loans, but it was understood that the houses would not actually meet these prices ( Upon the bursting of the real estate price bubble), real estate prices began to fall rapidly and loans could not be paid. This has caused a global economic crisis that has deeply affected all countries of the world, starting with the financial markets in the USA (Kırcı, 2016: 467 - 468).

### 2.3.1.5. Demographic Factors

Factors related to the structure of the population are another important factor affecting the real estate demand. What affects real estate demand are population, age distribution and marital status. Changes that occur with the growth of individuals living in the household are also expected to increase the demand for real estate. The increase in the average age of the individuals living in the household, the increase in the education level and the increase in the number of people working in the family increase the income and create the need for new real estate for the people. The increase in female employment is also a factor that positively affects the real estate demand. Population growth not only causes an increase in the demand for all goods and services, but also affects the demand for real estate. Migration and

urbanization process are demographic factors that determine real estate demand. Migration can take place not only from village to city, but also from city to city.

The population is increasing in the cities as there are more employment opportunities in the cities. With the increase in urbanization, an increase in the number of real estate is expected. When the existing houses cannot meet the need, there will be excess demand for real estate. This causes rents and real estate prices to increase. A positive relationship is expected between the rate of urbanization and real estate demand. Population and population growth, average income and demographic structure of the household were determined in the first studies as determinants of real estate demand (Martin, 1966).

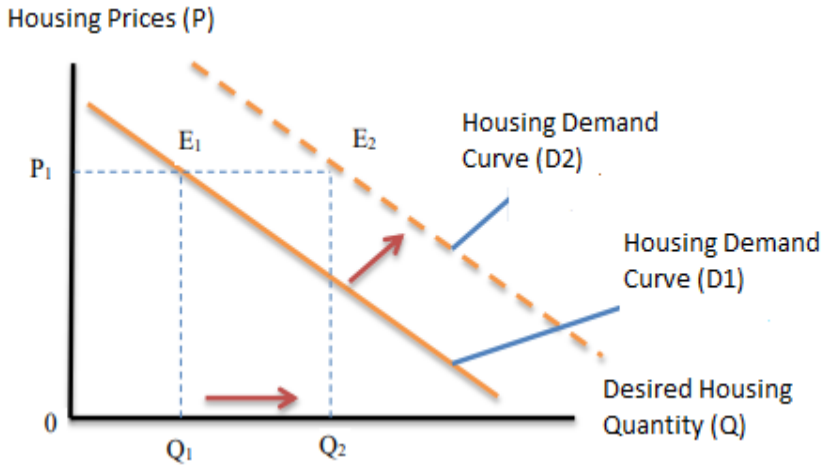


**Figure 2.6.** The Relationship Between Demographic Factors and Real estate Demand

As can be seen from Table 2.6 and Table 2.7; Increasing demographic factors will increase the household demand for real estate. This, in turn, will increase the demand for real estate from Q1 to Q2, allowing the demand for real estate to expand to the right (Akyol, et al, 2011).

# 3. DESIGN RELATED STUDIES

## 3.1. Studies on Determinants of Real estate Demand

A brief summary of the studies available in the literature on revealing the determinants of real estate demand is presented below, in order of publication date.

Lee (1963) examined the effects of age, occupation, individual's social environment and disposable income on real estate demand. According to the real estate purchase model created by the author; While reaching the conclusion that disposable income has a strong effect on buying a house, variables such as occupation, marital status, social environment and age of the house have no effect on owning a house.

Wabe (1971) examined the variables affecting house prices in the city center of London in his study. Real estate prices according to the results obtained; vary according to population and location of residence.

Öztürk and Fitoz (2009), in their study on the determinants of real estate supply and demand, took into account per capita income, CPI and PPI rates, interest rate, urbanization rate, the amount of cash in the economy (large money supply M2). The data used in the application were used on an annual basis during the 1968 - 2006 period. In the study, EKK method was used to solve the models created for real estate demand and supply

Ergöz Karahan (2009) aimed to find answers to the questions of how real estate demand is shaped by establishing a co-integrated model of household and real estate demand dynamics in his study. In this direction; Taking the province of Istanbul as an example, as a result of his analysis, the factors affecting the household; It has been determined that environmental, social and spatial factors are important determinants on the lifestyle of families and real estate demand.

İbicioğlu and Karan (2012) indirectly analyzed the real estate demand in Turkey through the real estate loan demand. In their analysis using the

2005:Q1-2012:Q2 period data; The authors, who determined one-way causality relationships from interest rates, unemployment rate and consumer confidence index to real estate loans and real estate demand, in their variance decomposition analysis based on the VAR model; They found that the most important determinant of the change in real estate loan demand is real estate loan interest rates.

Abar and Karaaslan (2013), in their study to determine the real estate demand structure of the personnel working at Erzurum Atatürk University and the characteristics of the houses they demand; The data obtained by applying a questionnaire to the university personnel were analyzed with the multiple concordance analysis technique. The main purpose of this study; It has been put forward as to determine the demand of university staff in real estate projects that can be realized in Istanbul, Ankara and Erzurum provinces. Within the scope of the survey; Relationships between people's duties, income levels, city preferences for real estate, preferred real estate type, age, and demanded real estate sizes were examined. In the results of working; It has been concluded that the personnel with high income prefer to buy houses in the provinces of Istanbul and Ankara, while the personnel with lower income level prefer the houses to be built in Erzurum. It has been observed that as age and income increase, preferences in real estate types also change.

Ören and Yüksel (2013) examined the factors causing the real estate problem by giving general information about the real estate market and the determinants of real estate policies in Turkey. For this reason, starting from the meaning of the real estate and real estate problem, one of the causes of the real estate problem; urbanization, population growth, migration, slums and illegal structures, income inequality and unemployment. At the end of the authors' work; They made predictions about how to solve the real estate problem.

Yayar and Gül (2014), in their study to determine the factors affecting the prices of apartments in Mersin city center; They obtained the data of 739

flats by face-to-face interviews with real estate agents. Writers; They established three different econometric models by trying three different function types as linear, semi-logarithmic and full logarithmic. As a result of the analyzes made; It has been determined that factors such as the usage area of the houses, the size of the kitchen, their distance from the neighborhood markets, the number of bathrooms the house has, the parking lot, the central satellite system, the private security services and the presence of the elevator increase the prices of the houses. It has been determined that the fact that the houses have a garden, are located in a site, are far from the stops of public transportation vehicles and are old (worn out) cause a decrease in house prices.

Çakır (2014) examined the real estate demands of the households living in the coastal areas of Ordu province according to their socio-demographic characteristics and economic status. In the study, the households living in 23 neighborhoods were selected by random sampling method and data were obtained with the help of the questionnaires prepared. The author who analyzed this data; It has been determined that the increase in the number of people living in the household plays an important role in determining the demand for real estate. Looking at the findings in general; It has been seen that the changes in education status and income level also affect the demand for real estate.

Lebe and Akbaş (2014), to determine short and long-term rates of real estate demand and real estate policy in Turkey; Data from the period 1970-2011 were used.

Omtatah (2014) analyzed the determinants of real estate demand in Kenya's capital, Nairobi, for the period 1979 - 2009, using the correlation analysis method and found that the variables most associated with real estate demand were; It has been determined that the number of households and national income is the number of households and the increases in interest rates reduce the demand for real estate in this country.

Özlük (2014) analyzed the determinants of demand and supply in the real estate sector in Turkey with the help of tables and graphs and found that the most important determinants of real estate supply are; Real estate prices, real estate costs, taxes, local government development plans, infrastructure investments and urban transformation programs are the main determinants of real estate demand; It has been determined that real estate prices, household income, interest rates of real estate loans, urbanization rate, population growth rate, marriages and divorces, and internal and external migrations.

Işık (2015) investigated the relationship between real estate prices and real estate features in Erzurum, using the hedonic price approach. According to the findings obtained at the end of the study; The number of rooms, bathroom, size of the house (m2), heating system, having an elevator, being in the site, proximity to public areas (park, garden, metro, station, school, hospital, etc.) and neighborhood variables increase the value of the houses, It has been determined that the age of the houses, being multi-storey, the height of the dues, being furnished, the distance to the city center and the exterior cladding method variables decrease the value of the house.

Uysal and Yiğit (2016), in their study investigating the factors affecting the real estate demand in Turkey; per capita income, real estate prices, rate of urbanization, interest and large money supply (M2). After using the VECM model to look at the relationship between the long-term and short-term in the regression equation, the researchers concluded that; While they found a positive relationship between real estate demand and per capita income, interest rate, and urbanization rate, they found a negative interaction between M2 money supply and real estate demand.

Tafirenyika and Paul-Francois (2016) investigated the determinants of house prices and new house construction activities for the Namibian real estate market with the help of VAR method for the period 2000:M01-2014:M12 and found that the real estate market in this country is affected by changes in population, mortgage interest rates and inflation. They

determined that there is a two-way causality relationship between real estate prices and new real estate construction.

In their study, Aktürk and Tekman (2016) aimed to examine the decisions of individuals residing in Erzurum, which are effective in acquiring real estate. To determine the real estate demand, they applied the questionnaire to individuals residing in Erzurum and considering buying a house, using a questionnaire. As a result of the analysis, the factors that are effective in buying a house; It has been determined that there are factors such as the price of the house, the location of the house on a secure site, the quality of the materials used, and its distance from the city center.

Cohen and Karpoviciute (2017) examined the determinants of real estate prices in Lithuania using the data for the period 2001:Q1-2014:Q4 with the help of Granger causality test and found that the most important determinants of real estate prices in this country are national income and unemployment rates.

Yıldırım (2017) analyzed the dynamics of the real estate market in Turkey for the period 2010:Q1-2017:Q2 with the help of DSGD (Dynamic Scholastic General Equilibrium) method and structural VAR (SVAR) method and in the short term; He found that monetary policy shocks have an impact on real estate prices, but that the main determinants of real estate prices in the long run are real estate market dynamics. Also in this study; It has also been determined that the magnitude of the effect of shocks belonging to the real estate market on the rest of the economy varies according to the values taken by the loan value ratios. According to this; The high loan to value ratio affects real variables such as consumption and output from the real estate market through monetary policy.

Altun (2017) analyzed the factors affecting the decision to buy a house in the province of Karaman, using the frequency distribution, percentage tables, Chi-Square and tests and one-way analysis of variance, on the data he obtained with the help of a questionnaire applied to 400 people.

factors; found that the house is in compliance with the new earthquake regulation, its price and that it can be sold at any time. In addition, family and friend advice, the seller's approach, advertisements and the presence of smart systems in the house were also found to be important variables in the demand for real estate.

Özelçi Eceral and Uğurlar (2017) tried to reveal the determinants of the real estate market in Ankara by analyzing the data obtained from the face-to-face survey of 534 households. As a result of the analyzes made; It has been determined that the economic structure of the household, lifestyle, type of real estate use and the campus where the real estate is located are effective on the real estate preferences of the individuals in Ankara.

Ahmed, Iqbal, and Siddiqui (2018) analyzed the determinants of real estate demand in urban areas of Pakistan with the help of the two-stage Heckman election model for the period 2004:M05 – 2010:M11 and concluded that house prices and household income are the most important determinants of real estate demand. they have reached.

Çelik and Kıral (2018) in their work; Balanced panel data analysis method was used to determine the factors affecting the real estate demand of Turkish provincial groups and hierarchical clustering method was applied according to the statistically significant results obtained. According to the results obtained as a result of the analysis; house prices, national income (GDP), average return of houses, number of immigration, number of immigration, marriage and divorce statistics affect the demand for real estate at a statistically significant level.

Yıldız (2018) examined the relationship between some selected variables and real estate demand in his study. These variables are; per capita income, consumer price index, real estate loan interest rates, consumer confidence index and urbanization rate. Looking at the analysis results; In the long run, the income variable has a positive effect on the real estate demand, and in the short run, the income variable and the real estate loan interest rate have significant effects on the real estate demand.

Kılcı (2019) investigated the relationship between interest rates on real estate loans and mortgaged house sales in Turkey, using the data for the period 2013:M01- 2018:M12, with the help of the Fourier SHIN (2016) cointegration test and the Fourier Granger (2016) causality test. It has been determined that interest rates have both short-term and long-term effects on mortgaged house sales.

Birlik and Aydın (2019) analyzed the factors affecting the decision of households to own a house in Turkey with logistic regression and support vector machines (SVM) methods and compared their findings. In the study, 10,000 observations compiled from the Household Budget Survey prepared by TUIK were used and it was found that the SVM method better predicts the household's decision to own or not.

### 3.2. Studies Using Fuzzy Logic Method

The first information about the concept of fuzzy appeared in 1965. It was put forward by Lütfi Asker Zade (1965). After Zadeh (1965) defined the concept of fuzzy sets, applications that consider fuzzy information in the regression model have been successfully applied in many branches of science. A brief summary of the studies that can be accessed using fuzzy logic or fuzzy regression analysis methods is presented below, in order of publication date.

Tanaka, Uejima and Asai (1982) proposed the first application in fuzzy regression with their study in 1982. In this study, it is assumed that the input and output variables are not fuzzy, but the logic of the system is fuzzy. The analysis was performed using linear programming technique.

Diamond (1988), similar to the classical least squares (LWC) regression method, introduced the fuzzy least squares (LUC) regression method. The author has developed models based on fuzzy least squares method for data whose input is exact number, output is fuzzy number, and input is fuzzy and output is fuzzy number. The author also derived criteria

equivalent to the normal equation for the applicability of fuzzy datasets to the model.

Moskowitz and Kim (1993), in their study to determine the relationship between fuzzy linear regression analysis, the spread of fuzzy parameters, membership functions and H value, they revealed the sensitivity of the spread according to the shape of the membership function and the H value.

Chang and Lee (1996) developed the generalized0 fuzzy weighted0 least squares0 method, which is based on the weighting to be made according to the membership degrees in case of outliers in the sample and interacts with the decision maker.

Wang and Tsaur (2000) found the modified fuzzy least squares method for solving problems with non-fuzzy independent variables and fuzzy dependent variables defined by Tanaka (1982).

Yang and Lin (2002) developed two new estimation methods for fuzzy variables based on fuzzy least squares method. Researchers also emphasized that it is necessary to use cluster analysis to identify heterogeneous datasets and outliers.

Lee and Chen (2003) reconsidered the generalized fuzzy linear regression model and showed that the nonlinear programming model can be used to determine fuzzy parameters.

Altunkaynak, Özer and Çakmakcı (2005) in their study; They aimed to estimate the amount of water demand in the future by considering the 3-period water consumption amount as the independent variable. The mean square error values were calculated for different model structures and the most effective model was selected. In this context, the TS fuzzy regression analysis model was applied to monthly water consumption fluctuations in Istanbul. As a result of the analyzes made; It was observed that the TS fuzzy

model preserved the statistics. It was also concluded that this model helps to make predictions with a relative error value of less than 10%.

İşbilen Yücel (2005), using the fuzzy regression method, in her application for the estimation of the informal economy; Emphasizing that classical regression analysis methods can provide precise and clear results for the analysis needs of numerical sciences, he preferred to use fuzzy regression analysis method, emphasizing that classical regression analysis methods are insufficient in the analysis of studies in social sciences. In this context, the author; He estimated the informal economy model in Turkey for the period of 1980-2004.

Yurtçu and İçağa (2007), in their study examining the fuzzy regression approach; An application has been made with numerical data in order to be an example in the comparison of classical regression and fuzzy regression. In the last part of his studies, information about the development of fuzzy linear regression analysis method is given and a summary of literature research on fuzzy regression analysis applications in the field of hydrology is presented.

Yanartaş (2009) used fuzzy linear regression analysis methods in his study, which deals with fuzzy linear regression analysis methods; analyzed under two main headings as methods based on linear programming and fuzzy least squares method. In the study, tests were carried out using different methods and it was determined that the most effective and preferred method for data with 48 definite inputs and fuzzy outputs was the least square mean method. It was stated that the most preferred method for samples with fuzzy input and fuzzy output was the IDFLS method.

Altıntaş (2009) examined the methods based on linear programming and fuzzy least squares method by considering fuzzy linear regression methods. The author, who gave information about fuzzy logic and fuzzy set in his work, also exemplified these methods, which he explained theoretically, with numerical data.

İçen (2010) started by introducing the historical development of fuzzy logic and fuzzy sets; explained the differences between classical and fuzzy set operations, discussed fuzzy linear regression analysis methods and examined fuzzy hypothesis tests. In the application part of the study; The unemployment rate in Turkey was discussed and this rate was estimated with the help of fuzzy linear regression analysis methods, the method of blurring the coefficients and the linear programming method.

Gök (2010) created models using fuzzy linear regression analysis and logistic regression analysis methods, which are two alternative methods to the classical regression analysis method, and made an example application with these models. In practice; The author, who tried both methods for estimating the sector shares of banks, determined that the logistic regression analysis method produced more successful results.

Pan et al. (2011) used pavement conditions with five membership functions and made estimates using fuzzy regression analysis method to explain the uncertainty of classical methods. Researchers constructing estimated fuzzy regression equations on a case study using pavement inspection data; They sought to provide a model that could assist road authorities in determining desired repair actions regarding anticipated pavement conditions. In their study where they emphasized the importance of fuzzy regression analysis.

Armutlu and Yazıcı (2012) conducted a fuzzy regression analysis with the data of 45 automobile brands, after giving the theoretical information of these analyses, and compared the results they obtained with the EKK method, which is a linear regression analysis method. They stated that it gave better results than the EKK method.

Nowaková and Pokorný (2013), in their study where they discuss interval and fuzzy regression technologies; stated that the linear fuzzy regression model is a more suitable method. Using genetic algorithm coefficients to describe fuzzy regression, the authors also show the

probability domain of the uncertain model by presenting a numerical example.

Kaya (2014) in his study; He explained the fuzzy regression model developed by fuzzy logic and fuzzy logic. In the first part of his work; Using the consumption amount and GDP data, the author constructs a consumption function and analyzes it with a fuzzy regression model. compared the results. In the author's work; observed that fuzzy regression analysis gave better results than classical regression analysis.

Chan and Engelke (2015) proposed a fuzzy regression method that explains the blurring that may occur when blurring due to human judgment is not taken into consideration in the methods for subjective image quality assessment (IQA). Addressing the uncertainty that is often neglected in the development of quality prediction models that relate subjective IQA and objective IQA in evaluation, the authors concluded that; They concluded that fuzzy regression models achieve more effective data fit and better generalization capacity when estimating subjective IQA at different image types and levels.

Bozkurt (2015) used fuzzy regression analysis method to analyze the effects of financial stability indicators on Turkey's CDS premiums and found that there is a negative relationship between financial stability and CDS premiums.

Yabuuchi (2017) examined the uncertainty possibilities in fuzzy regression models; Assuming that the uncertainty is included in a probability degree, a fuzzy regression model was created to remove the skewness in the data distribution. In this way, the author; It aimed to eliminate the uncertainty of a number and the distortion of models by using numerical examples created with random numbers. At the end of the author's work; He concluded that maximizing the degree of probability and adjusting the uncertainty of a grade allows constructing a fuzzy regression model that accurately describes a system without being affected by outliers.

Chen and Nien (2020) proposed the FPC operator used for constraints in a mathematical programming problem to formulate fuzzy linear regression models with fuzzy parameters using fuzzy observations. Comparisons with existing approaches have concluded that the proposed approach is stronger even when clear explanatory variables are used. When the studies in the literature are examined; It is seen that significant progress has been made in the field of fuzzy logic and this subject produces more successful results in solving different problems than classical analysis methods. It would be more accurate to use analytical regression analysis methods instead of classical regression analysis, especially when conducting studies that are human subjects and are very sensitive to changes in human behavior/decisions/expectations, such as social sciences. For this reason, general logical methodology was used when examining the collection of public real estate demands in Turkey from these records.

# 4. APPLICATIONS

## 4.1. Creating a Model with Fuzzy Logic

The MATLAB program was used to create a model with fuzzy logic for real estate value determination. Mamdani method with FIS and Sugeno methods with ANFIS were used. In 100 applications, Mamdani and Sugeno structures were compared with each other with different criteria. The effect of the number of criteria on value determination and the usability of Mamdanin for value determination were tested with Sugeno. In addition, the application was made in two parts, unstructured and built areas. The statistics program was used in the analysis of the survey studies. In addition, NETCAD software and MapInfo Professional SCP Geographical Information System software were used to create data sets.

### 4.1.1. Creating a Model with Mamdani Structure

Models were created with the help of the FIS (Fuzzy inference system) editor using the Fuzzy logic toolbox of the MATLAB program for the purpose of value determination with the Mamdani structure. Figure 4.1. shows the structure of the FIS editor working using the graphical user interface (GUI).

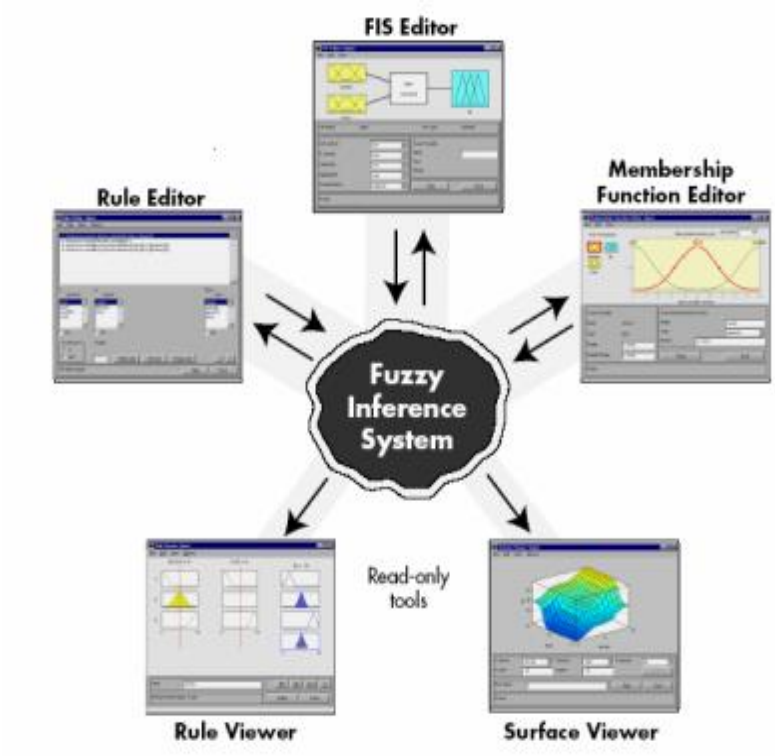


**Figure 4.1.** FIS structure in graphical user interface

The main components and tasks of the FIS structure created in the GUI in Figure 4.1. can be summarized as follows.

1- The FIS editor is the part where the fuzzy system is created and the input and output variables are defined.

2- Membership Function Editor is used to define the shapes of all membership functions associated with each variable.

3- The Rule Editor is for creating a list of rules that define the behavior of the system.

4- The Rule Viewer and Surface Viewer are used to examine the FIS as opposed to editing. These are strictly read-only tools. The rule viewer is a MATLAB based representation of fuzzy inference diagram representation. The rule watcher used as a control, for example, we can see which rules are active or how the shapes of the individual membership function affect the

results. In order to create a model with the help of the FIS editor in the Mamdani structure, the assignment of memberships, the creation of the rule base and the monitoring of the data were done in the relevant modules. Screenshots and explanations of the operations performed are summarized.

**1-FIS Editor:** When creating a model in the Mamdani structure for value determination, first of all, the variables must be defined. Figure 4.2. shows the model in the Mamdani structure created in the FIS editor for value determination.

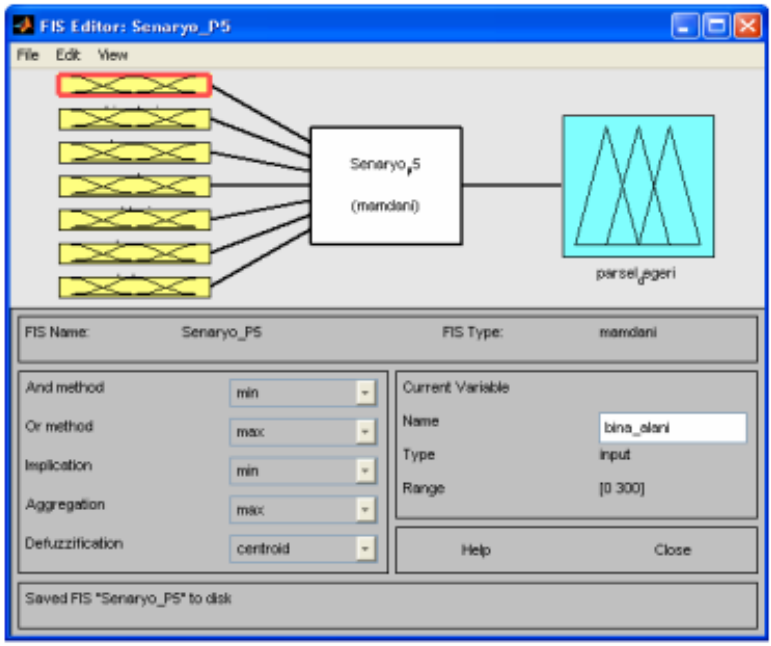


**Figure 4.2.** FIS editor

**2- Membership Function Editor:** The criteria to be used in valuation are blurred by separating each criterion into memberships with the help of the FIS editor. While assigning the criteria to membership, the results of the 1st stage survey study were taken into account. The memberships of the building area criteria were created by using the size concepts in the question Q4 “Determine the following size concepts”. By using the distance concepts

in the question S3 “Determine the following distance concepts”, the memberships of the distances to the health center (official institution), school, shopping centers (commercial areas), transportation centers (distance to main roads), places of worship, parks and green areas were determined. Some of the memberships belonging to the unstructured area (parcel) criteria are given below. In addition to the memberships of the criteria affecting the value, memberships were also determined in the m2 unit price of the parcel value (as an output variable).

for residential area
range=[0 - 300],
The number of memberships = 4 was determined.

The number of these memberships is determined by the classification of the conceptual features for the criteria to be assigned. Membership functions may also change depending on the application. In this application, triangle and trapezoid are used as membership functions. Membership intervals can be made according to expert opinion or, if there is data, according to data distribution. The membership intervals for this study were made by us and supported by the survey study. Function information regarding these memberships is determined as follows.

1. membership='small':'triangle',[0 96 140]
2. membership='normal':'triangle',[96 139 191]
3. membership='large':'triangle',[140 190 250]
4.membership='too big':'trapeze',[191 250 300 500]
For the facade length for the plot
range=[0 - 100]

The number of memberships = 3 was selected, while the membership was created, the function information regarding these memberships was expressed as follows.

1. membership='small':'triangle',[0 0 50]
2. membership='middle':'triangle',[10 50 90]

3. membership='big':'triangle',[50 100 100]

The section where these memberships are assigned in the FIS structure Figure 4.3. It is shown in

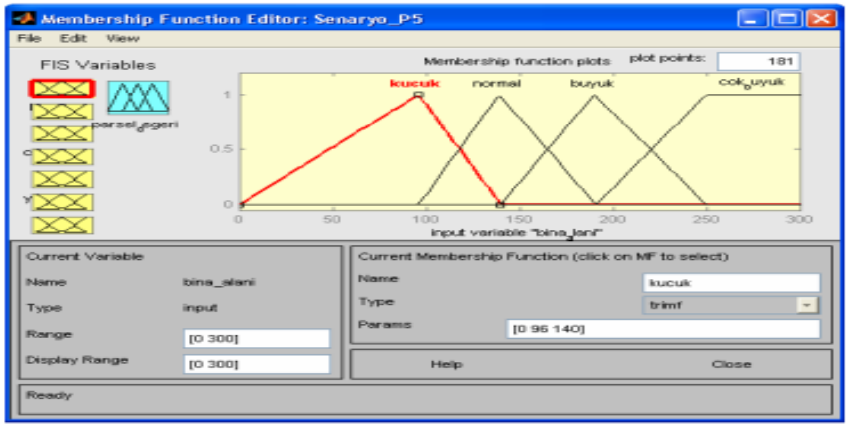


**Figure 4.3.** Memberships created according to the Mamdani method in the FIS structure

**3- Rule Editor:** Rules have been created according to the assigned memberships. These rules were created with expert opinion and supported by the data collected. The expert is the person or persons who know the region, know the market conditions and have knowledge about the criteria. The expert in this study is the person who did the study. According to expert opinion, each data was entered into the structure created one by one and tested. During this test, there was no rule triggering in some data, and in these cases, a new rule was written. Below are the codes of some rules created on the rule base in Mamdani.

1. 1,1,3,2,1,1,1: 1
2. 1,1,1,3,2,2,3: 1
3. 1,1,1,1,1,1,1: 2
4. 2,1,2,3,2,3,1: 2
5. 2,1,2,1,3,2,2: 2
6. 2,1,2,2,1,3,3: 2

7.2,1,3,2,3,2,3: 3
8. 2,1,3,2,1,2,3: 4
9. 2,1,3,3,1,2,3: 4
10. 2,1,3,3,2,2,3: 3

The numbers in the rule codes represent the membership numbers for each criterion. For example; Since the first criterion in the rules is the residential area, the membership expressed as "1" corresponds to the normal membership, expressed as small "2". According to the rule base, the 4th rule can be summarized as follows: "If the building area is "normal" and the facade length is "small", the parcel area is "medium" and the street width is "side street" and the number of floors is "low-rise" …… If …….., the parcel value will be "low"."

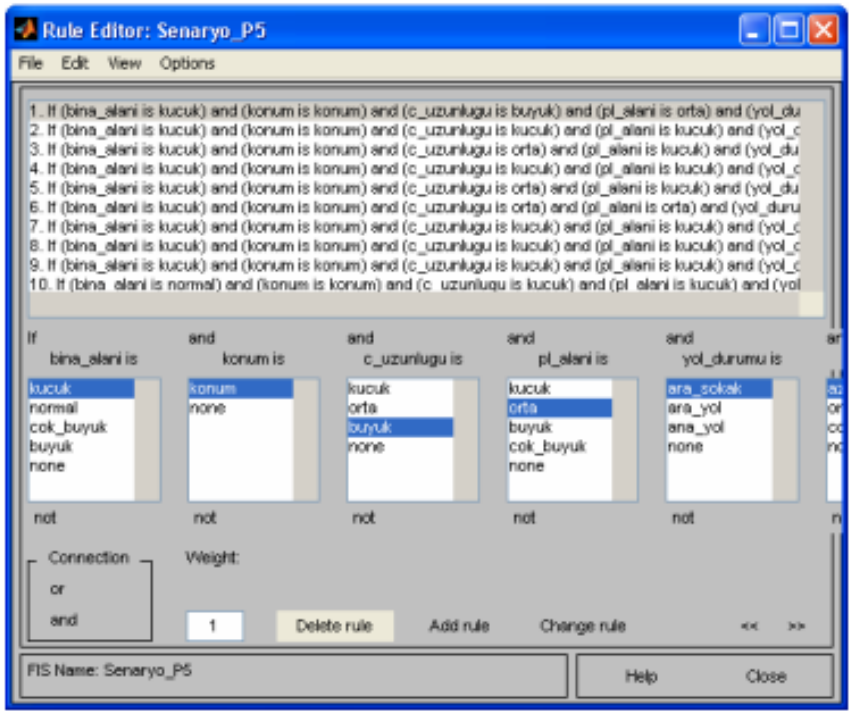


**Figure 4.4.** Rule base created in Mamdani structure

**4-Rule Follower:** It is the section where the memberships are assigned and the rule base is created and tested by entering the data. It is shown in Figure 5.5. that the parcel value is obtained with the data entered according to the rule base created in Figure 4.4. Looking at Figure 4.5., rule 11 triggered the membership of the output function because of the rule written, since there is membership for all values entered in the input section. There can be one or more rules triggered like this.

According to the suitable clarification method, the value is determined as marked in Figure 4.5.

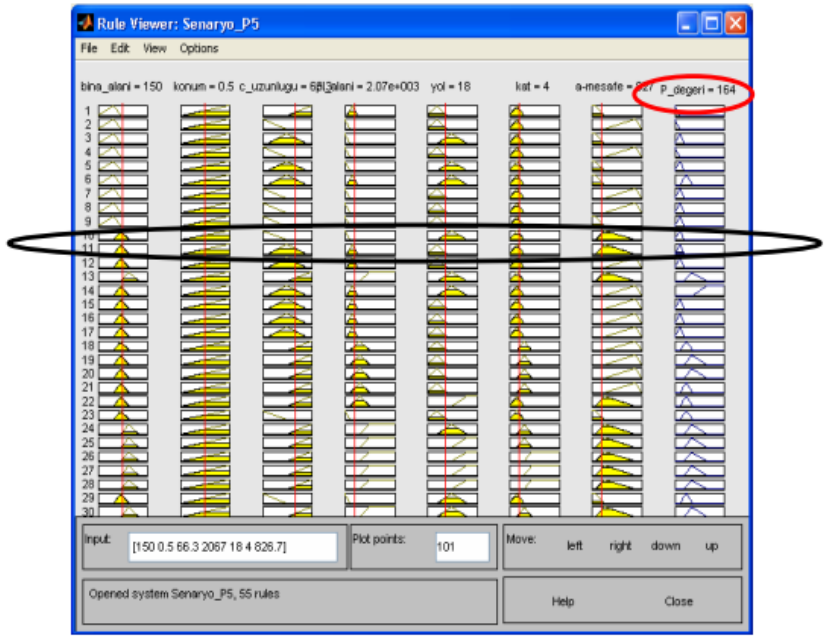


**Figure 4.5.** The part where the values are determined according to the rule base created in the Mamdani structure

Using the model created in the Mamdani structure, the usability of the model was tested with different criteria numbers.

### 4.1.2. Modeling with the Sugeno structure

With the Sugeno method, the most appropriate membership and the number of memberships were determined and a fuzzy structure was created in the unstructured and built area. Due to the fuzzy nature of Sugeno, it is necessary to create a structure with the data. For this reason, as it is understood from the literature studies, the data should be trained with approximately 2/3 and tested with the remaining 1/3 (Brondino and Silva 1999, Lokshina et al. 2003).

In Sugeno, the data is normalized for ease of operation and speed. Normalization method in practice; divided by the largest. In Özkan's (2007) study, normalization methods were tested with the data set and it was stated that the most appropriate method was division by the largest. Figure 5.6 shows the ANFIS editor where the data is trained and tested. Since the Sugeno structure is a structure formed by data, the function is created according to the outputs corresponding to the input data by iterating with the training data. The test data is used for the verification of this structure. Figure 5.7 shows the error of the training data in 10 iterations. It was decided that the number of iterations was sufficient as a result of the trials. The training and test error is obtained by multiplying the absolute values of the difference between the output value found from the structure formed as a result of the iteration and the output values in the data set by 100.

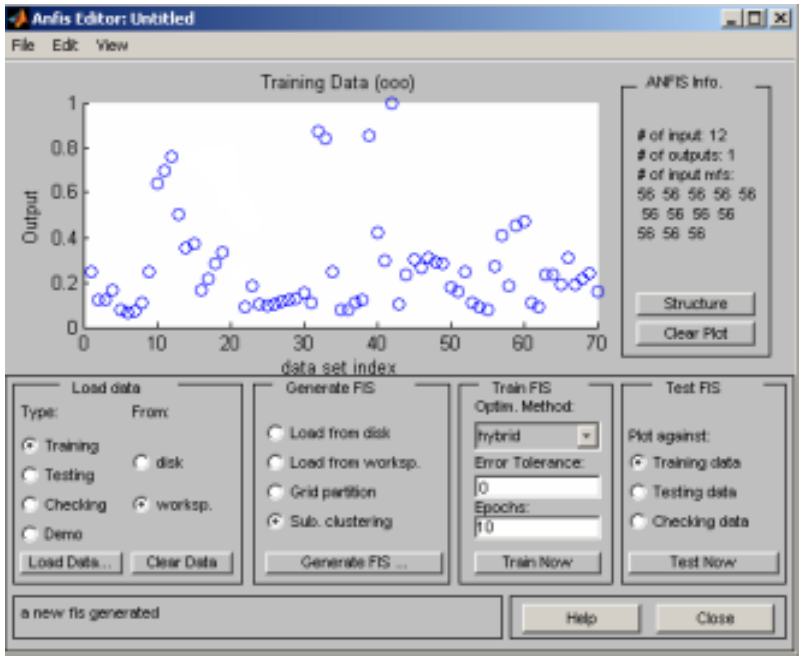


**Figure 4.6.** ANFIS editor

Figure 4.6. Error training and training data in Sugeno structure in ANFIS Editor.

Figure 4.7. shows the part where test data are loaded into ANFIS, while Figure 4.8. shows how closely the test data approaches Sugeno data and the test error graphically. It is possible to see the structure formed according to the Sugeno method in Figure 4.10.

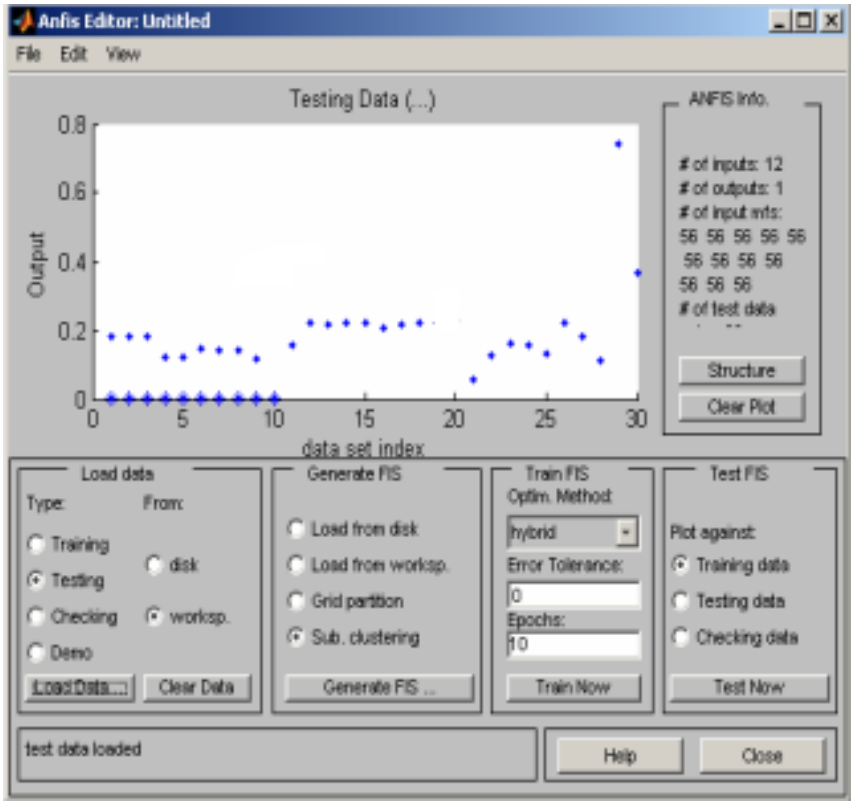


**Figure 4.8**. Distribution of test data in the Sugeno structure

Figure 4.9. Distribution of corresponding values of test data in Sugeno and test error.

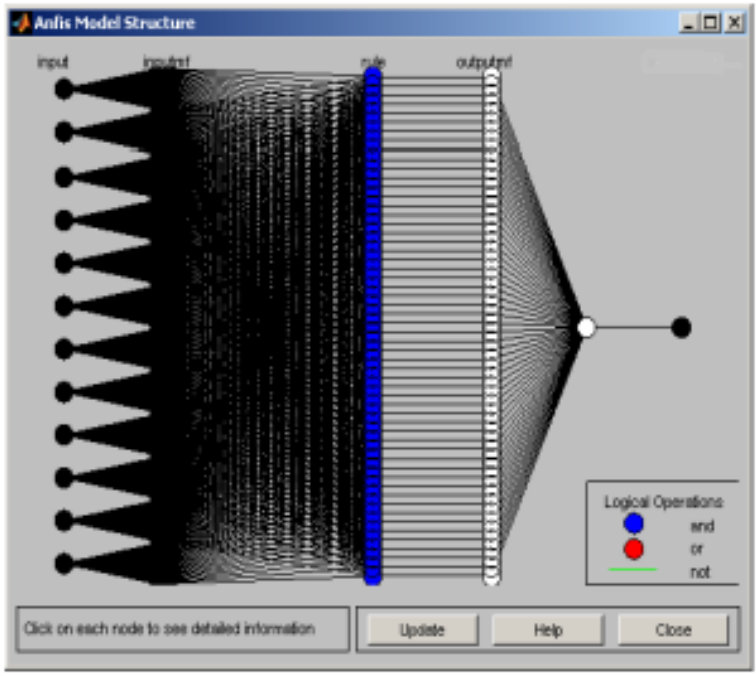


**Figure 4.9.** Structure formed in Sugeno

Training algorithms are applied in the ANFIS editor, which is used when using the Sugeno structure. These can be applied in two ways, the hybrid method and the back propagation algorithm.

## 4.2. Hybrid Learning Algorithm

To activate the parameters in the study;

S = S1 + S2

S1: parameters input

S2: output parameter (4.1)

A θ= B (4.2)

The θ vector in the matrix equation is the unknown vector consisting of the elements of the S2 output parameters.

$\theta^* = (A^T A)^{-1} A^T B$ (4.3)

$\theta_{i+1} = \theta i + {}_{Si+1} + a_{i+1} (b^T_{i+1} - a^T i + i + \theta_i$ (4.4)

$\Delta = \eta \, \partial E / \partial \alpha$ (4.5)

### 4.3. Model for Study Regions with Fuzzy Logic Methodology

Selection In practice, the selected data sets were tested by creating different structures with the criteria determined from the built and unstructured areas. Mamdani and Sugeno structures were created by applying different combinations of criteria in these scenarios. In the scenarios, it has been tried to determine the criteria that most affect the value of the real estate and to determine the appropriate number of criteria in order to create a faster and modular structure. As the number of criteria increases in the determination of the real estate value, the speed of work will increase and it will become more complex, it is aimed to obtain the closest result with the least number of criteria possible. For this reason, models were created with names such as Scenario P1, Scenario P2… in the unstructured area, and Scenario E1, Scenario E2, .. in the built area. The model created in the Mamdani structure and determined by obtaining the correct number of criteria was used in the Sugeno structure.

#### 4.3.1. Unbuilt area Work area

A zoned area in Turkey has been selected. The choice of the region was influenced by the fact that it is a new urbanization area and the active purchase and sale of parcels. With the 2nd stage survey study covering the sale of the plots, the data formed in the market were collected and analyzed and the data set for 100 plots was selected. Sixteen criteria, whose effect on the value was determined according to the survey results of the unstructured area, were used in modeling and calculation. Some of the criteria were obtained from the survey results, others as a result of their combination. These are expressed below:

- Residential area
- The location of the parcel within the island
- Facade length
- parcel area

• The width of the street where the parcel is located
• How many floors is it zoned?
• The distance to the health center (official institution)
• Distance to school
• Distance to shopping centers (commercial areas)
• Distance to transportation centers
• Distance to places of worship
• Distance to parks and green areas
• Weighted distance
• Location score (expression of parcel location)
• TAKS
• Number of flats A value assignment was made in order to make the criteria meaningful before the calculation and to convert them into a format that the computer can understand. Value assignment was made by using survey study and zoning plans. The residential area is the area determined according to the number of flats that will fit within the parcel area by finding the residential area of the building to be placed in the parcel area. The reason for choosing the residential area is to create a common criterion with the built area. The location of the parcel within the island was determined by using expert opinion and literature (Yomralıoğlu, 1997).

It is expressed with a value distribution between 0-1. Value distribution has been evaluated as follows from the corner

1st parcel=1 (corner)
2nd parcel = 0.9 (intermediate parcel with two sides to the road) 2nd parcel = 0.8 (intermediate parcel)
3rd parcel = 0.7
4th parcel= 0.55. parsel= 0.4
6. parsel ve diğerleri= 0.3

The length of the facade was obtained by measuring the frontal lengths of the parcel to the road in meters on the map in the NETCAD program. The parcel area is the area with the right of use in the title deed.

The width of the street where the parcel is located was obtained by measuring the width of the road facing the front of the parcel with the help of the NETCAD program. How many floors are zoned is the maximum number of floors that can be built on the parcel, which is appreciated in the zoning application. The distances to the health center (official institution), school, shopping centers (commercial areas), transportation centers (distance to main roads), places of worship, parks and green areas were taken from road routes in meters with the help of the NETCAD program. According to the results obtained from the 1st stage survey study, the concepts related to distance such as health center (S.M.), school (O.M.), shopping center (A.M.), transportation (U.M.), places of worship (İ.M.), park and green ( P.M.) weighted distance was found by calculating the weighted average from the distances to the areas. The percentages of the very important and important options in the questions E19, E15, E14, E13, E17, E18 in the 1st stage survey study were summed up and the weights were calculated by giving 1 to the largest of these values. These weights are as follows:

Weight of distance to health center (official institution) = 0.97

Weight of distance to school = 0.94

Weight of distance to shopping centers (commercial areas) = 0.87 Weight of distance to transportation centers = 1

Weight of distance to places of worship = 0.89

Weight of distance to parks and green areas = 0.86

The weighted distance (K) calculated using the above weights was obtained with the following formula.

$$K = \frac{\sum_{i=1}^{n} (w_i * \text{distance})}{\sum_{i=1}^{n} w_i}$$

In the formula, w: effect weights of the distance on the value.

TAKS value is a coefficient determined to find the building area to be placed in the parcel after the zoning application. It is also available on zoning plans. It is calculated according to the formula below.

TAKS = Building area/ Parcel area (4.7)

The number of flats is the maximum number of flats in the building to be placed in the parcel. It is obtained by multiplying the number of dwellings formed on the plot floor by the number of floors. In addition, the approximation ratio used in the constructed structures and the standard deviation of these ratios were found with the help of the following formulas.

$$Yak.\% = 100 * \left[ 1 - \frac{|x_a - x_b|}{x_a} \right]$$

$$ss = \sqrt{\frac{\sum_{i=1}^{n} (yak.\%_i - ort.yak.\%)^2}{(n-1)}} \qquad (5.8)$$

xa: market value
xb: the value found from the created structure
n: number of samples
ss: the standard deviation of the approximate values average approx.
%= arithmetic mean of approximations in the data set

### 4.3.2. Creating a model in the unstructured area with the Mamdani structure

In order to create a structure using fuzzy logic in the unstructured area and to test the accuracy of the structure, a model was created with different alternatives. In the unstructured area, a scenario was produced for value determination with the Mamdani structure and tested with 50 data selected from the results of the 2nd stage survey. In the application in the

unstructured area, the first structure was created with the following 12 criteria by making use of the 1st stage survey study. These criteria are the maximum number of criteria that can be used in the evaluation of the undeveloped area.

- Residential area
- The location of the parcel within the island
- Facade length
- parcel area
- The width of the street where the parcel is located
- How many floors is it zoned?
- The distance to the health center (official institution)
- Distance to school
- Distance to shopping centers (commercial areas)
- Distance to transportation centers
- Distance to places of worship
- Distance to parks and green areas

The arithmetic mean and standard deviation of these approximation values were found to mean approximation %= 47.97 ± 60.12%.

It takes a value like R2 = 0.6277. R2 represents the correlation between the value of the real estate obtained from the scenario and its market value. It shows that the relationship between the specified values increases as R2 gets closer to 1.

### 4.3.3. Clarification

It has been investigated whether the clarification methods, which are thought to be appropriate in model formation, have an effect on the model. The following 5 clarification methods were applied.

- Centroid method
- Weighted average method (bisector)
- Average largest membership (mom)

• The largest membership policy (lom)
• Minimum membership principle (som).

In order to obtain real estate price estimation in Turkey by Fuzzy method analysis, financial storage and data scraping techniques were used to obtain the data by using the R library "rvest". The data were obtained from online real estate advertisement portals. The data set consists of 1500 observations and 12 variables. These variables are advertisement number, district, district, creation date, property type, price, building age, total number of floors in the residence, floor number, apartment size (m2), number of rooms, number of bathrooms. The data obtained after cleaning and transforming the data for the entire data set consists of 200 flat advertisements. With these data, 5 univariate Fuzzy Linear Regression (BDR) models were created and estimated. The dependent variable in the BDR model is the "Price" variable. The independent variables are “Number of Bathrooms in the Residence”, “Apartment Size”, “Number of Rooms”, “Floor Number” and “Total Number of Floors in the Residence”. Analyzes were carried out in the RStudio environment using the R programming language. In the study, the "fuzzyreg" package available in the R library was used in the Fuzzy Regression Analysis phase. The "readxl" package was used to transfer the data from the excel file to R, and the "stringr" package was used in the data cleaning/conversion phase.

#### 4.3.3.1. Model formation in the unstructured area with the Sugeno structure

With the help of scenarios created in the Mamdani structure, studies were carried out to develop the most suitable model for unstructured areas. Since the most suitable model has been reached, the Sugeno structure has been formed from the criteria. The Sugeno structure was also studied with 150 data. As mentioned before, since the Sugeno structure was created with data, 2/3 of 150 data sets were used for training (100 data) and 1/3 for testing (50 data). The criteria, consisting of 6 inputs and one output, are as follows:

• Residential area
• The location of the parcel within the island
• Facade length
• The width of the street where the parcel is located
• How many floors is it zoned?
• Position score 21 memberships were created by making use of the Gaussian curve at each entry. In calculating the m2 values of the plots in Sugeno with 6 criteria, the hybrid method was applied to the training data. For this study, both hybrid method and back propagation algorithms have been tried and tested. Since the lowest error rate is achieved with the hybrid algorithm, the Sugeno structure was created according to this method.

#### 4.3.3.2. Models created in the built-up area

In the area where the structuring is intense, similar studies have been carried out in the areas where the structuring is low in the modeling studies for the value determination with the fuzzy logic method. The criteria selected in the model creation studies for the value determination in the built area, on the contrary to the application in the unstructured area, were created based on the scenarios starting from the minimum number of criteria. The data formed in the market with the 2nd stage survey study, which also includes the sales of houses belonging to this study area, were collected and examined and a data set for 60 houses was selected. Ten criteria, whose effect on the value was determined according to the survey results of the built-up area, were used in modeling and calculation. Some of the criteria were obtained from the survey results, others as a result of their combination. The criteria used are described below.

• Residential area
• Age of the building
• How many floors and how many floors
• Interior and exterior accessories of the flat
• Warming up
• Elevator status • Parking situation

- Number of rooms
- Facade of the flat
- Location score according to the district where the flat is located

The residential area is the area within the building that is reserved for families, excluding the common areas. The age of the building is the difference between the license date of the building where the residence is located and the year at the time of valuation. How many floors and how many floors is the total number of floors in the building where the house is located and on which floor it is located, excluding the ground floor of the house. What is meant by the interior and exterior features of the flat is the built-in cabinet, floor coverings, wall coverings, exterior cladding etc. Made for ease of use and comfort inside the house and on the exterior of the building where the house is located. Such features. As a type of heating, the characteristics of the system used for heating in the building where the residence is located, the capacity of the elevator used and the year of construction, the elevator status, the capacity and size of the car park, which is among the preferences of the vehicle owners, and the parking situation are among the criteria. The number of rooms is the total number of rooms placed in the residential area. The façade of the flat is also the orientation of the house according to the situation in the building. These criteria are due to the fact that the interior and exterior accessories of the apartment, the heating type of the building, the elevator situation, the parking situation, the number of rooms and the facade of the apartment are verbal variables.

#### 4.3.3.3. Model formation in the built area with the Mamdani structure

In the structured area, 80 out of 150 datasets of Mamdani structure were selected as test data. While selecting the test data, attention was paid to the regional distribution. According to these test data, the scenarios and their results are as follows. Since the scenario was started to be created based on the idea of least criteria, the following 4 criteria were selected in the built area, taking into account the 1st stage survey study.

• Residential area
• Age of the building
• How many floors and how many floors
• Property score of flat and building

Among these criteria, the feature score of the apartment and the building, the interior and exterior accessories of the apartment, the heating type, the elevator situation, the parking situation, the number of rooms and the arithmetic average of the facade score of the apartment were found.

#### 4.3.3.4. Model formation in the built area with the Sugeno structure

Since the values closest to the trading values were obtained in the Mamdani structure, it was decided that it was the most suitable model and was formed by taking the Sugeno structure. As in the unstructured area, the Sugeno structure was applied by creating different test and training data groups from the data set in order to ensure that the data distribution is correct. As in the unstructured area, 40 data, which is 1/3 of the 120 data, was chosen as the test data. Structures were created using the Sugeno method with a 40-member bell curve from which healthy data were obtained in the Sugeno structure.

### 4.4. Definition of the Model Created and Comparison of the Obtained Results

Model creation studies for the valuation of real estates with the fuzzy logic method can be seen in Figures 5.11 and 5.12. In Figure 5.11, the necessary steps for data collection (survey) are given in detail, while in Figure 5.12, the workflow in creating a model with the fuzzy logic method is given in full detail. The algorithm of the application made with the fuzzy logic method was created as follows. The algorithm has been prepared in an explanatory manner and according to the order of work done.

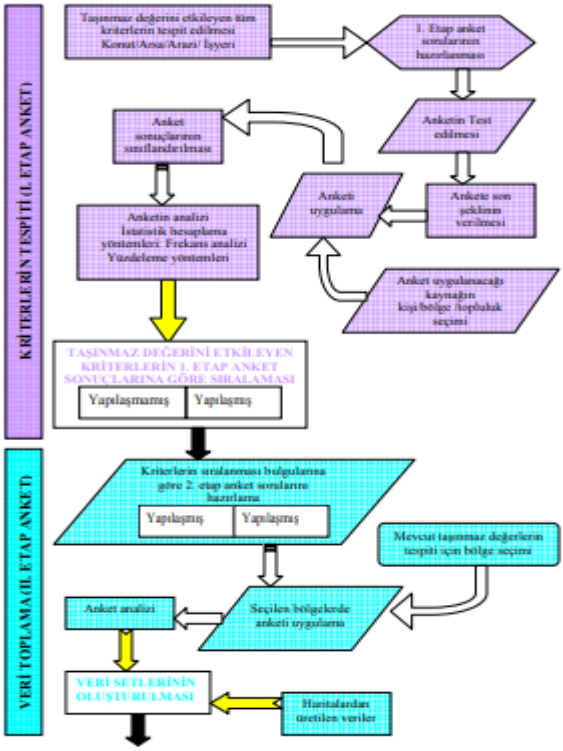


**Figure 4.11.** Work flow chart for survey work

Step 1: Determination of the criteria affecting the value of the immovable (First stage survey study);

1 a. Step: determination of all criteria affecting the value of the property; All of the criteria affecting the real estate value were tried to be examined and the criteria were determined.

1-a-I. Step: Preparation of survey questions; 1 a. A question was prepared for the criteria that were deemed appropriate to be included in the questionnaire.

1-a-II. Step 2: Testing the survey questions; 1-a-I. Before the distribution of the questions prepared in step 1 was made, it was made to eliminate any inaccuracies or deficiencies.

1-a-III. Step: Giving the final form of the questionnaire; The errors and deficiencies in 1-a-II were corrected and the questionnaire was given its final form.

1-b. Step 2: Selection of the source to which the survey will be applied; The area to be surveyed and the person (with a certain education level) were selected.

1-c. Step: Implementation of the questionnaire; 1-a-III. and 1-b. After the steps, a questionnaire was applied in Konya region with the help of interviewers.

1-d. Step: Classification of survey results; After step 1-c., 1010 people were reached and the questionnaire was classified according to question types and answer types.

1-e. Step: Making the first stage survey analysis; 1-d. The analyzes of the survey study were made statistically according to the classification in step. Frequency analysis and percentage methods were used in the application.

1-f. Step: Ranking of the criteria affecting the value of the immovable; 1-e. According to the results of the step, the criteria in the unbuilt and built immovables were sorted according to their importance.

Step 2: Data collection (Phase II survey):

2 a. Step: Application selection; It was determined that it was unstructured in Turkey and was built in two separate areas.

2-b. Step: Preparation of survey questions; 1-f. According to the results of the step, two different questionnaires were prepared by determining the criteria affecting the values of the immovables in the unbuilt and built area.

2-c. Step 2: Implementing the survey in the selected regions; 2 a. in the regions selected in step 2-b. A questionnaire was applied with the questions prepared in the step.

2-d. Step: Questionnaire analysis: The data collected as a result of the application in step 2-c. were analyzed for both regions.

2-e. Step 2: Creation of datasets; 2-d. After the step, 100 data sets from the unstructured area and 120 datasets from the built area were created as a result of the analysis.

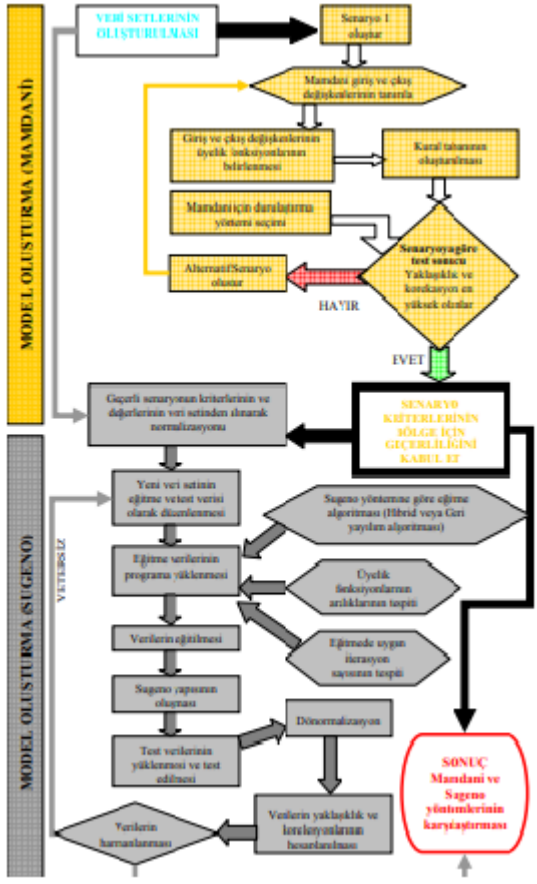


**Figure 4.12.** Work flow chart of the fuzzy logic method

Step 1: Creating a model according to Mamdani;

3 a. Step 1: Create scenario 1; 2-e. Scenario 1 was created with the criteria deemed appropriate for value determination according to step .

3-a-I. Step 1: Define the input and output variables for Mamdani; According to scenario 1 accepted in 3-a., the input and output variables of the real estate were determined for model building studies.

3-a-II. Step: Membership detection of input and output variables; 3-a-I. Triangular membership functions were created for the variables in the step.

3-a-III. Step 1: Create a rule base; 3-a-II. Rules were created according to the memberships in the step.

3-b. Step: Defuzzification; Centroid method, one of the defuzzification methods, was used to determine the output variable. In addition, other clarification methods were applied and their comparisons were made.

3-c Step: Test result according to the scenario; The approximation and correlations were calculated by testing the data according to 3-b and 3-a-III. 3-c-I. Step 2: No; If the rates in 3-c. were not accepted, the process steps were repeated by going to 3-a-I.

3-c-II. Step 2: Yes; If the approximation and correlation of the scenario in 3-c. is acceptable, the process is completed.

3-d. Step 2: Acceptance of the scenario criteria for the region; 3-c-II. The criteria of the scenario accepted in the step are considered valid.

Step 4: Creating a model according to Sugeno;

4-a. Step: Normalization; 3-d. scenario criteria in step, 2-e. It was taken from the data sets in the first step and normalized according to the method found suitable from the normalization methods.

4-b. Step 2: Editing the dataset as training and test data; 2/3 of the datasets in the unstructured area and the built area were used in training and 1/3 in the test.

4-h. Step 2: Uploading and testing test data;

4-g. the structure formed in step 4-b. The test data in step 1 was loaded and tested.

4-i. Step: Denormalization; 4-h. The results in step need to be converted to real values. For this reason, the data obtained from the Sugeno structure were denormalized.

4-i. Step: Calculating the approximation and correlations of the data; 4-i. with the results from step 2-e. The approximations and correlations between the values in the data sets in step 1 were calculated.

4-h. Step 2: Collation of data; 2-e. In order to ensure homogeneous distribution in the data set in step 1, training and test data were applied by changing.

4-h-I. Step: insufficient; when blending is found insufficient 4-b. The steps were repeated and the steps were repeated.

4-h-II. step: enough; ; When the blending was found sufficient, it was passed to the conclusion part.

Step 5: Conclusion; 3-c. and 4-h. The approximation ratios and R2's obtained according to the Mamdani and Sugeno methods created in the steps were examined and interpreted, and the appropriate model was determined.

## 5. CONCLUSION

In the application made with the fuzzy logic method, scenarios with different criteria were produced in unstructured and built areas by using Mamdani and Sugeno systems. According to the scenario results produced, the most suitable model for the selected regions was formed in Mamdani fuzzy structures with the following criteria.

Unbuilt Area

- Residential area
- The location of the parcel within the island
- Facade length
- Street width
- Number of floors
- Location score

Built Area

- Residential area
- Age of the building
- How many floors and how many floors
- Property score of flat and building
- Location score

Real estate area and location scoring are common criteria for the models created as a result of the work done in the unstructured and built area. The values used in these criteria, including the membership functions, ranges and membership numbers, are exactly the same. The models created in the Mamdani structure with the above criteria were also tested according to the Sugeno structure in order to investigate the reliability of the model. The average approximation ratios obtained from the Mamdani and Sugeno structures for these areas and the standard deviation of these ratios are shown below.

Unbuilt Area

Mamdani %82.7±2*10.9
Sugeno %84.6±2*14.2
Built Area
Mamdani %86.6±2*9.5
Sugeno %84.7±2*11.8

Assuming that the real estate values formed in the market are the closest values to the truth, they are compared with the values found according to Mamdani and Sugeno. The approximation ratios are the values that were found by calculating how accurate the value calculated using the model would be if the value in the market was 100% and averaged. Standard deviations, on the other hand, were calculated as a result of evaluating this percentage, which is expressed as the mean approximation value, together with other approximation rates in the data set. In their study, Açlar and Çağdaş (2002) accept 15% as the amount of deviation from the mean value in valuation. In this case, for values with mean approximation and standard deviations, 15% deviation limits from the mean are found and summarized below.

Unbuilt Area

Mamdani 11.1%< 12.44%
Sugeno 13.1%>12.7%

Built Area

Mamdani 9.5% < 13.%
Sugeno 11.8% < 12.7%

The first of these values represents the standard deviation of the data set, and the second represents the acceptable standard deviation limit. The acceptable deviation limit is 15% of the mean approximation. According to the above values, the standard deviation limit determined according to the Sugeno method applied in the unstructured area was larger than the acceptable standard deviation. For this reason, it is understood that screening

should be done from the data set in the unstructured area. Other rates were accepted because they were below the limit. In other words, as a result of this study, Sugeno is not recommended as a suitable modeling technique for the unstructured area in the real estate valuation made with Konya region data. In order to investigate the reliability of the model, the confidence intervals of Mamdani in the unstructured area, and both

Mamdani and Sugeno structures in the built area were calculated according to the formula below.

$$a = \frac{c * s}{\sqrt{n}}$$

c: a coefficient
s: standard deviation
n: number of data

Accuracy range = Avg. approx. ±c(5.2)

The coefficient c is determined based on the (n-1) degrees of freedom and the confidence coefficients γ. Since the deviation values are generally large in real estate valuation, it is correct to choose the confidence interval of γ 95% (Açlar and Çağdaş 2002).

According to this:

According to Mamdani in the undeveloped area:

Accuracy range= 82.60% ± 2.18% : 80.42% - 84.78% 9 According to Mamdani in built up area:

Accuracy range= 86.66%±1.73% : 84.93% - 88.39% 9 According to Sugeno in the built up area:

Accuracy range= 84.74%±1.13: It is seen that the accuracy of the work performed in the range of 83.61% – 85.87% can be achieved.

When the above results are examined, the accuracy of the approximation ratios according to the Mamdani fuzzy structure in the unstructured area has been obtained in the range of 80.42% - 84.78%. For the structured area, it can be stated that it would be appropriate to create a model in the Mamdani fuzzy structure, since both the average approximation and the range are better compared to the Sugeno fuzzy structure.

The accuracy of the Mamdani fuzzy structure for the built area was found to be 84.93% - 88.39%. In addition, in order to support the accuracy of the study, a linear correlation is expected between the Mamdani and Sugeno values, which can be calculated with the help of the created model, and the market values. R2's expressing this correlation and the correlation between the data were calculated and presented below.

Unbuilt Area

Mamdani R2 = 0.89 y= 0,85*x
Sugeno R2 = 0.76 y= 0,93*x

Built Area

Mamdani R2 = 0.81 y= 0.99*x
Sugeno R2 = 0.62 y= 0.98*x

As R2, which expresses the correlation, gets closer to 1, it is understood that the correlation, in other words, the real estate values obtained from the model and the market values approach each other. From the line equation that expresses the accuracy of the model created, as the slope, that is, the coefficient of x, approaches 1, it is understood that the value calculated from the model and the measured value are equal, and the reliability of the model increases. According to these results obtained, Mamdani output values in the unstructured area and relationship between market values was found to be as high as 0.91. Sugeno's correlation coefficient is undeniably low compared to Mamdani. Looking at the line equations expressing the model, the slope closest to 1 was obtained in the

Sugeno structure. In other words, while better results are obtained in Mamdani than correlation in unstructured area, it is observed that Sugeno is better according to the linear equation of the model. The correlation coefficient R2 obtained in the structured area is quite different for Mamdani and Sugeno fuzzy structures. The line slope obtained for the Mamdani fuzzy structure is closest to 1. According to these results in the structured area, it is seen that the Mamdani fuzzy structure is suitable for use in valuation. It has been concluded that the approximation rates in both application regions and in the structures created according to both systems are at acceptable rates, since the concept of value is a subjective approach. The value obtained in the Sugeno fuzzy structure in the unstructured area was higher than that of Mamdani. However, the usability of this method is only possible when the appropriate number of healthy data is available. Due to the structure of Sugeno, it is necessary to create a data set and separate the data as training and testing according to this data set.

The Sugeno structure creates a model with training data and examines the model with test data. Memberships formed in the Sugeno structure do not require much expert knowledge. Therefore, this accuracy obtained with the data set cannot always be expressed as the accuracy that can be reached. Sugeno fuzzy structure, the people who make it; training and test data selection will also vary according to membership intervals, iteration or algorithm preferences. Even for the same user, the Sugeno structure and results in the same application at different times may be different. There is no study in our country that uses fuzzy logic methodology for the determination of real estate values. There are not many examples of application of this method in the literature in determining the real estate value. Sarpoulaki et al. (2002) used the Mamdani structure in their study for habitable real estate, and obtained the values related to some criteria from scaled maps, as was done in this study.

In the Mamdani type fuzzy structure, the position (location), cost, dimensions and other features of the house are defined as the input variable, and the user definition for the suitable house is defined as the output

variable. Sarpoulaki et al. (2002) there are differences between the criteria used in this thesis and the criteria used in this thesis. The reason for this is that, as mentioned before, the selection of criteria depending on regional characteristics varies. The selection of criteria may differ from country to country and even from city to city. In the study of Bonisssone and Cheetham (1997), method comparisons were made and the mean errors of the methods used were expressed as follows.

As can be seen from the results of Bonisssone and Cheetham (1997), the lowest error rate in the application made according to different criteria and different methods is in the application made by selecting 11 to 30 criteria in the Mamdani structure. There is no detailed information about the criteria used in the study. In this present study, besides the usability of the fuzzy logic methodology, the feasibility of choosing the ideal combinations of criteria with the help of alternative scenarios has been tried to be revealed. For urban spaces, it can be said that the Mamdani fuzzy structure gives the most appropriate result in modeling in unstructured and built up areas. With this study, a modular structure suitable for country conditions was created (Figure 5.11-5.12), and acceptable accuracies were achieved with fewer criteria. The created working model is applicable to every region as a general real estate valuation method. The most important factor that has changed is that regional data can be collected and evaluated as suggested in the model.

The criteria affecting real estate value may vary depending on local factors and preferences. There will be different value ranges in each region. The model can be run for different regions by using the common criteria in the model created in this study and by adapting the value ranges according to the region. In addition, the scenarios created in the study can be used for different areas depending on the desired sensitivity.

High-capacity computer hardware is required for the urban-based applications of the created model. Keeping the rule base wide depends on the capacity of the computer hardware; It is possible to work in a wider area on an urban basis and to obtain results as close to the truth as possible, with the

width of the rule base. Real estate valuation is of great importance for national economies. Values are determined correctly and tax, expropriation, mortgage and so on. The fact that it is the subject of applications makes it necessary to create a suitable model for value determination. Today, information systems that are used in every field can be used for Real Estate Information System. The production of immovable value maps, which will form a basis for applications that require real estate valuation, will be provided with a healthy database and appropriate model. It has been demonstrated by this study that it is a method that can be used in the determination of immovable value with the fuzzy logic method.

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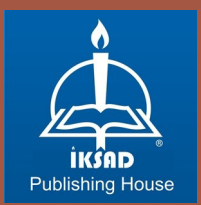


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