# Mass Valuation Techniques Used in Land Regıstry and Cadastre Modernızatıon Project of Republıc of TURKEY

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**Key words:** mass valuation, mass valuation techniques, multivariate regression analysis, artificial neural networks, decision trees, taxation

## SUMMARY

This is a summary on the paper on mass valuation techniques used in Property Valuation component of Land Registry and Cadastre Modernization Project conducted by General directorate of Land Registry and Cadastre (TKGM) with the support of International Bank for Reconstruction and Development in Turkey. One of the objects of the property valuation component is to carry out a "mass property valuation" pilot implementation in two municipalities with taxation purpose.

Mass valuation is as "Mass appraisal is the process of valuing a group of properties as of a given date and using common data, standardized methods, and statistical testing" by the International Association of Assessing Officers (IAAO). In this study it is explained that three different methods are used for mass valuation in chosen two pilot areas, Fatih/Istanbul and Mamak/Ankara. These methods are Multiple Regression Analysis, Artificial Neural Networks and Decision Trees.

In this study, following activities can be found:

- Mass valuation process (data management, data analyses, model building and ratio analyses)
- Mass valuation techniques (Multiple Regression Analysis, Artificial Neural Networks and Decision Trees) ,
- Results of the mass valuation models that built by these three methods for Fatih and Mamak,
- Comparisons of the results of these techniques.

# MASS VALUATION TECHNIQUES USED IN LAND REGISTRY AND CADASTRE MODERNIZATION PROJECT OF REPUBLIC OF TURKEY

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## 1. INTRODUCTION

Mass Valuation is defined by the International Association of Assessing Officers (IAAO) located in the USA as "Mass appraisal is the process of valuing a group of properties as of a given date and using common data, standardized methods, and statistical testing" (Standard on Mass Appraisal of Real Property 2013). In case many similar type of properties must be valued for the same purpose at the same date, such as taxation, mass valuation provides a statistical model approach to estimate the value of the properties taken into consideration in a confidence interval (Almy and Gloudemans 2011).

However Multiple Regression Analysis (MRA) is the most common method used for mass valuation activities in the whole world, in order to increase success of the mass valuation results especially academic studies have been made to apply alternative methods, such as decision trees, artificial neural networks (ANN), support vector machines, fuzzy logic approaches etc.

Mass valuation is commonly used with the purpose of property taxation in many countries such as USA, Netherlands, Finland etc. In Turkey the very first official implementation of mass valuation was conducted by General Directorate of Land Registry and Cadastre (TKGM) with the support of International Bank for Reconstruction and Development (IBRD). A loan agreement was signed between TKGM and IBRD for financing the Land Registry and Cadastre Modernization Project (TKMP) on June 9, 2008 (www.worldbank.org).

Two pilot studies for mass valuation of residential properties for the taxation purpose were conducted in Mamak/Ankara and Fatih/Istanbul districts within the scope of the "Property Valuation", one of the components of TKMP. Three different methods, multiple regression analysis, artificial neural networks and decision trees, were used in this study to make comparisons of these three approaches in terms of their applicability and success.

According to the results, it is understood that however ANN gives more successful results than the other methods, ANN is not preferred because this method is required high level expertise and causes difficulties to explain its results. Therefore, it is concluded that MRA is more preferable as it is easier and more understandable than the other methods.

## 2. DATA MANAGEMENT

Reliable data and specifying the variables are the preconditions of a statistical analyze. Therefore data accuracy and quality should be ensured as much as possible and variables that

explain the "value" adequately should be specified to build a successful model for mass valuation.

## 2.1 Variables

Characteristics, attributes, features or situations which can get different values according to each observation are called as variable. Variables may be qualitative or quantitative. Qualitative variables take on values that are names or labels to describe a quality or characteristic of a data unit while quantitative variables are numeric. When conducting research, like model building activities, variables are basically divided into two groups. In general terms, if a variable is explained via the other(s) (in other words; depending on the other(s)), the explained variable is defined as "dependent variable" and the other explanatory variable(s) associated to this variable is defined as "independent variable" (Akdeniz 2011).

Within the scope of the mass valuation, dependent variable is value/price information of the properties and independent variables are the factors positively or negatively affecting the value of the properties, for instance number of rooms, distance to the city centre, etc.

Preliminary field studies and a wide literature review performed and 80 features were determined for each property. Almost half of them are not used in the analysis because of various reasons, such as some of them were descriptive statistics (like parcel number, block number etc.) or used only for evaluation of taxation policy (like development plans) or not have a significant effect on the property value (for example parking area is not common in Fatih, it was not used in modelling since it is impossible to understand the effect of it with only few data).

The other half of 80 features were used as the in the independent variables for modelling activities. Those variables were categorized at 5 groups as follows

1. Parcel details: Parcel type, location of the parcel, development of the region, street width, parking area and capacity etc.
2. Parcel zoning details: Construction surface area, ownership type etc.
3. Distances: Distance to metro station, hospital, university, historical places etc.
4. Building details: Number of floors, architectural project details, residential usage licence, age of the building, elevator, strengthening etc.
5. Individual unit details: Number of rooms, balcony, heating system, surface area (indoor and outdoor), floor number etc.

Independent variables are shown in Chart 1.

| | | | |
|---|---|---|---|
| 1 | Neighbourhood | 25 | Gross Outdoor Area of the Single Space |
| 2 | Street/Road | 26 | Gross Area of the Storeroom/Coal Cellar |
| 3 | Development Status | 27 | Number of Baths |
| 4 | Location of Parcel | 28 | Does it have a Balcony? |
| 5 | Slope | 29 | Is the Living Room Independent? |
| 6 | Street Width | 30 | Area Per Share |
| 7 | Earthquake | 31 | Distance to City Centre |
| 8 | Occupancy Permit | 32 | Distance to an Elementary School |
| 9 | Does it have Road Frontage? | 33 | Distance to a High School |
| 10 | Building Age | 34 | Distance to a University |
| 11 | Physical Status of Building | 35 | Distance to a Grocery |
| 12 | Exterior Material | 36 | Distance to a Bazaar |
| 13 | Does it have an Elevator? | 37 | Distance to a Shopping Centre |
| 14 | Parking Space | 38 | Distance to a Mosque |
| 15 | Is it in a Building Complex? | 39 | Distance to a Hospital |
| 16 | Facility Management | 40 | Distance to Cultural Areas |
| 17 | Number of Floors | 41 | Distance to Sea |
| 18 | Heating System | 42 | Distance to Recreational Areas |
| 19 | On Which Floor | 43 | Distance to a Main Road |
| 20 | Location of Single Space | 44 | Distance to a Bus Stop |
| 21 | Direction of Single Space | 45 | Distance to a Metro Station |
| 22 | Number of Single Space Directions | 46 | Distance to a Metrobus Station |
| 23 | Number of Rooms | 47 | Distance to a Tramway Station |
| 24 | Gross Indoor Area | 48 | Distance to a Marmaray Station |

**Chart 1:** Independent Variables

## 2.2 Data Quality

Data quality is one of the most crucial items of mass valuation. Data regarding all variables must be available without any missing values and should be as accurate as possible and reliable. There is no doubt higher quality data is the main requirement of any statistical analysis or model building works.

In this study, one of the biggest challenges was to collect the data for each variable from several different sources. Independent variables were obtained mainly from TAKBIS (Land Registry and Cadastre Information System), relevant municipalities, Land Registry Offices and field.

1. Even though TAKBIS is a well-designed system holding official registers of every single property in the whole country, data definitions and formats are not standardized. For instance, in some cases floor numbers of the individual units are not entered as numerical values and it causes different types of data entries and spelling errors.
2. TAKBIS is not a reliable system in terms of price data as well. In Turkey, property transactions are carried out by Land Registry Offices. Although it is compulsory according to the Charges Law no 492 that the seller and buyer must declare the real price information during the transaction, buyers/sellers generally prefer to declare the "current value" as the transaction value because of the fee amount calculated as 4% of sales price. The current values, always too lower than the market price, are calculated unscientific methods and announced by the municipalities for the purpose of property taxation. In sum, TAKBIS registers are ineligible since they include the current values as price data but sales price.
3. It was necessary to make a plenty of studies at the municipality archives especially for parcel zoning details. Although both municipalities have their own urban information systems, they were insufficient since they do not contain all information required for mass valuation.
4. The third major challenge is the fact that TAKBIS and IT systems of the municipalities have different data formats.

Thus, data mining studies had to be required to ensure the data quality. A small database was designed and all gathered data was digitized and data quality control studies were completed in three phases.

1. Comparing the digitized data and data collection forms or original documents (original documents are the official registers at relevant institutions),
2. Reviewing spelling errors and data formats,
3. Logical controls via various queries.

In order to be performed the statistical analyses and modelling studies, it is necessary that the variables are composed of the numerical values. For this reason, the text type-variables were converted into numerical values by coding. For example, the coding may be as follows for the building status variable; 1 is for "poor, 2 is for "mid-level" and 3 is for "good".

Dependent variable as mentioned above is the value or price information of the properties. However accurate and reliable official registers are preferred to achieve a successful mass valuation, as a matter of fact that in the world mass valuation implementations rely on sales, independent valuations, valuation reports for mortgage purposes, data of advertisements of real estate agencies, etc. as the indicators of value (IOV) because of the missing or unreliable data. As TAKBIS records could not be used as IOV, this was one of the other biggest challenges to be handled. Thus it was decided to prefer using values obtained from single valuation reports, unofficial small questionnaires made by TKGM staff with sellers/buyers at the Land Registry Offices, advertisements and real estate agencies.

## 3. DATA ANALYSES

Data analyses can be defined as a part of data mining activities. After data quality control, the next step is to try to understand the data in an integrative way through finding similarities, exceptional situations, unusual points and making data transformations, relevant tests and analyses.

Descriptive statistics (min-max values, means, medians, modes etc.) and frequencies for each variable were calculated for Fatih and Mamak data. Scatter plots, histograms and box plots are also drawn via the package programme for each variable. These efforts make us understand and "know" the data very well, see the unusual points and make logical deductions in terms of property market in both areas.

Data analyses also include Correlation Analysis that is especially very important for multiple regression analysis. In this study Pearson's Correlation that is denoted by "r" is used. Pearson's correlation is defined as a measure of the direction and strength of association between two variables. Pearson's correlation draw a line of best fit through the data of two variables and with the value of r coefficient it is understood how far away all these observations are to this line. Pearson's correlation coefficient can be in the interval of [-1, 1] which means that

- if r is close to 1, there is a very strength and positive association between those two variables,
- if r is close to -1, there is a very strength and negative association between those two variables,
- if r is close to 0, there is not a considerable association between those two variables (Gujarati and Porter 2008).

Correlation analysis should be performed before the model building since highly correlated variables can cause especially multicollinearity problems in multiple regression analysis. In this study, if r is greater than 0.7, it is concluded there is a high correlation between those two variables. In Fatih and Mamak especially distance variables are highly correlated with each other. For example in Fatih, Pearson' Correlation coefficient is greater than 0,7 between "distance to the city center" variable and most of the other distance variables like distance to metro station, bus station etc.

### 3.1 Unusual Points

There is a very big data obtained from different sources in different formats. It is necessary to find out unusual points before the modelling activities since they can cause problems. Extreme values, outliers, leverage and influential points are different terms used to represent unusual points in the data set. They reflect different impacts on models and analyses and results can be manipulated. There are several methods or statistical tests to detect these unusual points (such as Cook's Distance, Mahalanobis' Distance, standard deviation, confidence intervals etc.) (Akdeniz 2011). In this study several types of methods were used to detect those points and all the tests were made at 95% confidence level ($3\sigma$ was taken as the distribution level.).

Before these analyses there had been 2.702 data for Fatih and 2.722 data for Mamak. After eliminating problem data, new data sizes were 2.447 and 2.372 for Fatih and Mamak respectively.

### 3.2 Training and Testing Data

Data set should be divided into two groups by selecting the properties randomly in the data set in order to make model building activities. First group is called "training data" which includes approximately 80% of the whole data and the second group called "testing data" which includes the other rest (20%). Models are built by using training data and then the values of the properties (dependent variable) in the testing data are calculated by using this model. These calculated values and the real life prices are compared to measure the success of the model.

In this study, numbers of training and testing data are 1.934 and 513 respectively for Fatih, and 1.885 and 487 for Mamak.

## 4. MODEL BUILDING AND RATIO ANALYSIS

Mass Valuation is the process of valuing a group of properties as of a given date and using common data, standardized methods, and statistical testing. Although there are various methods for this purpose, Multiple Regression Analysis is the most commonly used for mass valuation in the world (Yıldız 2014). When relevant literature is reviewed, it's seen that other modern techniques are started to apply in some countries and in academic research studies as well as multiple regression analysis; for example artificial neural network is used in mass valuation activities in Spain (Arijón 2012).

It was determined that the techniques based on especially artificial intelligence applications delivered more successful results than the Multiple Regression Analysis. However all techniques certainly have their own advantages and disadvantages, using different methods on

the same data makes the results comparable and more successful. This makes deciding what method might be more convenient for that mass valuation study as well.

In this study, three different methods were used for mass property valuation:

1. Multiple Regression Analysis
2. Artificial Neural Networks
3. Decision Trees

### 4.1 Multiple Regression Analysis

Multiple regression analysis (MRA) is used when it is wanted to predict the value of an independent variable based on the value of two or more dependent variables. MRA is used to estimate the property value based on property attributes. Also MRA can determine overall fit of the model and the relative contribution of each independent variable to the total variance explained. For instance, how much of the variation in property value can be explained by 10 attributes (independent variables) as a whole and also relative contribution of each attribute in explaining the variance (Yıldız 2014).

Since MRA is the most common method that is used in mass valuation implementations, it is explained more extensively compared to other methods in this paper.

One of the disadvantages of MRA is that data must meet assumptions listed below in order to get valid results:

1. Dependent variable should be continuous (interval or ratio),
2. There should be two or more independent variables (continuous or categorical),
3. Independence of observations should be ensured,
4. Linear relationship between the dependent variable and each of independent variables,
5. Linear relationship between the dependent variable and independent variables collectively,
6. Data should show homoscedasticity,
7. Data shouldn't show multicollinearity,
8. There should be no unusual points such as significant outliers, high leverage points or highly influential points,
9. Residuals (errors) should be approximately normally distributed (Hoffman 2010).

If MRA is chosen as the modelling method, firstly hypothesis testing should be done whether data meets these assumptions. Unless any problems with these assumptions are solved, it is impossible to build a MRA model significantly. However statistical package programs can make almost all statistical analysis easily and fast, to carry out a successful mass valuation study, senior statisticians and experienced experts are definitely required because of the complexity of these operations.

In order to check these assumptions there are different approaches or statistical tests; for instance to check linear relationships, scatter plots or partial regression plots can be used or for independence of observations Durbin-Watson statistic can be used (Öztürk 2011).

It will be beneficial to explain multicollinearity since it is one of the biggest obstacles in these assumptions. Multicollinearity occurs when two or more independent variables are highly correlated with each other. Especially for mass property valuation implementations, there are a lot of independent variables and multicollinearity problem happens frequently. Various approaches are applied to overcome this problem, such as correlation analysis, data transformations, dimension reduction, etc. (Hoffman 2010). It is obvious that these assumptions make much more important the data analyses mentioned in Section 3.

In this study, a widely used statistical package program was used to make model building activities and outputs of MRA will be explained in Fatih briefly in the following paragraphs.

Adjusted coefficient of determination (Adj $R^2$) value is the proportion of variance in the dependent variable. For Fatih data Adj $R^2$ is 0.701 and it means dependent variable can be explained by the independent variables which are included in the model at the rate of 70.1%. This proportion indicates a good level of prediction statistically.

To understand the statistical significancy of the model, p-value (or F-ratio) in the ANOVA is used. ANOVA table shows whether the overall regression model is good fit for the data. In Fatih, ANOVA table showed that the independent variables significantly could predict the dependent variable (property value) (p-value is $0.001 < 0.05$).

| | Dependent Variables | Coefficients | | Dependent Variables | Coefficients |
|---|---|---|---|---|---|
| | (Constant) | 63.593,85 | **10** | Does it have mainroad Frontage? | 9.031,56 |
| **1** | Indoor Surface Area | 1.740,40 | **11** | Outdoor Surface Area | 290,89 |
| **2** | Floor Number of the Individual Unit | 5.982,67 | **12** | Location of Parcel | 6.920,88 |
| **3** | Distance to Metro Station | -8,65 | **13** | Storage Surface Area | -1.385,26 |
| **4** | Distance to University | -16,25 | **14** | Balcony | 6.123,64 |
| **5** | Elevator | 25.187,25 | **15** | Distance to Supermarket | -9,45 |
| **6** | Age of Building | -571,25 | **16** | Distance to Metrobus Station | -4,73 |
| **7** | Street Width | 777,37 | **17** | Development Status | 4.349,91 |
| **8** | Area of Share | 511,58 | **18** | Distance to Mainroad | 25,81 |
| **9** | Distance to Recreation Places | 8,99 | **19** | Distance to Bus Station | -10,83 |

**Chart 2:** Coefficients of Dependent Variables

MRA gives the estimated model coefficients, thus it can be understood which attribute of a property have how much effect on property value. Statistical significancy of each of the independent variables is tested as well. The general form of the equation to predict the

property value is obtained via these coefficients. For Fatih data, the coefficients of the statistically significant variables are seen on Chart 2.

There were almost 40 variables at the beginning of the analysis and as it is seen in Chart 2 only 19 of them are included to the model. MRA is a statistical model building method which takes all the variables into consideration while building the model by making lots of tests and analysis. It takes statistically significant variables to the model and omits the other ones which are insignificant in explaining the dependent variable. In this study MRA omitted 21 independent variables and built the model with 19 variables listed in Chart 2.

While the fixed value in the model is about 63.594, the value of the property increases 1.740 TL per gross square metre. That the resident is on higher floors makes a positive contribution to the value of the resident, whereas that it is on ground level makes a negative contribution to the value of the resident. As the size of the area of share increases, the residence increases in value. The values of the residences decrease about 9 TL for each meter as moving away from the metro station and 16 TL for each meter as moving away from the university. That the building is old has a negative effect on the value and the building has an elevator positively affects the value.

By using this MRA model, values of all the properties in training and testing data were calculated. Accordingly for training data, the average of estimated values was calculated about 158.067 TL and the average estimation success rate was calculated as 84.03%. And for the testing data, the average of estimated values was calculated about 156.982 TL and the average estimation success rate was calculated as 82.52%. These success rates are calculated by comparing the estimated values via MRA and real life prices.

However it was tried to be built models for both Fatih and Mamak by using MRA, unfortunately Mamak data couldn't met all assumptions (especially multicollinearity problem as the biggest obstacle), and MRA could be used only on Fatih data.

### 4.2 Artificial Neural Networks

Artificial neural network (ANN) is a kind of programme designed for the purpose of simulating the biological human neural system. In other words, artificial neural network technology is one of the latest products that imitating human brain. Artificial neural networks are computer systems developed in order to achieve different kind of abilities automatically through the "learning" which is one of the characteristics of human brain. It is impossible or quite difficult to achieve these abilities, such as producing and inventing new information, via traditional programming methods (Güneri and Apaydın 2004).

ANNs are mathematical systems consisting of good deal of processors (neurons) bounded each other with their weights. A processor in fact is an equation called transfer function. This processor takes the signals from neurons, combines them, transforms these signals and gives a numerical output. In general, processors roughly correspond to the neurons and they are

connected to each other in a network. This structure forms the artificial neural networks (Güneri and Apaydın 2004).

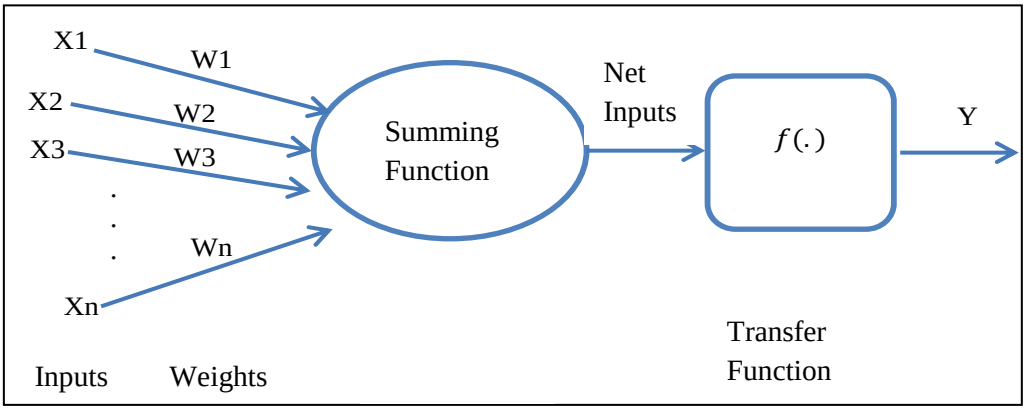


**Figure 1**: Structure of Artificial Neural Networks

ANNs review the samples (data), generalize the relevant samples, learn their style and when face with the similar samples that never met before, ANNs can make decisions by using the "knowledge" that they learned before (Güneri and Apaydın 2004).

ANNs really have complex structures and are required senior expertise and knowledge. Recently few countries have tried to use ANNs for mass property valuation activities and many academicians have some studies on this subject. According to the results of those research studies, ANNs mostly give more successful results than the other methods. On the other hand, because of its disadvantages there is a hesitation to use them for mass valuation purpose. Some of these disadvantages are listed below.

- The biggest problem is the fact that attitudes of the network cannot be explained. When ANNs produce a solution for a problem, it gives no clue how and why this is the solution.
- There is no rule to determine the convenient network structure; it is a trial and error learning system.
- There is no rule to determine the parameters such as learning coefficient, number of neurons or layers, etc. There is not only a standard, but also there is a different approach for each problem.
- ANNs depend on hardware, it is impossible to solve a problem without using computers (Güneri and Apaydın 2004).

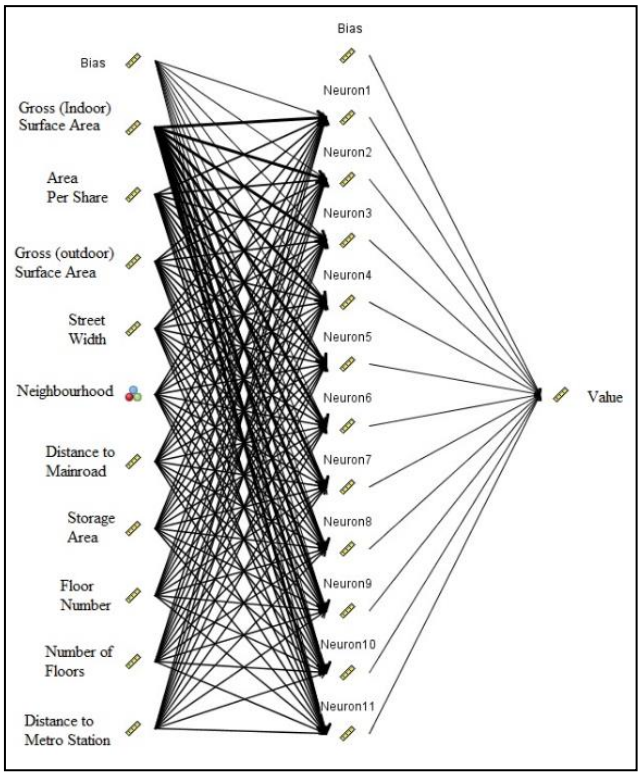


**Figure 2:** A section of the ANN Structure for Fatih Data

In this study, mass valuation of residential properties was made for both Fatih and Mamak via ANNs. In Fatih; for training data, the average of the estimated values was 157.610 TL and the average estimation success rate was 89.26%. And for the testing data, the average of the estimated values was about 157.201 TL and the average estimation success rate was 80.40%.

In Mamak, for training data, the average of the estimated values was 106.482 TL and the average estimation success rate was 96.80%. And for the testing data, the average of the estimated values was about 106.079 TL and the average estimation success rate was 85.45%.

### 4.3 Decision Trees

Decision trees method is a graphical technique based on data mining processes. The main goal is to create a model that can predict the value of the dependent variable based on independent variables. Actually decision trees method is a kind of machine learning modelling approach used in statistics. Decision tree method makes decision makers understand the problem in an easier way by using some symbols like dots, circles, lines etc. (SPSS Tutorials 2014).

A decision tree example is shown on Figure 3 very roughly.

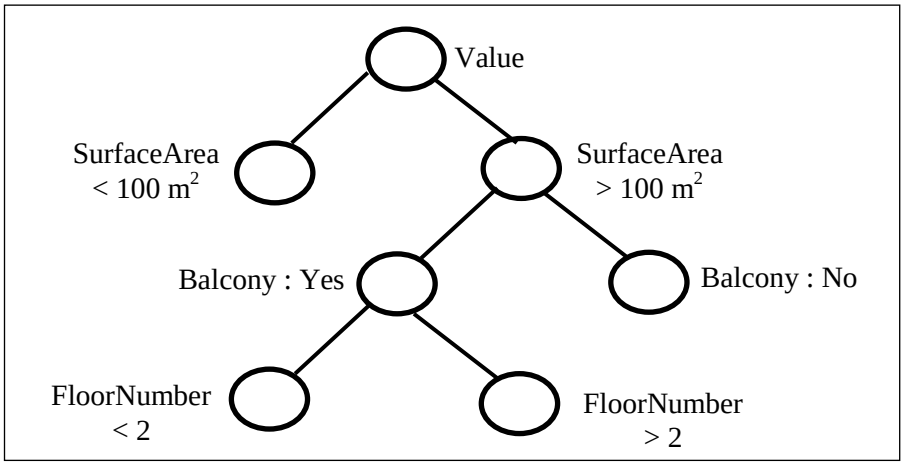


**Figure 3:** An Example Figure for Decision Trees

According to this figure, surface area has the maximum significancy on value of a property and the difference happens when the surface area is 100 $m^2$. If the surface area is bigger than 100 $m^2$, balcony is the other variable affecting the value. After that for the properties having balcony, floor number is the third independent variable having an effect on the value of the property. Number of data and predicted value also are written on the circles (leaves) to understand the contribution of each independent variable in terms of value.

Even though in this rough example (Figure 3) each leaf is divided into two groups, it is possible that refractions can be created by more than two subgroups. These are different techniques of decision trees. If leaves are divided into two groups, it is called C&R Tree (Classification & Regression Tree) and if more than two groups, it is called CHAID (CHi-squared Automatic Interaction Detector).

While conducting model building studies with Decision Trees, grouping and tree diagram refractions both may be automatically done based on statistical significance status and may be performed in full or in part according to knowledge and experience in line with suggestions and experience of experts in the field (SPSS Tutorials 2014).

In this study, mass valuation was made for both Fatih and Mamak via Decision Trees.

In Fatih; for training data, the average of the estimated values was 157.982 TL and the average estimation success rate was 81.47%. And for the testing data, the average of the estimated values was about 158.142 TL and the average estimation success rate was 79.23%.

In Mamak; for training data, the average of the estimated values was about 106.486 TL and the average estimation success rate was 86.78%. And for the testing data, the average of the estimated values was about 104.060 TL and the average estimation success rate was 85.5%.

## 5. EVALUATION OF THE RESULTS

Multiple Regression Analysis is the most common technique used in mass property valuation implementations in the world. In addition, it is decided that the new approaches also should be used to make the results much more comprehensive and to compare the success rates of the various modeling methods. These methods and their success ratios for Fatih and Mamak can be seen on Chart 3 and Chart 4 respectively.

| Method | Training Data | | | Testing Data | | |
|---|---|---|---|---|---|---|
| | Average of Estimated Values | Average estimation success rate | St. Dev. | Average of Estimated Values | Average estimation success rate | St.Dev. |
| **Multiple Regression Analysis** | 158.067 TL | 84,03% | 12,9% | 156.982 TL | 82,52% | 14,4% |
| **Artificial Neural Networks** | 157.610 TL | 89,26% | 8,94% | 157.201 TL | 80,40% | 16,28% |
| **Decision Trees** | 157.982 TL | 81,47% | ,25% | 158.142 TL | 79,23% | 17,51% |

**Chart 3:** Fatih – Mass Valuation Methods Results

| Method | Training Data | | | Testing Data | | |
|---|---|---|---|---|---|---|
| | Average of Estimated Values | Average estimation success rate | St. Dev. | Average of Estimated Values | Average estimation success rate | St. Dev. |
| **Artificial Neural Networks** | 106.482 TL | 96,80% | 3,6% | 106.079 TL | 85,45% | 11,0% |
| **Decision Trees** | 106.486 TL | 86,78% | 11,8% | 104.060 TL | 85,50% | 12,5% |

**Chart 4:** Mamak – Mass Valuation Methods Results

Since the mass valuation implementation is realized for taxation purpose, it is acceptable that the estimated values cannot be higher than their market values to use it for real estate tax calculations. Standard deviations for each method in Fatih and Mamak are on acceptable levels and when the whole data is reviewed, it's seen that averagely almost 45% of the estimated values are close to the real life prices at the rate of 90%, averagely almost 35% of

the estimated values are close to the real life prices at the rate of between 80% - 90%. Only %5 of estimated values are below than the real life prices.

A ratio study systematically compares value estimates to the corresponding indicators of value. The International Association of Assessing Officers (IAAO) has published a Standard on Ratio Studies that represents a consensus on proper ratio study procedures and on the interpretation of results of ratio studies.

There are two measures to understand the valuation uniformity in the scope of ratio studies : the price-related differential and the coefficient of dispersion. The price-related differential (PRD) is the mean ratio divided by the weighted mean ratio. It is an indicator of bias in valuations. PRDs close to 1.0 signify uniform appraisals. IAAO considers that PRDs between 0.98 and 1.03 to be acceptable. The chief measure of uniformity within a group of properties, the coefficient of dispersion (COD), measures the average percentage deviation of individual ratios from the median ratio. IAAO has adopted acceptable ranges of CODs for various types of property. The range for older properties (and yet includes condominiums) is between 0.5 and 1.5 (or 5% to 15%). All the coefficients of dispersion (COD) and price-related differential are between the ranges adopted by IAAO and by this way follow the requirements (Standard on Ratio Studies 2013).

In conclusion, all Multiple Regression Analysis, Artificial Neural Networks and Decision Trees have really successful results in terms of success levels and IAAO standards. Using these tree methods on the same value enables to compare their results and success that it seems ANNs are more successful compared to other two methods for this study. On the other hand, as it is mentioned before ANNs have some disadvantages in terms of explaining the results to the third parties who does not have enough knowledge about ANNs or mass valuation. Also this method requires really high level expertise and software. Therefore, in mass valuation implementations MRA is more preferable as it is easy to make modeling and explaining the results.

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| Ada Real Estate Valuation and Consultancy Corporation | 2008 – 2009 |
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