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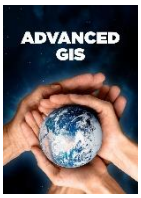

Valuation of commercial real estate in Ankara middle east industry and trade center (MEITC)

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ABSTRACT

Commercial real estate is an important part of the real estate sector. In the commercial real estate market, value estimates are made with the help of the characteristics of the samples that are subject to purchase and sale, and they are used in transactions such as taxation, insurance and privatization. In this study, collective valuation processes are aimed by applying the Multiple Regression Analysis (MRA) statistical method to the commercial properties offered for sale in the Middle East Trade and Industry Center (MEITC) in Yenimahalle district of Ankara. In this direction, 31 office sales data were collected for valuation, 29 criteria affecting the value were determined, and a mathematical model was developed according to independent variables. R^2, Root Mean Square Error (RMSE), Mean Absolute Error (MAE), and Mean Absolute Percent Error (MAPE) were considered. Their results were found as 0.938; 0.00; 0.04; 0.42 respectively. Based on these values, it has been concluded that the regression method, which is seen to produce high accuracy, can be used in commercial real estate valuation. Geostatistical analyzes were made using market values and estimated values, and value maps were produced in the Geographical Information Systems (GIS) environment.

1. Introduction

Real estate comes first among the basic needs that people need in order to continue their lives (Özkan & Yalpır, 2005). It is the part of the earth where shelter and other activities are carried out, especially food. With the state tax, citizens provide economic income with their production on real estate. This situation reveals the necessity of presenting real estate values in an accurate, objective, reliable and transparent manner. Objective real estate valuation can be made with the help of standard criteria determined by legal basis and the most appropriate method. The sound and good operation and maintenance of a real estate valuation system is one of the most important duties of the country's administration (Erdem, 2017). Real estate valuation; It is used in many transactions such as taxation, expropriation, insurance, nationalization, privatization, zoning practices, consolidation, sale and leasing.

Real estate valuation is defined as the art or science of estimating the value for a specific purpose of the property at a given time, considering all its characteristics and also taking into account all key economic factors (Millington, 2001). Real estate valuation is seen as a complex process because there are many criteria that affect the value (Yomralioglu, 1993). Scientific, objective, quantitative, practical and sensitive methods should be used in determining the real estate values. However, local needs and personal preferences vary according to the technical and legal characteristics of the land, plots and buildings within the scope of the real estate (Yomralıoğlu, 1997; Tanaka & Shibasaki, 2001).

Current mass appraisal studies are mostly concentrated on residential real estate (Tecim & Çağatay, 2006; C˘eh et al., 2018; Dimopoulos & Bakas, 2019). However, mass appraisal studies on commercial property remained limited. Commercial properties play an important role in urban planning (Lau & Li, 2006). In addition, commercial properties have unique characteristics that differ from residential properties (Fisher et al., 1994). One of the most important features of commercial properties is spatial autocorrelation (Kato, 2012). The properties of commercial properties are geographically dispersed and therefore models

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should be established to explain their prices (Hajime et al., 2013).

There are various criteria that can be used for every commercial property, but are not the same. Eboy & Jurah (2021) used the ordinary least squares method (OLS) in a study that showed a modeling and valuation comparison between two commercial property areas of Putatan and Limbang, which represent the city's suburbs in Sabah and Sarawak. They aimed to find an effective approach to develop a suitable model for commercial real estate valuation and to identify criteria that affect commercial properties for both fields of study. OLS results for Limbang and Putatan region are compared. OLS model for Limbang area, 6 criteria consisting of market, gas station, public toilet, recreation park, position and office; In the Putatan district, 5 criteria, namely renovation, road, main dump site, shopping complex and hotel, were found to be the criteria that most affected the property value. As a result, Eboy & Jurah (2021) stated that this study will benefit local authorities, investors and businessmen in determining the property value impact and estimated value using this approach with low cost, less time and less people needed.

Zhang et al. (2014) conducted a case study in Shenzhen's Huaqiang business area for a collective assessment of commercial properties based on spatial analysis. To achieve high precision and reduce valuation cost, they propose an innovative framework through the introduction of an improved spatial error model (SEM), fuzzy mathematics and econometrics. In the study; They considered criteria such as area, street front, number of floors, width of the property's proximity to the street, height of the property, vacancy rate, depth of the property, and commercial level. As a result of the study, Zhang et al. (2014) stated that the model applied in the analysis could be widely adopted in China, provide data support for fiscal decentralization, provide technical support for the ongoing property tax reform, and provide data supporting macro regulation of the real estate market. They also stated that the evaluation results can be used as a benchmark for the market equilibrium price.

In their study in the USA, Ghysels et al. (2007) considered a log-linearized version of the discounted rent model to price commercial real estate as an alternative to traditional hedonic models. First, they confirmed an important implication of the model, namely that ceiling rates predict commercial real estate returns. They did this using two different methodologies: time series regressions of 21 US metropolitan areas and aggregated REIT returns and mixed data sampling (MIDAS) regressions. They also explored the source of predictability. According to the study, Ghysel et al. (2007) concluded that the economic conditions used in the hedonic pricing of real estate cannot fully explain the future movements in returns, commercial real estate prices are better modeled as financial assets and the discounted rent model may be more appropriate than the traditional hedonic models, at least collectively.

Clayton et al. (2009) examined the role of key factors and investor sentiment in commercial real estate valuation. In real estate markets, heterogeneous properties are traded in illiquid, highly fragmented, and information-inefficient local markets, and the inabilityto short-sell private real estate limits the ability of knowledgeable traders to enter the market and eliminate mispricing. They report that these features appear to make private real estate markets highly susceptible to sentiment-induced mispricing. Using error correction models to carefully model potential delays in the adjustment process, this paper extends previous work on capital ratio dynamics by examining the extent to which fundamental principles and investor sentiment help explain time series variation in capping rates at the national level. As a result, they found evidence that investor sentiment affects pricing even after controlling for changes in expected rental growth, stock risk premiums, T-bond yields, and lagged adjustments from the long-term equilibrium.

Fisher et al. (2021) examined the effect of hurricanes on the value of commercial real estate in their study in the USA. It is the first study to examine all major hurricanes that have occurred since 1988, including 19 storms that affected different parts of the United States. After controlling for property size, age, location, time (market conditions), and occupancy, they found that hurricanes had a significant impact on property values, value growth (excluding investments), and overall returns. Fisher et al. (2021) emphasize that it is especially important for investors who decide whether to allocate additional capital if the risk of additional hurricanes is increasing in an area due to climate change. They note that the impact on property values and returns they found goes beyond any impact from physical damage to properties. They noted that the depreciation appears to last up to 5 years after the hurricane occurs, and is likely the result of higher risk premiums and lower tenant demand after a hurricane has occurred.

Hoesli & Malle (2021) analyzed the effects of the 2019 coronavirus disease (COVID-19) epidemic on commercial real estate prices in their study, focusing especially on European markets. The authors reported that retail and hospitality facilities and, to a lesser extent, office buildings were most affected by COVID-19, with the residential and industrial sectors less affected. They argued that the future course of prices will vary between sectors, and the type and location of assets will become increasingly important in their valuation.

In the study of Yomralıoğlu (1997), it has been determined that local, environmental, legal, spatial and local characteristics are among the widely accepted criteria as well as the purpose of use of the real estate in determining the value.

GIS; it is a computer-based system used to obtain, process, control, store, display and analyze spatial data such as climate, landforms, population. In this context, it is possible to benefit from GIS technology in collecting, controlling, analyzing and presenting the data related to the criteria affecting the real estate value in certain standards. In the application of multi-criteria decision-making analysis in real estate valuation studies, first of all, accurate, reliable, up-to-date, spatial and non-spatial data of the real estate are collected and correlations are

established between them. The criteria affecting the value of the immovable are determined and entered into the system together with their previously calculated weights. In order to make location-based decisions with the data stored in the GIS base, operations such as viewing and querying are performed with the help of analyzes, and new information is obtained from the data collected as a result of the analyzes to be made (Erbil, 2014). This system allows the database prepared with GIS to be analyzed with mathematical models, making valuation and producing value maps (Tanrıvermiş, 2018).

The aim of this study is to analyze the performance analysis results and value maps by estimating the market values of commercial real estate in the MEITC region of Ankara with MRA. Commercial buildings, which are rarely seen among the studies on valuation, are considered as immovable type. MRA was applied by arranging the market value of the commercial places put up for sale in Ankara Yenimahalle district Middle East Trade and Industry Center (MEITC) as the dependent variable and the criteria affecting the value as the independent variable. It is important that it can be used in many transactions such as mass appraisal in commercial areas, taxation, insurance, sale and rental as in residences.

2. Material and Method

2.1. The study area

Ankara is located in the Central Anatolia Region and is the capital of Turkey. It is the second most populated city in the country and the third largest city in terms of surface area. Its population is 5,747,325 people in 2021 (TUIK, 2021). This population; He lives in 25 districts and 1425 neighborhoods connected to these districts. Approximately 72.13% of the population works in civil service, transportation, communication and trade, which can be defined as the service sector, 24.64% in industry and 3.23% in agriculture (Report, 2018).

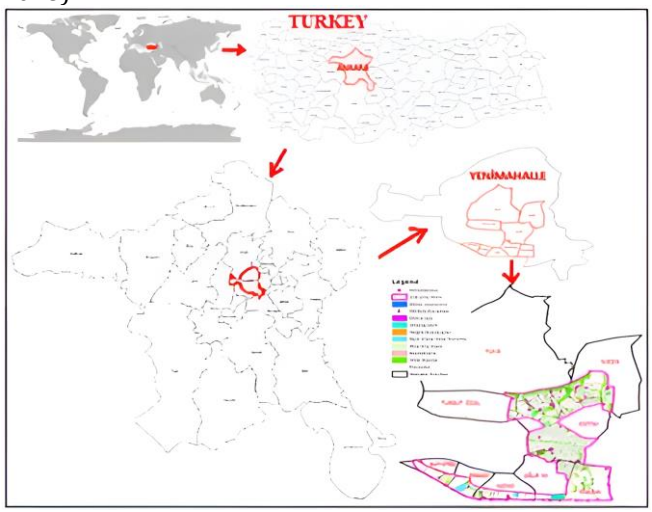


Figure 1. Ankara MEITC study area

The industry is especially concentrated in the textile, food and construction sectors. Middle East Industry and Trade Center, or MEITC for short, is an industrial site in Ankara. MEITC is Turkey's largest small and medium-sized industrial production area (Figure 1). More than 2500 workshops, approximately 1400 workplaces and offices and 1800 residences were built through the MEITC Small Industrial Site Building Cooperative. There are 5000 companies that are members of MEITC. 31% of the companies are trading, the rest are manufacturing. Manufacturing areas are 62% metal processing, 20% plastic-rubber, 8% electricity and 4% chemical production (Erdoğan et al., 2007).

2.1.1. Data

Commercial offices were offered for sale on the internet, and a data set was created between March-April 2021 from 31 offices with a homogeneous distribution by conducting research for market values and other information one by one. The data collection process was completed by verifying the island and parcel information on the Parcel Inquiry website of the General Directorate of Land Registry and Cadastre. In order for the study conducted in a region to reflect that region and to be statistically significant, it is necessary to collect data as much as a certain sample number. It is stated that an increase in the sample size at a certain level will decrease the margin of error and error rate (Patton, 2014). Since it is not always possible to control the variables that affect the process in studies in the field of science and engineering, the confidence interval is accepted as 95% in many studies (Karasar, 2007). In parallel with this situation, sampling error is preferred as 5% (Glantz, 2012).

In literary studies; area, street front, number of floors, property width near street, property height, vacancy rate, property depth, commercial level, repair, main roads, secondary roads, education centers, entertainment centers, banks, police stations, post offices, bus stops or taxis, ferry terminals, public toilets, places of worship, gas stations, parking lots, shopping complexes, office complexes, sports complexes, farmers' markets were used as criteria (Zhang et al., 2014; Eboy & Jurah, 2021).

In this study; the zoning plan of Ankara province, Yenimahalle district, MEITC study area was used. Considering the office features in the literature and in MEITC, criteria have been determined under 4 main headings and 11 subheadings in the form of legal, structural, physical and spatial features. As a result, a total of 29 independent variables that affect the office value are discussed (Table 1).

2.2. Preparing data for analysis

The criteria; There is no standard on how it is used in mass appraisal and in what form it is converted into digital form (Ünel, 2017). However, quantitative data is needed to perform analyzes for value estimation. For this reason, when the studies in the literature were examined (Nişancı, 2005; Demirel et al., 2016; Doldur & Alkan 2021) it was seen that coding was done (Figure 2).

Table 1. Criteria affecting the commercial real estate value

Address	Legal Feature	Building Feature	Physical Feature	Location Feature (Distance)
District	Setback Distance	Net Building Area	Road Width	Healthcare Provider
City Block	Number of Floors	Building Age	Transportation Facilities	Secondary Education
Plat	Land Area	Number of Rooms	Frontage	Municipality
Site		Floor Location	Direction of Facades	Open Penitentiary İnstitution
Ad Number		Office Type		SubwayStation
		Number of Balconies		Bus Station
		Heating System		Shopping Area
		Dues		Green Area
		Parking		Worship Place
		Elevator		Town Center
		İnterior Features		
		External Features		

Internal features are determined ADSL, kitchen, steel door, bathroom, white goods, toilet, parquet, ceramics, central satellite system, furniture, cloakroom, suspended ceiling, industrial electricity, sound insulation, fire alarm system, cable TV-satellite, jacuzzi windows.

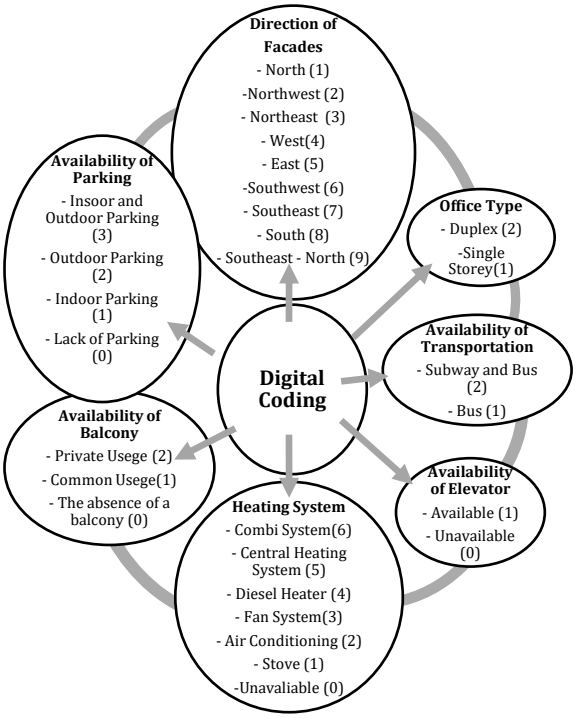


Figure 2. Data codding

Except for the toilet and the bathroom, all of them are coded to be numerically expressed as 1. In the toilet and bathroom criteria; Existence of a bathroom was expressed as 1, absence of it as 0, private use of toilet as 2, common use as 1, and absence as 0 and added to interior features.

As external features, fire escape, security, heat insulation, water heater, generator, glass cladding, garden, camera system, information service, warehouse, card access system, system room, open area are listed as. All of them are expressed numerically as 1 according to their existence status.

2.3. Method

In mass real estate valuation, peer comparison, income and cost methods, which are called traditional valuation methods, are insufficient (Pagourtzi et al., 2003). While seeing that the use of statistical and modern methods in mass appraisal has increased its contribution to valuation studies, it offers the opportunity to give objective results instead of subjective findings (Nişancı, 2005). In studies in the literature, the multiple regression method is generally given as a comparison method in the performance and accuracy analyzes of the method to be developed (Zurada et al., 2011; Yalpır & Tezel 2013; Kartal & Corum, 2020; Esen & Tokgöz 2021; Tabaret al., 2021). In this study, "Multiple Regression Analysis" was used as the valuation method of commercial real estate. The data contain differences in terms of unit and value ranges, and normalization process was performed to standardize the data. In addition, performance analyzes were made to examine the differences between the prices of commercial real estate and their estimates, that is, the amount of errors.

2.3.1. Normalization

Normalization can be named as the process that enables the data sets that have been converted to digital to be standardized [0,1], [1,2] or [-1,1] by pulling them to a certain range and used together in value estimation by converting them to values in the same unit. Normalization methods enable them to be examined together by converting existing values to values without units (Özdağoğlu, 2014)

In this study, Min-Max Normalization method was applied. The Min-Max Normalization method de-unitizes a data and reduces it to the range of 0 to 1 with Equation (1).

• Normalization in the range of $\boldsymbol{0 \leq X \leq 1}$

$$X_N = \frac{X_i - X_{min}}{X_{max} - X_{min}} \quad (1)$$

Where X_i is the value in row $i$for the relevant criterion of the dataset. X_{min} and X_{max} are the smallest and largest values of the relevant criteria.

Criteria affecting the value of commercial real estate located within the borders of Ankara MEITC have been determined and the criteria data together with the market value have been recorded in matrix format. A

numerical coding system was applied to the recorded criteria. The numerical values used in the regulations do not mean that they increase or decrease the value of the real estate at the same rate. A coding system has been created, taking into account the fact that it affects the value of the immovable and that it is accepted under legal conditions. For example; Considering the explanation in the table showing the square meter normal construction cost values of the buildings published based on the Real Estate Tax Law, if the presence of an elevator is evaluated according to the absence of an elevator, it is given as 1 because it will positively affect the price, and 0 if there is no elevator (Figure 2). The normalization process in the range of [0-1] was applied to the numerically coded data. Thus, each criterion had a value between 0 and 1.

2.3.2. Multiple regression analysis

MRA method is one of the most used methods in real estate valuation because the number of criteria affecting the property value is more than one. In MRA, it is aimed to make functional sense of the relationship between the variables and to explain this relationship with a model (Chatterjee & Hadi, 2015). In the MRA method, there is only one dependent variable and there is more than one independent variable affecting this dependent variable. The dependent variable is the market value, and the independent variables are the legal, structural, physical and spatial features that affect the market value (Figure 3). In this method, the closest estimation of the market value to reality is tried to be made (Türeoğlu, 2008).

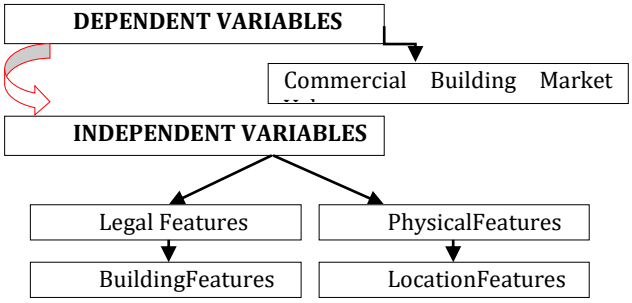


Figure 3. The dependent and independent variables

The process of determining the $y = f(x)$ function between the independent x and dependent y variables given by the values (x_1y_1),(x_2y_2),.....(x_ny_n) is called balancing function determination, relationship research or regression analysis (Şişman & Şişman, 2016). A first-order linear regression Equation (2),

$$y = a_0 + \sum_{i=1}^{k} a_i x_i + \varepsilon \quad (2)$$

It is a model with dependent and independent variables. Here y; dependent, x_i; independent variables, a_0; constant value, a_i regression coefficient, ε; represents the random error term.

F test and R^2 found as a result of MRA are important tests that should be checked first (Altunışık et al., 2010);

• The F test is a test with ANOVA to examine whether the regression model is significant.

• The significance level corresponding to the F value obtained as a result of the ANOVA test helps in the decision whether the model is suitable or not.

• It is interpreted that the result of the F test is significant ($p<.05$), and that the model in question makes a significant contribution to explaining the dependent variable.

• The R^2 value indicates what percentage of the variance in the dependent variable is explained by the independent variable.

• The closer this value is to 1, the better the model is explained by the independent variables.

2.3.3. Performance analysis

Performance analysis is the evaluation of the work done, seeing the deficiencies and taking measures to eliminate them, revealing the factors affecting the performance and controlling them and arranging the resources accordingly (Bayyurt, 2007).

Three parameters are considered for the performance analysis. In order to compare the model values obtained from all and reduced criteria with the market values, the results of Root Mean Square Error (RMSE), Mean Absolute Error (MAE), Mean Absolute Percent Error (MAPE) were used in performance analysis.

The RMSE was calculated by squaring the estimation errors and subtracting their mean from the square root (3), and the MAE was calculated by averaging the absolute values of the estimation errors (4). MAPE is calculated by taking the average of the ratio of the absolute value of the estimation errors to the market values (5) (Akgüngör & Doğan, 2010; Aslay & Özen, 2013)

The value of R^2 (6) was examined to examine how much the estimated values reflect the market values. Equations (3-6) were used for Performance Analysis;

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2} \quad (3)$$

$$MAE = \frac{1}{n}\sum_{i=1}^{n}|y_i - \hat{y}_i| \quad (4)$$

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\frac{|y_i - \hat{y}_i|}{y_i} \quad (5)$$

$$R^2 = 1 - \frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{\sum_{i=1}^{n}(\hat{y}_i - \bar{y})^2} \quad (6)$$

y_i market values, $\hat{y}_i$ model values, $i = 1,2,3,\ldots n$, and n represents the selected sample number.

3. Results

Independent variables based on the market value of the dependent variable in the Statistical Package for the Social Sciences (SPSS) software developed by IBM using normalized data; area, drawing distance, number of floors, direction of facades, etc. MRA was performed by assigning values.

ANOVA test was used to determine whether the F

test was p<0.05 and the R^2 value was close to 1 in MRA. Among the results of the ANOVA test, the significance of the F test was 0.000, and it was determined that the value estimation model made a significant contribution to explaining the dependent variable (Table 2).

Table 2. ANOVA test

ANOVA[a]					
Model		Sum of Squares	Mean Square	F	Sig.
1	Regression	1.632	.056	13.795	.000[b]
	Residual	.118	.004		
	Total	1.751			

In the regression equations coefficients, the positive sign (+) has an increasing effect on the real estate value, while the negative (-) coefficient has a decreasing effect. Considering the sign of the model coefficients, the criteria that have the most positive effect on the value are; net building area (0.669), floor (0.102), dues (0.244) and metro station (0.116). The criteria that have the most negative effect on the value are; external features (-0.198), distance to Yenimahalle Municipality (-0.232) and open penalty execution distance (-0.356) (Table 3).

The mathematical model of the MRA is presented in Equation (7) using the coefficients in column B of Table 3;

$$\boldsymbol{Market\ Value} = 0.566 + 0.006 * landarea - 0.114 * setbackdistance + 0.074 * numberoffloors + 0.669 * netarea - 0.085 * buildingage - 0.003 * numberofrooms + 0.102 * floorlocation + 0.094 * officetype + 0.052 * numberofbalconies + 0.006 * heatingsystem + 0.244 * dues + 0.075 * parking - 0.026 * elevator - 0.051 * interiorfeatures - 0.198 * externalfeatures - 0.017 * roadwidth + 0.019 * transportationfacilities + 0.018 * frontage - 0.005 * directionoffacades - 0.052 * healthcareprovider - 0.086 * secondaryeducation - 0.232 * municipality - 0.356 * penitentiaryinstitution - 0.158 * shoppingarea - 0.064 * towncenter + 0.050 * greenarea + 0.116 * subwaystation - 0.031 * busstation - 0.121 * worshipplace \quad (7)$$

The market value was estimated with the model obtained as a result of the MRA. Since the data were normalized, the predicted value was calculated in the range (0, 1).

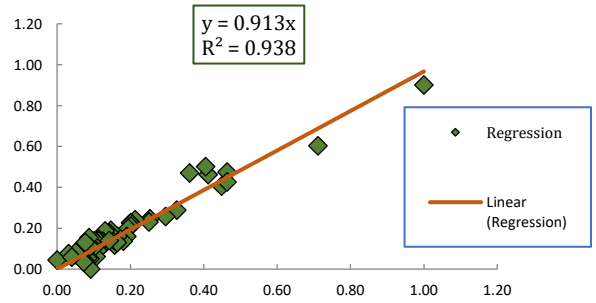


Figure 4. Comparison of Market Value and Prediction Value

Table 3. Regression Analysis Coefficients

Coefficients[a]					
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Constant	.566	.180		3.142	.004
Land Area	.006	.091	.011	.065	.949
Setback Distance	-.114	.094	-.133	-1.206	.238
Numberof Floors	-.074	.068	-.108	-1.090	.285
Net Building Area	.669	.070	.670	9.629	.000
Building Age	-.085	.060	-.120	-1.402	.171
Number of Rooms	-.003	.044	-.005	-.064	.949
Floor Location	.102	.090	.114	1.141	.263
Office Type	.094	.054	.164	1.725	.095
Number of Balconies	.052	.036	.139	1.430	.163
Heating System	.006	.051	.008	.121	.904
Dues	.244	.076	.304	3.229	.003
Parking	.075	.062	.178	1.212	.235
Elevator	-.026	.067	-.049	-.395	.695
Interior Features	-.051	.063	-.062	-.818	.420
External Features	-.198	.079	-.339	-2.494	.019
Road Width	-.017	.040	-.037	-.424	.675
Transportation Facilities	.019	.033	.050	.581	.566
Frontage	.018	.077	.029	.236	.815
Direction of Facades	-.005	.038	-.009	-.120	.905
Healthcare Provider	-.052	.061	-.076	-.855	.400
Secondary Education	-.086	.063	-.147	-1.377	.179
Yenimahalle Municipality	-.232	.237	-.242	-.980	.335
Open Penitentiary İnstitution	-.356	.220	-.503	-1.616	.117
Shopping Area	-.158	.090	-.283	-1.766	.088
Town Center	-.064	.123	-.085	-.523	.605
Green Area	.050	.095	.061	.522	.606
Subway Station	.116	.132	.180	.877	.388
Bus Station	-.031	.073	-.045	-.426	.673
Worship Place	-.121	.068	-.167	-1.777	.086

a. Dependent Variable: Market Value

Performance analyzes were performed to compare the difference between the market value and the prediction value found as a result of the MRA. For this, R^2, RMSE, MAE and MAPE were calculated and it was examined how close the prediction values were to the market value. R^2 is close to 1 with a value of 0.938, showing that the predicted value approximates the market value very well (Figure 4).

As a performance analysis, it was determined that the estimation values of RMSE (0.00), MAE (0.04) and MAPE (0.42) ratios approached the market values very well (Table 4).

Table 4. Performence Analysis Results

Performence Analysis Method	Value
Root Mean Square Error (RMSE)	0.00
Mean Absolute Error (MAE)	0.04
Mean Absolute Percent Error (MAPE)	0.42

3.1. Value maps

The entire area included in the MEITC was determined as the study area and the samples were shown on the map by placing dots on the plots where the samples were located. Since commercial real estate is a structure built for office and bureau use, the sample points on the map and unit values are associated with the ArcGIS program. The unit values were also found by dividing the market and prediction values by the net building area. Therefore, each point gives the value of one square meter construction area belonging to the samples. This value includes the land share.

The value map was produced using the inverse distance weighting method. It has been determined that the maps produced from the market and prediction unit values are visually very close to each other. In the market unit value map, the southwestern facade displays a more valuable spatial distribution than the northeast (Figure 5a). The prediction unit value map is also very similar to the market unit value map, with little change in value on the southeast front (Figure 5b).

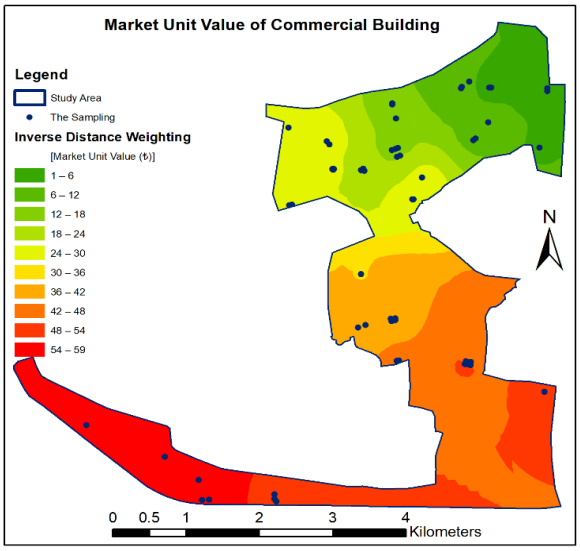
Market and prediction unit value maps also help to obtain information about the values of real estates outside of our samples in the study area.

4. Conclusion

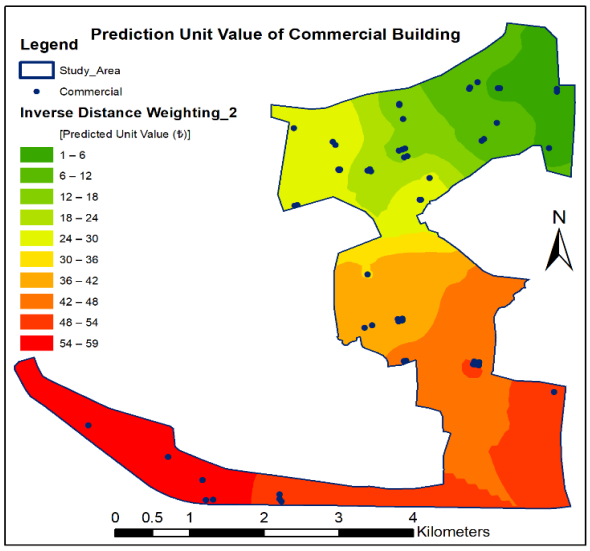
In this study, which focuses on the valuation of real estate, which is one of the most important parts of social and personal wealth, an examination has been made on determining the criteria affecting the real estate value and generating estimated value.

In order to measure the effects of independent variables, in other words, qualitative ones at the classification measurement level, on the dependent variable, all qualitative and quantitative variables were made suitable for analysis.

The regression model obtained in this study revealed the relationships between the real estate values and the criteria affecting the values for the study area. According to the estimated results, the root mean square error of the values found as a result of the performance analysis was 0 (zero) and the R^2 value was found to be 0.938, and it was determined that the mathematical model was significant and very close to the market value.



(a) The market unit value



(b) MRA prediction unit value

Figure 5. Value map

The prediction values of commercial real estate and their market values were matched in the GIS environment and value maps were produced. The estimated values of the regions outside the samples are also shown on the maps.

With the pandemic, a trend towards horizontal architecture has started in people's life and housing preferences. It is seen that the transaction volume in the real estate sector has decreased due to the changing office preferences of the shop and office market after the pandemic and the transition of many companies to the flexible working system. The prolongation of the epidemic has created a great risk for the world economy and all sectors in a chain way. The stagnation in commercial real estate sales during the pandemic period also made the data collection phase difficult. Despite the possible price changes during this period, a high level of accuracy was achieved. The results of the study showed that the method used can be used in real estate valuation applications and a suitable model can be created for the study area by considering the criteria, and valuation studies can be done quickly and objectively. In future studies, it is planned to increase the number of samples and apply different modern valuation methods.

Author Contributions

GY: Data collecting, writting, analyzing, visualization; **FBU:** Designing, editing, mapping; **AU:** Editing.

Statementof Conflicts of Interest

There is no conflict of interest between the authors.

Statement of Research and Publication Ethics

Research and publication ethics were complied in the study.

References

Akgüngör, A. P., & Doğan, E. (2010). Farklı yöntemler kullanılarak geliştirilen trafik kaza tahmin modelleri ve analizi (in Turkish). *International Journal of Engineering Research and Development,* 2(1), 16-22.

Altunışık, R., Coşkun, R., Bayraktaroğlu, S., & Yıldırım, E. (2010). *Sosyal Bilimlerde Araştırma Yöntemleri SPSS Uygulamalı (in Turikish*). Sakarya Yayıncılık.

Aslay, F., & Özen, Ü. (2013). Estimating soil temperature with artificial neural networks using meteorological parameters. *Journal of Polytechnic*, 16(4),139-145. https://doi.org/10.2339/2013.16.4

Bayyurt, N. (2007). İşletmelerde performans değerlendirmenin önemi ve performans göstergeleri arasındaki ilişkiler. *Journal of Social Policy Conferences (in Turkish)*. 53, 577-592.

Chatterjee, S., & Hadi, A. S. (2015). *Regression analysis by example.* John Wiley & Sons.

C˘eh, M., Kilibarda, M., Lisec, A., & Bajat, B. (2018). Estimating the performance of random forest versus multiple regression for predicting prices of the apartments, *ISPRS International Journal of Geo-Information*7(5), 168. https://doi.org/10.3390/ijgi7050168

Clayton, J., Ling, D. C., & Naranjo, A. (2009). Commercial real estate valuation: Fundamentals versus ınvestor sentiment. *The Journal of Real Estate Finance and Economics,* 38:5–37 https://doi.org/10.1007/s11146-008-9130-6

Demirel, S. B., Reyhan, O., Atasever, Ü. H., & Kesikoğlu, M. H (2016). The Using of Artificial Neural Networks in Flat Type Real Estate Valuation. *UZAL-CBS 2016*, Adana, Turkey.

Dimopoulos, T., & Bakas, N. (2019). Sensitivity analysis of machine learning models for the mass appraisal of real estate. Case Study of residential units in Nicosia, Cyprus. *Remote Sensing,* 11(24), 3047. https://doi.org/10.3390/rs11243047

Doldur, M., & Alkan, R. M. (2021). Producing GIS-based land value maps by using nominal valuation method: Case study in Avanos/Nevşehir 21,045502, 846-863. https://doi.org/10.35414/akufemubid.888502

Eboy, O. V., & Jurah, A. K. A. (2021). Modeling the commercial property value using ordinary least squared (OLS); A case study of Putatan, Sabah and Limbang, Sarawak. *Malaysian Journal of Social Sciences and Humanities (MJSSH),* 6(3) , 290 – 296. https://doi.org/10.47405/mjssh.v6i3.686

Erbil, E. H. (2014). Taşınmaz mal değerleme amaçlı coğrafi bilgi sistemi tasarımı (in Turkish). *UZAL-CBS,* İstanbul, Turkey.

Erdem, N. (2017). Toplu (Küme) değerleme uygulama örnekleri ve ülkemiz için öneriler. *TMMOB Harita ve Kadastro Mühendisleri Odası, 16. Türkiye Harita Bilimsel ve Teknik Kurultayı (in Turkish),* Ankara, Turkey.

Erdoğan, A., Günel, G., & Kılcı, A. (2007). Ankara in History. *Ankara Metropolitan Municipality*, 8(2), 38-45.

Esen, Y., & Tokgöz, H. (2021). A different perspective to real estate valuation with fuzzy logic modeling. *Journal of Engineering Sciences and Design*, 9(4), 1155-1165. https://doi.org/10.21923/jesd.876523

Fisher, J. D., Geltner, D. M., & Webb, R. B. (1994). Value ındexes of commercial real estate-a comparison of index construction methods. *Journal of Real Estate Finance and Economics,* 9(2), 137-164. https://doi.org/10.1007/BF01099972

Fisher, J. D., & Rutledge, S. R. (2021). The impact of hurricanes on the value of commercial real estate. *Business Economics,* 56:129–145 https://doi.org/10.1057/s11369-021-00212-9

Ghysels, E., Plazzi, A., & Volkanov, R. (2007). Valutation in US commercial real estate. *European Financial Management,* 13,3, 2007, 472–497. https://doi.org/10.1111/j.1468-036X.2007.00369.x

Glantz, S. A. (2012). *Confidence Intervals. In: Primer of biostatistics.* McGraw-Hill Medical.

Hajime, S., Yoshiki, Y., & Morito, T. (2013). Automatic selection of a spatial weight matrix in spatial econometrics: Application to a spatial hedonic approach. *Regional Science and Urban Economics*, 43, 429-444. https://doi.org/10.1016/j.regsciurbeco.2013.02.002

Hoesli, M., & Malle, R. (2021). Commercial real estate prices and COVID-19. *Journal of European Real Estate Research, 15(2),* 295-306.

Karasar, N. (2007). *Bilimsel araştırma yöntemi: kavramlar, ilkeler, teknikler (in Turkish).* Nobel Yayın Dağıtım.

Kartal, U., & Corum, A. (2020). Regression equation determining house price: Case study in Maltepe. *International Journal of Advances in Engineering and Pure Sciences*, 1, 57-67. https://doi.org/10.7240/jeps.605719

Kato, T. (2012). Prediction in the lognormal regression model with spatial error dependence. *Journal of Housing Economics*, 21(1), 66-76. https://doi.org/10.1016/j.jhe.2012.01.003

Lau, K. M., & Li, S. M. (2006). Commercial Housing Affordability in Beijing, 1992-2002. *Habitat International,* 30(3), 614-627. https://doi.org/10.1016/j.habitatint.2005.02.004

Millington, A. F. (2001). *An Introduction to property valuation (5th ed.).* Estate Gazette.

Nişancı, R. (2005). *The production of pixel based urban land value maps with nominal valuation method*

using GIS (Publication No. 35893) [Doctoral Thesis, Karadeniz Technical University]. YÖK National Thesis Center.

Özdağoğlu, A. (2014). The Effects of the normalization methods to multi criteria decision making process–moora method review. *Ege Academic Review,* 14(2), 283-294.

Özkan, G., & Yalpır, Ş. (2005). Valuation and economic view to real estate. 1*0. Türkiye Harita Bilimsel ve Teknik Kurultayı (in Turkish)*, Ankara, Turkey.

Pagourtzi, E., Assimakopoulos, V., Hatzichristos, T., & French, N. (2003). Practice briefing real estate appraisal: A review of valuation methods. *Journal of Property Investment & Finance*, 21(4), 383-401. https://doi.org/10.1108/14635780310483656

Patton, M. Q. (2014). *Qualitative research & evaluation methods: Integrating theory and practice.* Sage publications.

Report. (2018). *Ankara Provincial Industry Status Report (Ankara İl Sanayi Durum Raporu-in Turkish)*, Ankara.

Şişman, A., & Şişman, Y. (2016*).* Konutun değerine etki eden faktörlerin araştırılması (in turkish). *International symposium on Engineering, Artifical Intelligence & Applications-ISEAIA2016*, Girne, KKTC.

Tabar M E, Başara A C & Şişman Y (2021). Housing Valuation Study in Tokat Province with Multiple Regression and Artificial Neural Networks. *Turkish Journal of Land Management* 3(1),01-07. https://doi.org/10.51765/tayod.832227

Tanaka, H., & Shibasaki, R. (2001). Creation of *Spatial Information Database for Appraisingthe Real Estate. 22nd Assian Conference on Remote Sensing*, Singapore.

Tanrıvermiş, H. (2018). *Gayrimenkul değerleme esasları. Sermaye Piyasası Lisanslama ve Sicil ve Eğitim Kuruluşu yayınları (in Turkish),* 502, İstanbul.

Tecim, V., & Çağatay, U. (2006). Coğrafi bilgi sistemi tabanlı taşınmaz değerleme çalışmaları vasıtasıyla taşınmaz değer haritalarının oluşturulması için model bir çalışma. 4*. Coğrafi Bilgi Sistemleri Bilişim Günleri (in Turkish)*, İstanbul, Turkey.

TUIK. (2021). *Address based population registration system address results (Adrese dayalı nüfus kayıt sistemi adres sonuçları).* TUJK. Retrieved April 22, 2021, from https://biruni.tuik.gov.tr/medas/?kn=64&locale=tr

Türeoğlu, Z. E. (2008). *Real estate appraisal in the housing financing system* (Publication No. 219621) [Master Thesis, Marmara University]. YÖK National Thesis Center.

Ünel, F. B. (2017). Development of geography data model for criteria of real estate valuation (Publication No. 485118) [Doctoral Thesis, Selçuk University]. YÖK National Thesis Center.

Yalpır, Ş., & Tezel, G. (2013). Konut değerlerinin tahmini için SVM ve MRA yöntemlerinin karşılaştırması*, 6. Mühendislik ve Teknoloji Sempozyumu (in Turkish),* Çankaya University, Ankara, Turkey.

Yomralioglu, T. (1993). A nominal asset value based approach for land read justment and its ımplementation using geographical ınformation system*s.* [Doctoral Thesis, University of Newcastleupon Tyne]. , Department of Surveying. https://web.itu.edu.tr/tahsin/PAPERBOX/T01.pdf

Yomralıoğlu, T. (1997). Taşınmazların değerlendirilmesi ve kat mülkiyeti mevzuatı. *JEFOD-Kentsel Alan Düzenlemelerinde İmar Planı Uygulama Teknikleri (in Turkish)*, Trabzon, 153-169.

Zhang, R., Du, Q., Geng, J., Liu, B., Huang, Y. (2014). An improved spatial error model for the mass appraisal of commercial real estate based on spatial analysis: Shenzhen as a casse study. *Habitat International,* 46, 196-205. https://doi.org/10.1016/j.habitatint.2014.12.001

Zurada, J., Levitan, A. S., & Guan, J. A. (2011). A comparison of regression and artificial intelligence methods in a mass appraisal context. *Journal of real estate research,* 33(3), 349-388. https://doi.org/10.1080/10835547.2011.12091311