Proceedings of the 2023 International Conference on Management Research and Economic Development
DOI: 10.54254/2754-1169/18/20230106

Real Estate Value Analysis Using Models

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Abstract: Housing is an indispensable material basis for people's lives, and its price significantly impacts their lives. There are various forms of valuation to determine the price, and the simplest is to determine the price at which the property would have traded on a particular date. However, there is a wide range of purposes for which valuation is required. The cost of a property depends on factors such as size, floor, location, parking space, etc. The purpose of this paper is to use a multivariate back model as a basis for sub-categorizing the factors that affect the price of real estate and provides a reference for residential real estate price management and regulation.

Keywords: real estate value, housing, the models

1. Introduction

Real estate development is one of the showcases of national economic development. It significantly impacts the economic development of many countries and regions, even the pillar industry in some areas. As real estate continues to grow, the demand for real estate is growing exponentially. If we see housing as an investment, it involves purchasing real estate, earning rental income, and reselling it later. This paper only discusses the purchasing and reselling stages and mainly focuses on factors influencing selling prices. In past decades, many scholars have analyzed the relationship between house prices with demographic and economic factors. However, the interaction among influencing factors has not been studied. It is essential to clarify relationships and levels they interact with each other as these factors solely and jointly affect house prices.

2. Literature Review

As Bojan and Darja argue, they classified three categories of factors considering buyers' satisfaction: physical, living, and socioeconomic.[1] Detailed factors such as location, size, parking options, and central heating are also included in our model. In the following two years, as Yusof and Ismail argue, three determinants usually are related to the price and rental of a home, including structural factors, neighborhood factors, and locational factors.[2] He mentioned that the structural aspect of the building is related to the size and floor of the building, which we have in our database. A study by the National Association of Realtors [3] revealed that the quality of schools nearby is essential when looking for a new home. In this paper, we also discuss the influence brought by schools but focus on the quantity of them. In a recent study, Hayes found that today's house price is affected by the costs

DOI: 10.54254/2754-1169/18/20230106

of comparable properties, the neighborhood, the home's age and condition, property size, and the state of the housing market.[4] To conclude, we keep some reliable variables from the past and variables that emerged in recent years.

3. Materials

With limited time and capability, it is not convenient for us to collect extensive data. Instead, we choose a dataset from Kaggle to run regressions. It includes 5891 original data on real estate sold in Daegu, South Korea, with their prices, sizes, floor, and other elements that might influence transactions. The sample is large enough to make the research creditable, with nearly 29 statistics items to make the research reliable. It meets the requirements to be good secondary data.

4. Methodology

Regression is a statistical method to analyze the linear relationship between a dependent variable and several independent variables. The equation, one of the most important outcomes of the regression, is to estimate the value of the dependent variable with all the independent variables. In this research, the sale price of real estate is the dependent variable, and regression is used to find the factors that have the most significant impact on the sale price of real estate. In this research, we select ten numeric and three descriptive independent variables. As for the descriptive data, they are transformed into 0 and 1 to do the later process.

After selecting independent variables, we use a correlation matrix to ensure factors are not highly correlated, making the regression more accurate. Next, run a regression to see whether the whole model and each independent variable are statistically significant. If some independent variables have p-values greater than 0.05, they need to be removed or transformed, like LOG, LN, SQUARE ROOT transformation, etc. Then, run a new regression to find a better Adjusted R Square, which means the model is superior to the former. When all the p-values become lower than 0.05, it comes with a suitable regression. However, there are still some methods to explore a better model. For example, histograms could demonstrate the distribution of all the variables, which helps to select if any variable needs to be processed. Additionally, collecting more relevant data to build new regression models is always feasible but costly and time-consuming. The regression with the highest Adjusted R Square would be the optimal choice.

Finally, we get the optimal model and establish the equation between the sale price and influencing factors. Also, the factors significantly affect the sale price can be ranked. Then, conclusions based on them will focus on these factors to seek more profitable real estate.

5. Application of Multiple Regression

To better understand the application of multiple regression in analyzing factors affecting real estate prices, we discuss an example in Daegu, Korea. The multiple regression intends to explain to what extent different factors play a role in making up the sale price. In other words, the rank of factors when investing in real estate. The analysis reveals which factors buyers pay for their houses, apartments, building, etc. The likely factors that influenced price are gathered. The study begins with a close examination of the correlation between independent variables (factors related to size, number of nearby facilities, number of nearby schools, floor, hallway type, heating type, etc.) and the dependent variable (sale price of real estate in Daegu from 2007 to 2017).

According to Table 1, the correlation matrix shows that the correlation between variables is good. Even if the correlation coefficient between the number of schools nearby and the number of facilities nearby is high, with a figure of 0.806516, it is still acceptable. Before we exercise multiple regression,

DOI: 10.54254/2754-1169/18/20230106

we transform these three descriptive variables (hallway type, heating type, and Apartment Management type) into 0 and 1 using the if function. Then, we get the initial regression.

Table 1: Correlation matrix of variables.

	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
Y	1.00									
X_1	0.70	1.00								
X_2	0.34	0.18	1.00							
X_3	-0.13	0.19	-0.12	1.00						
X_4	0.47	0.18	0.33	-0.39	1.00					
X_5	0.16	0.03	0.14	0.16	0.67	1.00				
X_6	0.36	0.29	0.25	0.04	0.70	0.61	1.00			
X_7	0.21	0.24	0.03	0.56	0.19	0.51	0.56	1.00		
X_8	-0.42	-0.26	-0.09	0.12	0.04	0.25	0.14	0.04	1.00	
X_9	-0.38	-0.27	-0.04	0.07	0.15	0.43	0.17	0.06	0.81	1.00

i.e., Y Sale Price of real estate; X_1 Size (SQF); X_2 Floor; X_3 Number of Parking lots (Ground); X_4 Number of Parking lots (basement); X_5 Number of Apartments; X_6 Number of Managers; X_7 Number of Elevators; X_8 Number of Facilities Nearby (Total); X_9 Number of Schools Nearby (Total).

According to Table 2-Table 4, the results show that the R-square figure is 0.747666, which means that the prediction power of these independent variables is so high that they could explain the price to the extent of 77.77% as a positive signal. In addition, the figure of Significance F is 0, which means that the whole model is statistically significant in explaining the dependent variable price, which is also a positive signal. As for P-value tests of variables, that figure is uncommon for size (SQF), with a figure of 0. To illustrate this, we make a simple regression only between size and sale price.

Table 2: Initial regression of variables-Regression statistics.

Regression Statistics	
Multiple R	0.864677
R Square	0.747666
Adjusted R Square	0.747107
Standard Error	53498.93
Observations	5891

Table 3: Initial regression of variables-ANOVA (model).

	df	SS	MS	F	Significance F
Regression	13	4.98E+13	3.83E+12	1339.502	0
Residual	5877	1.68E+13	2.86E+09		
Total	5890	6.67E+13			

Table 4: Initial regression of variables-ANOVA (variables).

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	-120222.11	12317.05	-9.76	2.45E-22	-144368.05	-96076.16
X_1	156.25	2.31	67.74	0	151.73	160.78
X_2	1410.49	100.53	14.03	5.21E-44	1213.40	1607.57
X_3	-50.16	6.17	-8.13	5.16E-16	-62.25	-38.06

DOI: 10.54254/2754-1169/18/20230106

Table 4: (continued).

X_4	-24.75	7.78	-3.18	0.001465	-40.00	-9.51
X_5	13570.78	873.08	15.54	2.01E-53	11859.22	15282.34
X_6	1993.31	527.82	3.78	0.000161	958.59	3028.03
X_7	-1034.66	215.65	-4.80	1.64E-06	-1457.42	-611.90
X_8	4664.22	568.08	8.21	2.68E-16	3550.57	5777.87
X_9	-6191.87	403.90	-15.33	4.83E-52	-6983.66	-5400.08
X_{10}	75366.14	4982.00	15.13	9.51E-51	65599.59	85132.70
X_{11}	-21801.06	3264.87	-6.68	2.65E-11	-28201.41	-15400.72
X_{12}	108563.98	7295.99	14.88	3.47E-49	94261.15	122866.80
X_{13}	12559.12	4023.60	3.12	0.001809	4671.38	20446.85

i.e., Y Sale Price of real estate; X_1 Size (SQF); X_2 Floor; X_3 Number of Parking lots (Ground); X_4 Number of Parking lots (basement); X_5 Number of Apartments; X_6 Number of Managers; X_7 Number of Elevators; X_8 Number of Facilities Nearby (Total); X_9 Number of Schools Nearby (Total); X_{10} Terraced Hallway; X_{11} Mixed Hallway; X_{12} Individual Heating; X_{13} Self-Management.

According to Table 5-Table 7, it turns out that it is reasonable for the p-value of size to be equal to 0 in the initial multiple regression model. It means that size can 100% explain the price.

Table 5: Simple regression of size and sale Price-Regression statistics.

Regression Statistics	
Multiple R	0.697199
R Square	0.486086
Adjusted R Square	0.485999
Standard Error	76270.92
Observations	5891

Table 6: Simple regression of size and sale Price-ANOVA (model).

	df	SS	MS	F	Significance F
Regression	1	3.24E+13	3.24E+13	5570.126	0
Residual	5889	3.43E+13	5.82E+09		
Total	5890	6.67E+13			

Table 7: Simple regression of size and sale Price-ANOVA (variables).

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	35905.35	2674.446	13.42534	1.68E-40	30662.45	41148.24
X_1	193.9292	2.598428	74.63327	0	188.8353	199.0231

i.e., X_1 Size (SQF).

So far, the initial regression model should be the optimal choice, and the equation is as follows:

$$Y = -120222 + 156.25X1 + 1410.49X2 - 50.06X3 - 24.75X4 + 13570.78X5 + 1993.31X6 - 1043.66X7 + 4664.22X8 - 6191.87X9 + 75366.14X10 - 21801.10X11 + 108564X12 + 12559.12X13$$

i.e., X_1 Size (SQF).

X_2 Floor.

X_3 Number of Parking lots (Ground).

DOI: 10.54254/2754-1169/18/20230106

X_4 Number of Parking lots (Basement).
X_5 Number of Apartments.
X_6 Number of Managers.
X_7 Number of Elevators.
X_8 Number of Facilities Nearby (Total).
X_9 Number of Schools Nearby (Total).
X_{10} Terraced Hallway.
X_{11} Mixed Hallway.
X_{12} Individual Heating.
X_{13} Self-Management.

Focusing on the slope of the equation, we could understand for each factor, changes in one unit lead to a variation in price by a certain amount. Other than viewing the correlation coefficient as the slope of the equation, it also reveals the opportunity cost of using different variables. For example, if real estate chooses to provide central heating rather than individual ones, the sale price decreases by 108564, according to its correlation coefficient.

6. Discussions and Findings

There are numerous ways to optimize multiple regression. We attempt to optimize the model by changing variable distributions and the number of relevant variables. Since adding correlated variables requires more data to run new models, this paper will only discuss the possibility of optimizing the regression by optimizing the distributions of some independent variables. To be detailed, using a LOG transformation ensures variable distributions are more likely normal distributions. To begin with, charting histograms to decide which variable to introduce log transformation (see Figure 1-Figure 10).

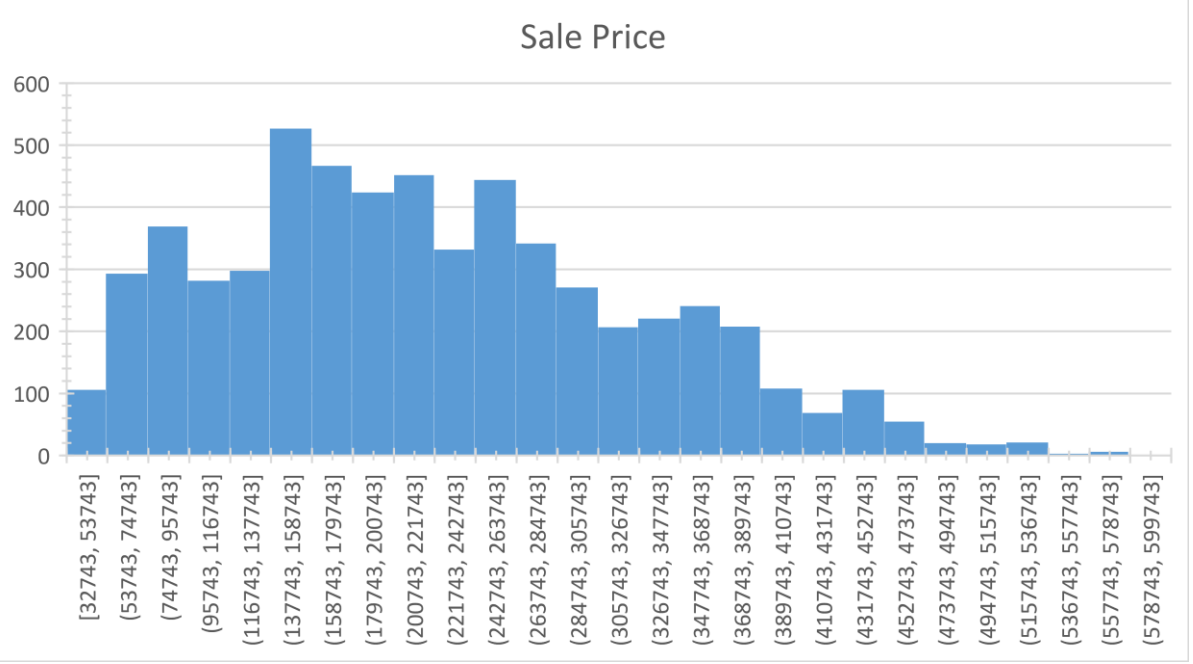

Figure 1: Histogram of sale price.

DOI: 10.54254/2754-1169/18/20230106

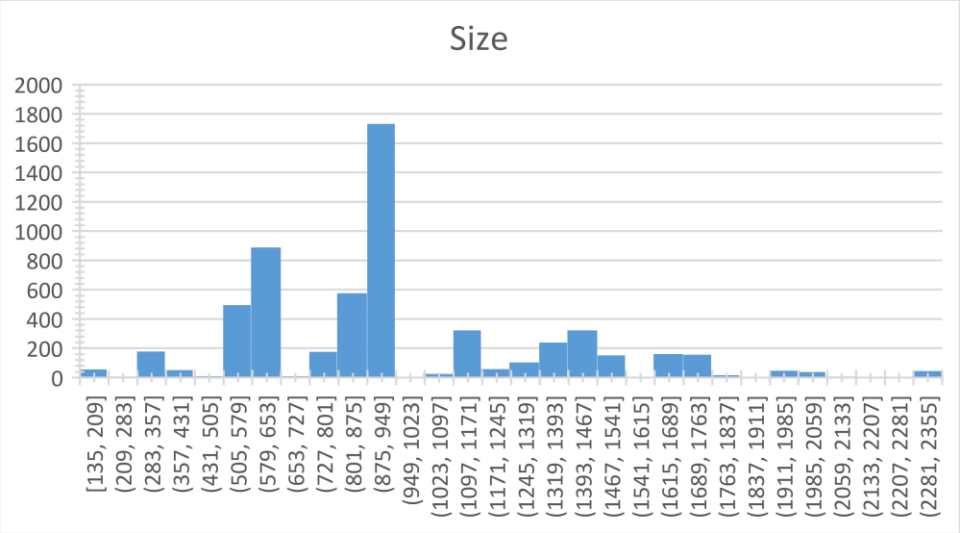

Figure 2: Histogram of size.

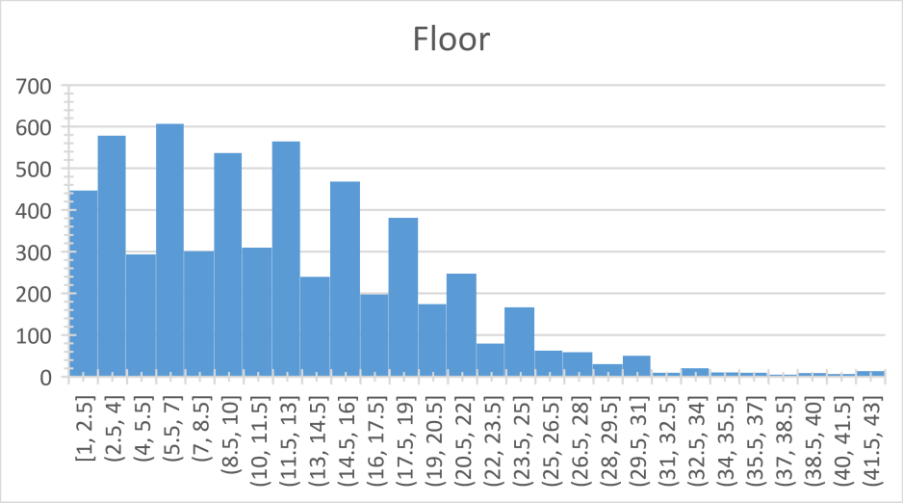

Figure 3: Histogram of floor.

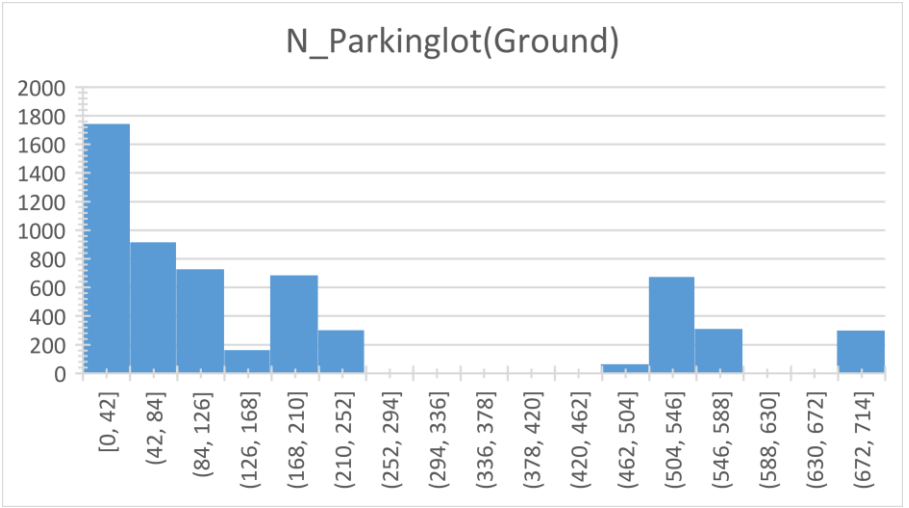

Figure 4: Histogram of the number of parking lots (Ground).

DOI: 10.54254/2754-1169/18/20230106

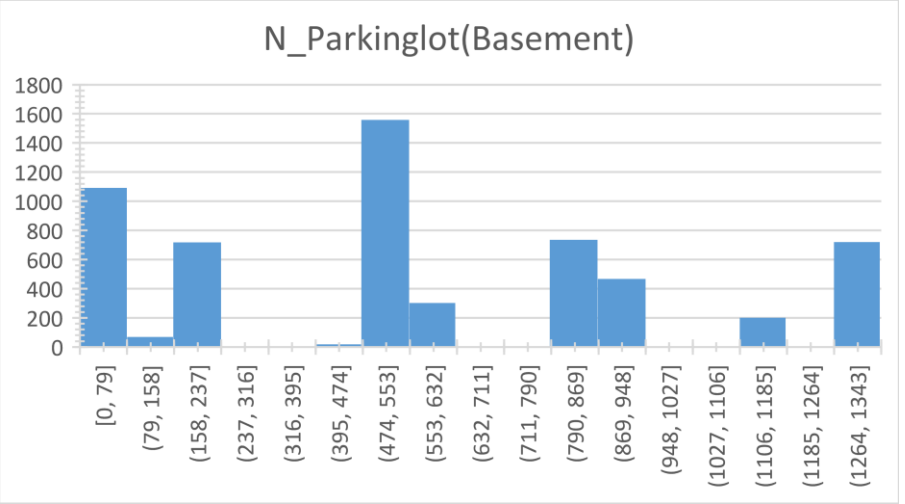

Figure 5: Histogram of the number of parking lots (Basement).

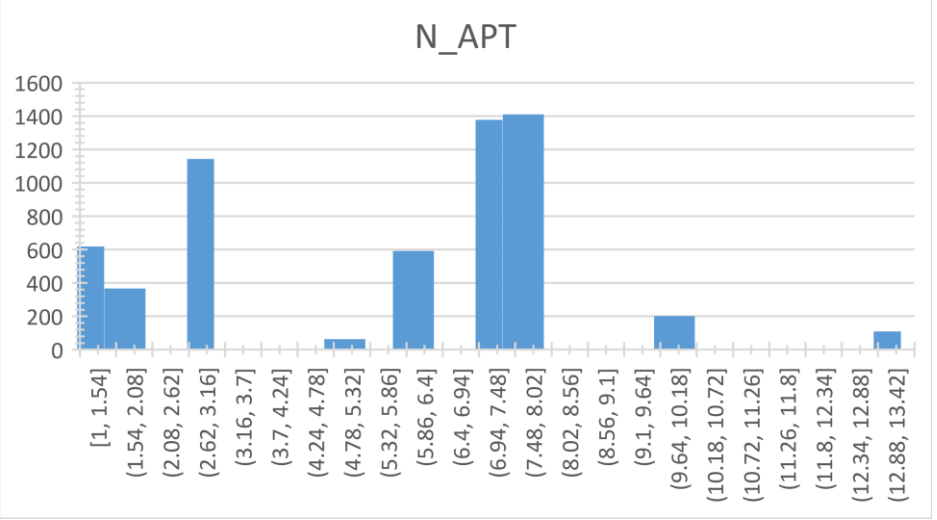

Figure 6: Histogram of the number of apartments.

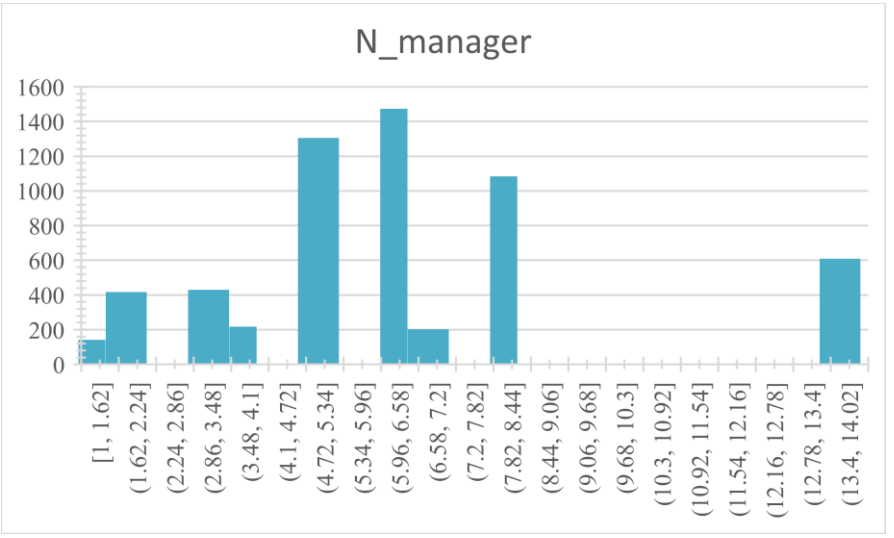

Figure 7: Histogram of the number of managers.

DOI: 10.54254/2754-1169/18/20230106

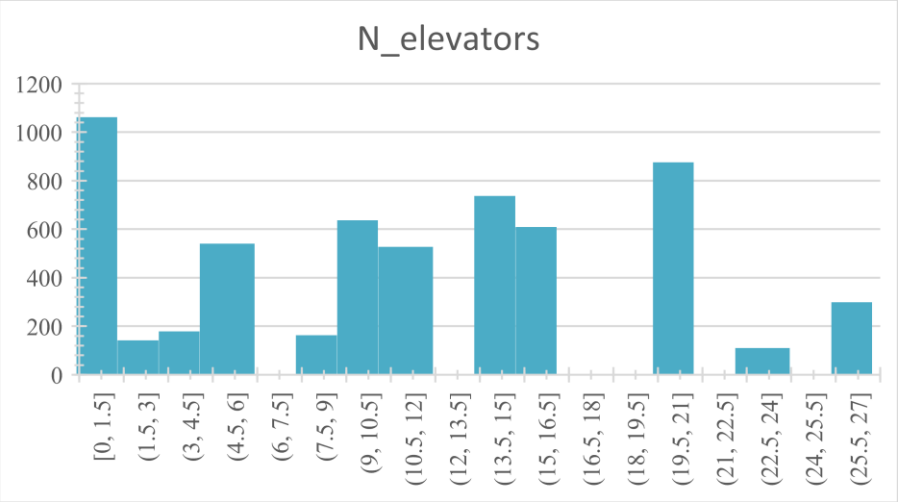

Figure 8: Histogram of the number of elevators.

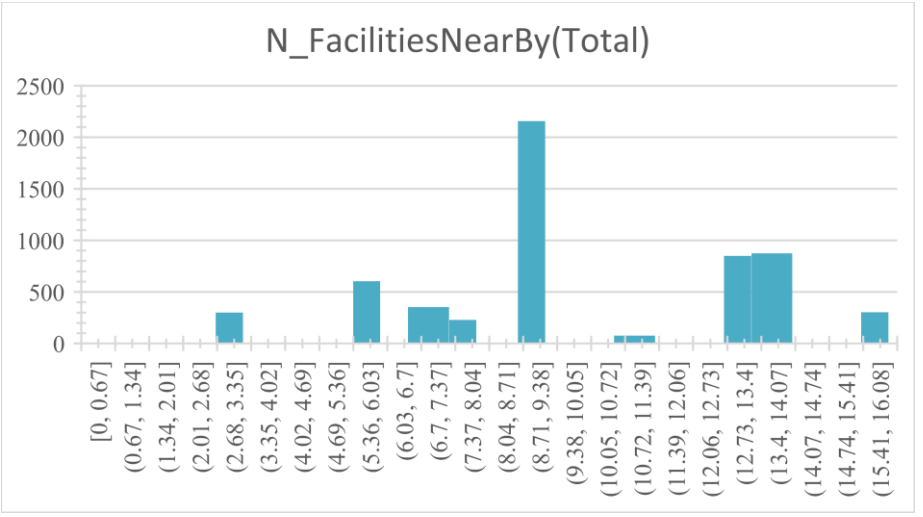

Figure 9: Histogram of the number of facilities nearby (Total).

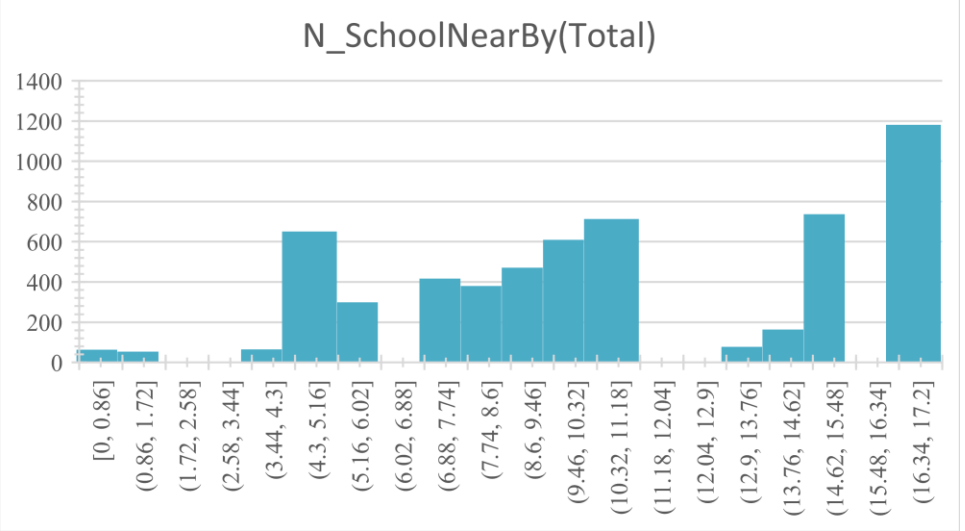

Figure 10: Histogram of the number of schools nearby (Total).

DOI: 10.54254/2754-1169/18/20230106

Based on all Figures above (Figure11-Figure16), independent variables for Floor, Number of Parking lots (Ground), Number of Parking lots (Basement), Number of Managers, Number of Elevators, and Number of Schools Nearby (Total) need LOG transformation (see Figure11-Figure16).

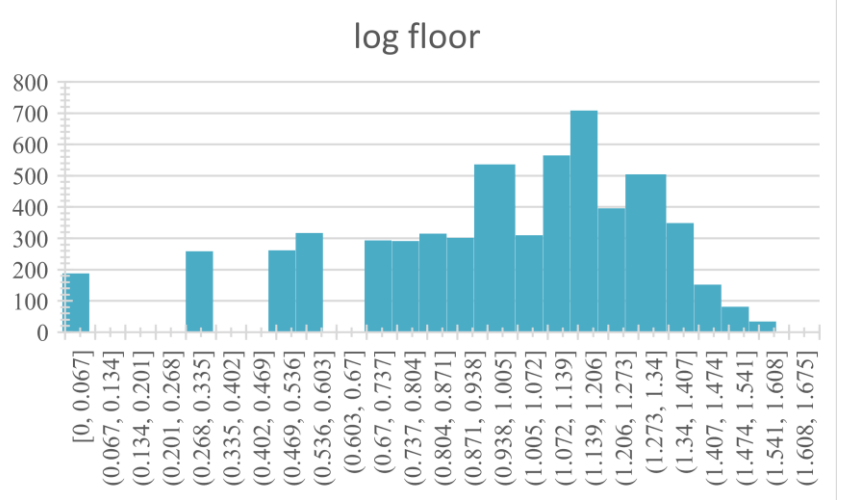

Figure 11: Histogram of LOG (Floor).

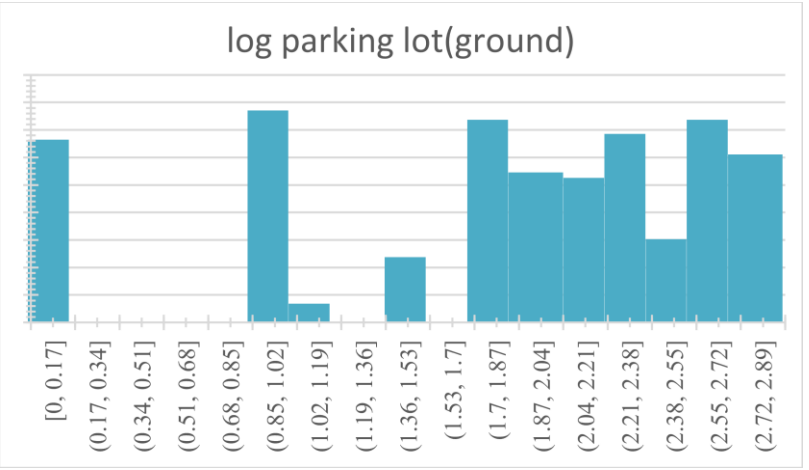

Figure 12: Histogram of LOG (number of parking lots (Ground)).

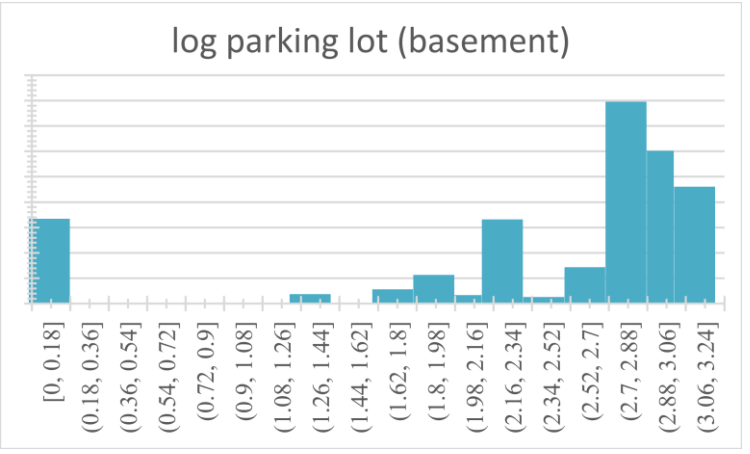

Figure 13: Histogram of LOG (number of parking lots (Basement)).

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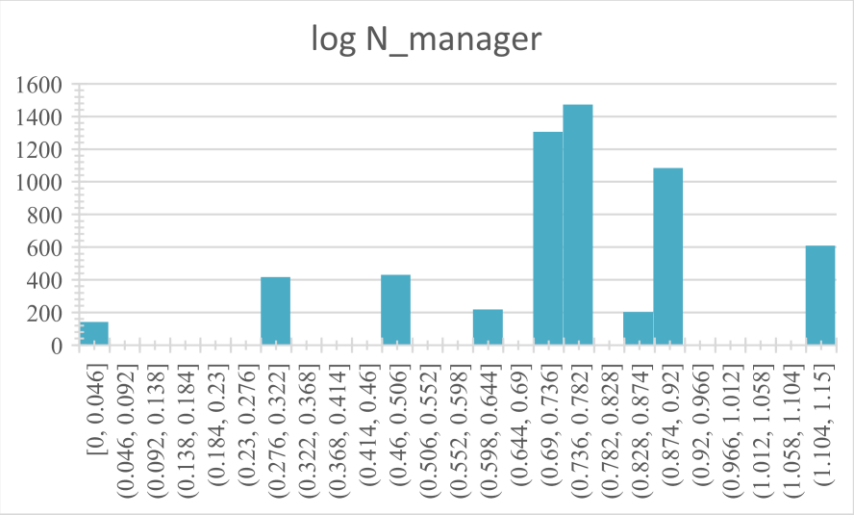

Figure 14: Histogram of LOG (number of managers).

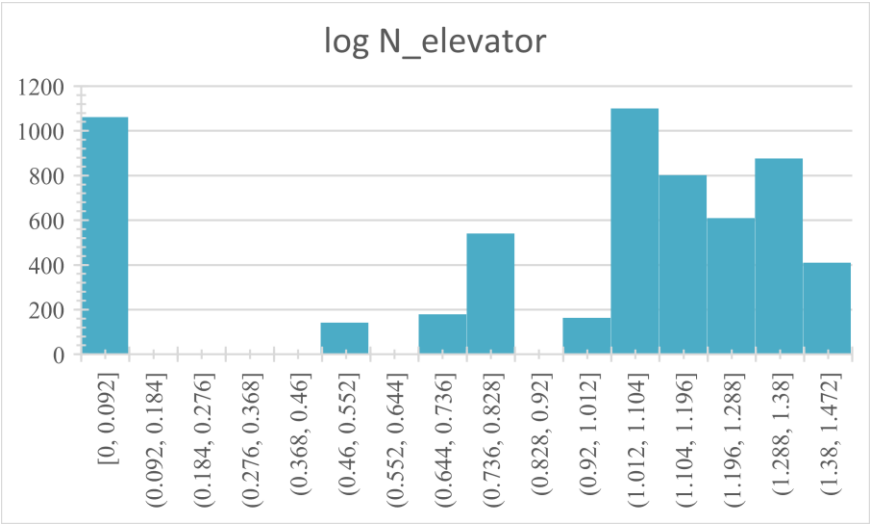

Figure 15: Histogram of LOG (number of elevators).

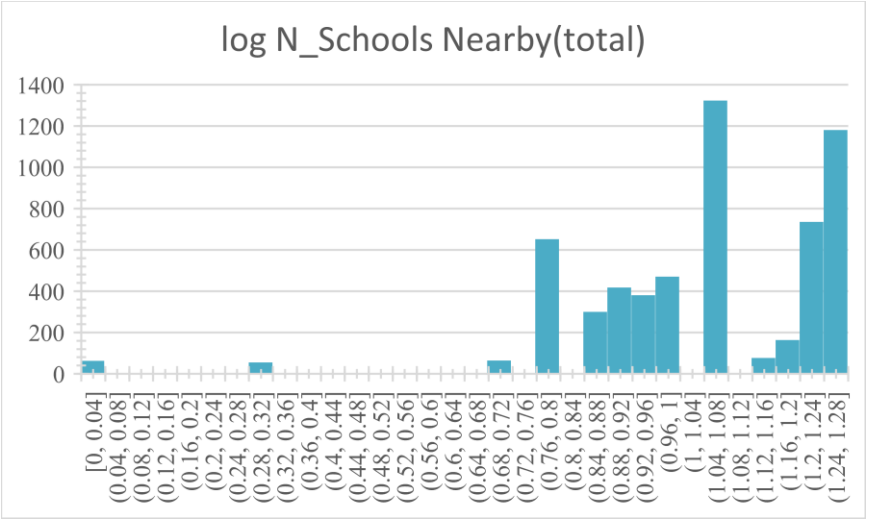

Figure 16: Histogram of LOG (number of schools nearby (Total)).

DOI: 10.54254/2754-1169/18/20230106

Based on the above (Figure 11-Figure 16), the result shows that not all the distribution changes are favorable. Before regression, a new correlation matrix is necessary to examine whether variables have met the lowest standard for the model. The criteria require the correlation coefficient for each variable should be lower than 0.9 (see Table 8).

Table 8: Correlation matrix after LOG transformation.

	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
Y	1.00									
X_1	0.70	1.00								
X_2	0.26	0.11	1.00							
X_3	-0.32	-0.06	-0.17	1.00						
X_4	0.40	0.17	0.28	-0.39	1.00					
X_5	0.16	0.03	0.10	0.06	0.38	1.00				
X_6	0.33	0.26	0.17	-0.25	0.34	0.72	1.00			
X_7	0.27	0.30	0.00	0.11	-0.09	0.25	0.43	1.00		
X_8	-0.42	-0.26	-0.06	0.16	-0.15	0.25	0.20	-0.08	1.00	
X_9	-0.32	-0.19	-0.04	0.14	0.06	0.39	0.23	-0.02	0.73	1.00

i.e., Y Sale Price of real estate; X_1 Size (SQF); X_2 LOG (Floor); X_3 LOG (Number of Parking lots (Ground)); X_4 LOG (Number of Parking lots (basement)); X_5 Number of Apartments; X_6 LOG (Number of Managers); X_7 LOG (Number of Elevators); X_8 Number of Facilities Nearby (Total); X_9 LOG (Number of Schools Nearby (Total)).

The results of Table 8 shows that the correlation between variables is appropriate. Then run a regression with variables under LOG transformation (see Table 9-Table 11).

Table 9: Regression of variables after LOG Transformation-Regression statistics.

Regression Statistics	
Multiple R	0.868643
R Square	0.754541
Adjusted R Square	0.753998
Standard Error	52765.02
Observations	5891

Table 10: Regression of variables after LOG transformation-ANOVA (model).

	df	SS	MS	F	Significance F
Regression	13	5.03E+13	3.87E+12	1389.686	0
Residual	5877	1.64E+13	2.78E+09		
Total	5890	6.67E+13			

Table 11: Regression of variables after LOG Transformation-ANOVA (variables).

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	-79360.30	8717.68	-9.10	1.18E-19	-96450.16	-62270.45
X_1	160.17	2.20	72.79	0	155.86	164.48
X_2	24775.58	2120.38	11.68	3.38E-31	20618.87	28932.30
X_3	-11394.11	1212.95	-9.39	8.1E-21	-13771.94	-9016.29
X_4	-19819.67	2243.84	-8.83	1.33E-18	-24218.42	-15420.92
X_5	13327.27	492.76	27.05	6.1E-152	12361.29	14293.25

DOI: 10.54254/2754-1169/18/20230106

Table 11: (continued).

X_6	-1964.07	5854.14	-0.34	0.73726	-13440.33	9512.20
X_7	-24706.36	2176.90	-11.35	1.51E-29	-28973.88	-20438.84
X_8	4826.71	420.94	11.47	4.05E-30	4001.51	5651.90
X_9	-129135.54	5759.13	-22.42	6.5E-107	-140425.56	-117845.52
X_{10}	115840.42	5244.19	22.09	6.2E-104	105559.88	126120.96
X_{11}	5406.98	4554.25	1.19	0.235182	-3521.02	14334.98
X_{12}	162068.27	7270.70	22.29	9.9E-106	147815.02	176321.52
X_{13}	17406.75	3769.03	4.62	3.95E-06	10018.06	24795.44

i.e., Y Sale Price of real estate; X_1 Size (SQF); X_2 LOG (Floor); X_3 LOG (Number of Parking lots (Ground)); X_4 LOG (Number of Parking lots (basement)); X_5 Number of Apartments; X_6 LOG (Number of Managers); X_7 LOG (Number of Elevators); X_8 Number of Facilities Nearby (Total); X_9 LOG (Number of Schools Nearby (Total)); X_{11} Mixed Hallway; X_{12} Individual Heating; X_{13} Self-Management.

As shown in Table 11 above, the variable LOG (Number of Managers) fails to pass the P-value test; the model still has room to improve (see Table 12-Table 14).

Table 12: Regression of variables after LOG transformation (without X_6)-Regression statistics.

Regression Statistics	
Multiple R	0.868641
R Square	0.754537
Adjusted R Square	0.754035
Standard Error	52761.04
Observations	5891

i.e., X_6 LOG (Number of Managers).

Table 13: Regression of variables after LOG transformation (without X_6)-ANOVA (variables).

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	-80381.72	8168.18	-9.84	1.12E-22	-96394.35	-64369.08
X_1	160.01	2.15	74.57	0	155.80	164.21
X_2	24703.16	2109.20	11.71	2.46E-31	20568.35	28837.97
X_3	-11197.16	1061.34	-10.55	8.62E-26	-13277.77	-9116.54
X_4	-19873.92	2237.84	-8.88	8.68E-19	-24260.90	-15486.94
X_5	13240.45	419.30	31.58	2.7E-202	12418.46	14062.44
X_7	-24997.66	1996.10	-12.52	1.58E-35	-28910.75	-21084.57
X_8	4804.21	415.53	11.56	1.38E-30	3989.61	5618.80
X_9	-129021.58	5748.68	-22.44	4.2E-107	-140291.10	-117752.06
X_{10}	115909.69	5239.73	22.12	3.2E-104	105637.90	126181.49
X_{11}	5358.36	4551.60	1.18	0.239144	-3564.44	14281.17
X_{12}	162469.05	7171.36	22.66	5.1E-109	148410.56	176527.55
X_{13}	17593.09	3727.60	4.72	2.42E-06	10285.61	24900.56

i.e., Y Sale Price of real estate; X_1 Size (SQF); X_2 LOG (Floor); X_3 LOG (Number of Parking lots (Ground)); X_4 LOG (Number of Parking lots (basement)); X_5 Number of Apartments; X_6 LOG (Number of Managers); X_7 LOG (Number of Elevators); X_8 Number of Facilities Nearby (Total); X_9 LOG (Number of Schools Nearby (Total)); X_{11} Mixed Hallway; X_{12} Individual Heating; X_{13} Self-Management.

DOI: 10.54254/2754-1169/18/20230106

Table 14: Regression of variables after LOG transformation (without X_6)-ANOVA (model).

	Df	SS	MS	F	Significance F
Regression	11	5.03E+13	4.57E+12	1642.361	0
Residual	5879	1.64E+13	2.78E+09		
Total	5890	6.67E+13			

i.e., X_6 LOG (Number of Managers).

In this scenario, the Mixed Hallway should be removed, as the requirement of the P-value test is that the figure is supposed to be under 0.05. After deleting this variable, we finally get the optimal regression (see Table 15-Table 17).

Table 15: Regression of variables after LOG transformation (without X_{11})-Regression statistics.

Regression Statistics	
Multiple R	0.868607
R Square	0.754479
Adjusted R Square	0.754019
Standard Error	52762.77
Observations	5891

i.e., X_{11} Mixed Hallway.

Table 16: Regression of variables after LOG transformation (without X_{11})-ANOVA (model).

	Df	SS	MS	F	Significance F
Regression	12	5.02979E+13	4.19149E+12	1505.711647	0
Residual	5878	1.63627E+13	2783727250		
Total	5890	666606E+13			

i.e., X_{11} Mixed Hallway.

Table 17: Regression of variables after LOG transformation (without X_{11})-ANOVA (variables).

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	-77705.30	7845.67	-9.90	6.03069E-23	-93085.70	-62324.89
X_1	160.41	2.12	75.72	0	156.26	164.56
X_2	24575.39	2106.48	11.67	4.14956E-31	20445.92	28704.86
X_3	-10731.09	984.77	-10.90	2.17269E-27	-12661.61	-8800.58
X_4	-17958.04	1536.09	-11.69	3.14319E-31	-20969.34	-14946.74
X_5	13161.44	413.91	31.80	6.8859E-205	12350.02	13972.86
X_7	-24916.79	1994.98	-12.49	2.37911E-35	-28827.69	-21005.89
X_8	4748.64	412.86	11.50	2.71525E-30	3939.29	5557.98
X_9	-127270.26	5553.04	-22.92	2.028E-111	-138156.25	-116384.27
X_{10}	110962.86	3130.22	35.45	1.2558E-249	104826.46	117099.25
X_{12}	157524.88	5813.13	27.10	1.7405E-152	146129.00	168920.76
X_{13}	17274.29	3717.88	4.65	3.45348E-06	9985.88	24562.70

i.e., Y Sale Price of real estate; X_1 Size (SQF); X_2 LOG (Floor); X_3 LOG (Number of Parking lots (Ground)); X_4 LOG (Number of Parking lots (basement)); X_5 Number of Apartments; X_7 LOG (Number of Elevators); X_8 Number of Facilities Nearby (Total); X_9 LOG (Number of Schools Nearby (Total)); X_{11} Mixed Hallway; X_{12} Individual Heating; X_{13} Self-Management.

Compared with the Adjusted R Square shown in Table 2, the figure of the optimal regression has nearly increased by 0.007. Thus, optimizing the regression by changing the distribution of its variables is feasible.

DOI: 10.54254/2754-1169/18/20230106

7. Conclusion

Buying a home is one of the most important financial transactions in an individual's life. One of the critical decisions homeowners make when selling their homes is choosing an initial listing price. Given the magnitude of house price changes, even a tiny percentage change in the final sale price can translate into a considerable amount. Therefore, sellers must choose a listing price that maximizes the final price. The study used 5891 real estate properties in Daegu, Korea. This paper aims to illustrate how a regression model can be used to analyze house prices using the regression model. As shown by the equation, size, floor, number of parking spaces, number of managers, and elevators positively correlate with the sale price, which means as those variables increase, the price will rise as well. Investors or entrepreneurs will notice which parts are essential in this case. The outliers in our house data can perfectly explain the primary element of price because all the data is the same except the size. After using a log for the histogram graphs, it is easy to obtain the distribution of each variable. We found a statistically significant relationship between these independent variables and real estate unit values from the analysis results.

However, there is still some room for improvement in our research. We fail to exclude outliers which would impose an undue influence on the whole model. Moreover, we lack further analysis on some real estate sold more than once. These data only vary in the Sale Price, Year Sold, and Month Sold, while other factors remained the same. All these limitations could be developed in future studies.

Acknowledgment

Minyi Jin, Qisong Zhou, Mingyang Fang and Xinyu Xing contributed Queally to this work and should be considered co-first authors.

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