VIETNAM NATIONAL UNIVERSITY – HO CHI MINH CITY
INTERNATIONAL UNIVERSITY
DEPARTMENT OF MATHEMATICS

REPORT

Analyzing House Prices in District 7 HCMC Using Linear Regression Model

Lecturer: Dr. Nguyen Phuong Anh

Group Members: Tran Thanh Dat - MAMAIU17036
Tran Viet Hang - MAMAIU18079

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Thank you very much!

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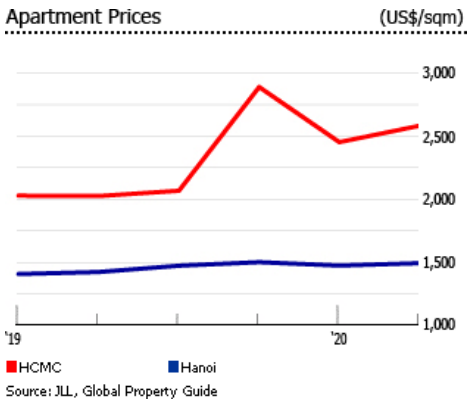
Chapter 1

INTRODUCTION

1.1 An overview of house price in Ho Chi Minh City

Vietnam is emerging as a thriving and fast-growing high end real estate market in South-east Asia. With a fast growing economy, improving legal real estate policies, rising FDI and growing number of local millionaires, it is now widely seen as a luxury real estate hotspot.

In Ho Chi Minh City, apartment prices surged 27.5% in Q2 2020 from a year earlier (23.6% inflation-adjusted), to an average of US$2,582 per square metre, according to JLL Vietnam. Quarter-on-quarter, apartment prices in the city increased 5.3% in Q2 (6.3% inflation-adjusted).



Likewise in Hanoi, property prices have been continuously rising, albeit at a slower pace. The average price of apartments in the capital rose by 4.9% y-o-y (1.7% inflation-adjusted) to US$1,493 per sq. m. in Q2 2020. On a quarterly basis, prices increased 1.3% during the latest quarter (2.2% inflation-adjusted).

Viet Nam is having much attention from overseas real estate investors who come from

more mature Asia-Pacific markets with more limited real estate growth potential such as Japan and South Korea. Increasing numbers of Japanese and Korean investors are looking to the local market, assessing land options at the right price.

1.2 Research objectives

For the above reasons, it is very important to understand the house price as well as which factors determine it. This paper aims to investigate the determinants of house price in District 7, Ho Chi Minh City, which many Korean people are living in. Through that, it also measures the level of influence of these determinants as well as estimate the implicit prices. Finally, the result and finding from this research could introduce some implications in term of smart real estate investment and policies.

It could be employed as a reference for accommodation developers, planners or house investors to understand the property market in Vietnam. In other words, the findings in this study could assist their decision-making for investment strategies or development plan. Besides, along with the serve shortage of houses in this city, it is time for local authorities to come up with feasible solutions to tackle it and accommodate their citizens. Furthermore, data in this research could be referenced to understand factors causing houses unaffordable and whether they could adjust it. Additionally, it can also be referenced as literature for further research about this sector in Ho Chi Minh city. In fact, although there are many papers about prices of apartments, there is not sufficient research about house price in the specific district of this city. It could be the difficulty in data collection and the heterogeneity of each variable in this sector. Hopefully, the completion of this research could contribute to the limited literature in this field.

1.3 Research questions

The research aims to answer the following research questions:

1. What are the determinant to the house price in District 7, Ho Chi Minh city?
2. Does the difference among house price reflect the difference among the attributes significantly?
3. How do the attributes contribute to the house price in District 7, Ho Chi Minh city and what is the importance of the attributes?

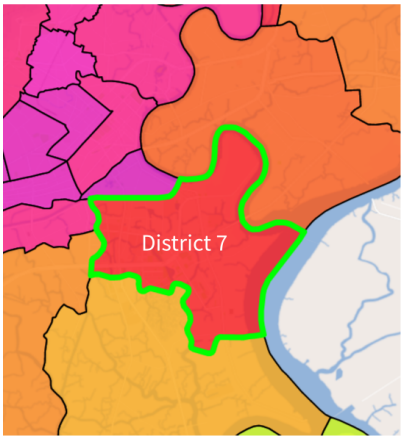
The rest of the research is organized as follows: section 2 discusses literature about previous papers about house price in Ho Chi Minh city context and other important concepts. Section 3 presents the data collection process, database use and methodology employed to understand determinants of house price. Section 4 discusses the result and findings. The theories and formulas presented in Section 2 will be applied to let us know which aspects have a big impact on house prices. Finally, section 5 concludes the research.

Chapter 2

LITERATURE REVIEW

2.1 Current house prices in Ho Chi Minh City

Due to high population density and limited land resources, new housing projects in Ho Chi Minh city are usually concentrated on suburban districts such as district 7 where land price is lower than that in the urban areas. Villa and houses in the new projects here are competitors for luxurious and high-class apartments in the city center. With a budget of from 100.000 USD to 200.000 USD, people can buy a detached house or a villa in these areas – equal with an average to a small apartment in the urban districts.



For the limitation of land resource, there are more apartment than house projects in Ho Chi Minh city. Price of these projects varies from 800 USD/m2 to more than 2500 USD/m2. In details, prices of a luxurious apartment in the new residential area – Phu My Hung of district 7 are more than 2500USD/m2. The high-class apartment is about 1400-2500USD/m2, average apartment is from 800 – 1400 USD/m2 and price for a low-cost apartment is around 800 USD/m2. [1]

2.2 Former studies about property prices

Property price has long been studied by economists and researchers worldwide with both macroeconomic and microeconomic perspectives.

In terms of macroeconomic factors, a research by Hort [2] stresses the impact of resident's income, construction cost and user cost on the fluctuation of house price during the given time. Besides interest rate is also emphasized to have long time effect on the increase of house price in this paper. Studying the case of Lithuania from 2008 to 2015, Gasparėnienė, Remeikienė, and Skuka [3] also indicate the impact of interest rate as well as bank loans to the changing of house price in this period. Similar result is also shared by research in the context of Asian countries. One research on this topic in the context of Penang, Malaysia by Kamal, Hassan, and Osmadi [4] mentions that from developers' points of view, location, macroeconomic factors, demographic factors, and industry factors have strong impacts to house price in this city. In specific, macroeconomics factors include interest rate and inflation rate, etc while demographic factors include population rate, resident's lifestyle, the standard of living. Another paper exploring determinants of house price in Shanghai, China applying econometric model by Wang and Jiang [5] identified that variables such as land transaction price, cost of constructing, urbanization rate, investment and CPI of resident have a strong impact on property price in this city. In their paper explaining factors influencing house price in Hangzhou, China, Rahman, Khanam, and Xu [6] employed Ordinary Least Square method to analyze a panel dataset throughout a time span of 20 years commencing from 1990. The paper's finding shows that whereas family's income, the urbanization rate, local government and foreign investment all have positive and significant effect to the price of houses in this city, residents' saving deposits affected negatively to this price.

Aside the macroeconomic factors, microeconomic perspective also plays strong impact to the variation of house price. Studies show that location or accessibility to main public transport highly influence to the house price. In their research about house price in the USA, Sander and Polasky [7] emphasize the correlation of location and the value of house. In other words, the nearer the house to the open space such as lakes, parks or streams is, the more valuable it is. Similar result can also be found in paper in the context of Asian. In their empirical research about urban houses in Hangzhou – China, Wen, Jia and Gou [8] also apply the Hedonic pricing model to determine house characteristics influencing the price. 14 variables were chosen. Variables belong to four groups such as structure (decoration, attic, garage...), neighborhood (environment, inner environment, entertain-

ment....), location (distance to the business district, traffic...) and other characteristics (transition time). The results emphasize the importance of location of house on its price. In details, distance to central business district, West lake and universities nearby, has a negative impact on the price. This means that the further the houses from the central business district area, West Lake and universities, the less expensive they are. Additionally, size of house, rooms and attic also have influence on the house price in this city.

Obviously, house price could be influenced by both macroeconomic and microeconomic factors, depending on the scale of research. About macroeconomic factors, house price is mostly influenced by the payment ability of home-buyers namely their income, interest rate and construction rate of the property. As far as microeconomic perspective is concerned, location and environment are main factors that influence the fluctuation of house price whereas structural factors such as number of rooms and size of the house also have impact but in a smaller scale.

Although studies about determinants of house price all over the world are abundant, this topic in the context of Ho Chi Minh city, espcially district 7, is still limited. Moreover, studies on property price in Ho Chi Minh city just focus on apartment price, not the house price. Beside, area attribute of the property, the number of bedrooms, bathrooms might not have been analyzed deeply in these studies. For these reasons, this paper will fulfill these gap to contribute to the current literature on property price in district 7, Ho Chi Minh city.

Chapter 3

DATA COLLECTION, DESCRIPTION AND DATA ANALYSIS

3.1 Data collection

Data was collected from one of the most famous real-estate platforms in Vietnam, which is www.chotot.com.

On this website, those who want to sell their properties advertise and provide all the information of the properties on the website, then the buyers will contact according to the phone number provided on the website. Variables of observations were collected according to the information provided in these ads. Data was chosen randomly and 81 properties were included in the dataset. Locations of these houses vary among 10 wards of District 7, Ho Chi Minh City.

3.2 Data description

As mentioned in the previous part, there are 81 observations in the dataset. There are 8 variables including dummy variables. These variables include:

- PRICE: Price of the house (dependent variable);
- AREA: Area of the house (estimated in meter square);

- WARD: The ward that the house locates in District 7;
- BEDRMS: The number of bedrooms of the house;
- BATHS: The number of bathrooms of the house;
- ASAP: The level of urgency that sellers want to sell the house;
- WARDPOP: Population of the ward in District 7;
- WARDPRICE: Price of each m^2 of the house in a specific ward of District 7.

3.3 Data analysis

Our research applies the ordinary least square multiple regression approach to analyze factors determing house price in District 7, Ho Chi Minh city. The Ordinary least squares regression approach is a popular and widely-used statistical method of analysis. It is employed to estimate the relationship between one dependent variable to one or more than one independent variable by minimizing the total number of squares between predicted and observed values of dependent variable.
The regression model is linear in the parameters, which is specified in the form:

$$Y = \beta_0 + \sum_{i=1}^{6} \beta_i x_i + u_t, \text{ where:}$$

- Y is the dependent variable;
- x_i is the independent variable;
- β_0 is the intercept;
- β_i is the coefficient of independent variable;
- u_t is the error term.

We have the regression model:

$$\begin{aligned} \text{PRICE} = \beta_0 + \beta_1\text{AREA} + \beta_2\text{BEDRMS} + \beta_3\text{BATHS} + \beta_4\text{ASAP} \\ + \beta_5\text{WARDPOP} + \beta_6\text{WARDPRICE} + u. \end{aligned}$$

In order to build the multiple regression models, it is necessary to check the accuracy of the model with the support of software R, there are five steps to follow, which are: test for the statistical significance, test for heteroscedasticity, test for multicollinearity, test the assumption of normality and test for autocorrelation.

```
Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)  2.190e+10  1.926e+09  11.372  < 2e-16 ***
AREA         4.204e+07  7.689e+06   5.467 5.92e-07 ***
BEDRMS      -7.247e+08  9.708e+07  -7.465 1.32e-10 ***
BATHS       -2.246e+08  9.666e+07  -2.324 0.022899 *
WARDPOP      8.124e+04  2.243e+04   3.622 0.000533 ***
ASAP         1.971e+08  3.582e+08   0.550 0.583788
WARDPRICE    8.767e+00  1.233e+01   0.711 0.479404
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 974900000 on 74 degrees of freedom
Multiple R-squared:  0.858,     Adjusted R-squared:  0.8465
F-statistic: 74.52 on 6 and 74 DF,  p-value: < 2.2e-16
```

Figure 3.1: Multiple regression with six variables
(ASAP, AREA, BEDRMS, BATHS, WARDPRICE, WARDPOP)

Run the regression of house price on ASAP, AREA, BEDRMS, BATHS, WARDPRICE, WARDPOP and test for the significance of the coefficient. The individual significant test and the join significant test are used to test for the statistical significance.

3.3.1 Test for the statistical significance

3.3.1.1. Individual significance test

a) Test for x_1 (AREA)

$H_0 : \beta_1 = 0$. The variable AREA is not relevant to the house price

$H_1 : \beta_1 \neq 0$. The variable AREA is relevant to explain house price

After running the regression of house price on six variables and testing for the significance of the coefficient, it is observed that p-value = 5.92e-07 < 0.05. Hence, H_0 is rejected and this concludes that AREA is relevant in explaining house price.

b) Test for x_2 (BEDRMS)

$H_0 : \beta_2 = 0$. The variable BEDRMS is not relevant to the house price

$H_1 : \beta_2 \neq 0$. The variable BEDRMS is relevant to explain house price

After running the regression of house price on six variables and testing for the significance of the coefficient, it is observed that p-value = 1.32e-10 < 0.05. Hence, H_0 is rejected and this concludes that BEDRMS is relevant in explaining house price.

c) Test for x_3 (BATHS)

$H_0 : \beta_3 = 0$. The variable BATHS is not relevant to the house price

$H_1 : \beta_3 \neq 0$. The variable BATHS is relevant to explain house price

After running the regression of house price on six variables and testing for the significance of the coefficient, it is observed that p-value = 0.022899 < 0.05. Hence, H_0 is rejected and this concludes that BATHS is relevant in explaining house price.

d) Test for x_4 (ASAP)

$H_0 : \beta_4 = 0$. The variable ASAP is not relevant to the house price
$H_1 : \beta_4 \neq 0$. The variable ASAP is relevant to explain house price
After running the regression of house price on six variables and testing for the significance of the coefficient, it is observed that p-value = 0.583788 > 0.05. Hence, H_0 is failed to reject and this concludes that ASAP is not relevant in explaining house price.

e) Test for x_5 (WARDPOP)
$H_0 : \beta_5 = 0$. The variable WARDPOP is not relevant to the house price
$H_1 : \beta_5 \neq 0$. The variable WARDPOP is relevant to explain house price
After running the regression of house price on six variables and testing for the significance of the coefficient, it is observed that p-value = 0.000533 < 0.05. Hence, H_0 is rejected and this concludes that WARDPOP is relevant in explaining house price.

f) Test for x_6 (WARDPRICE)
$H_0 : \beta_6 = 0$. The variable WARDPRICE is not relevant to the house price
$H_1 : \beta_6 \neq 0$. The variable WARDPRICE is relevant to explain house price
After running the regression of house price on six variables and testing for the significance of the coefficient, it is observed that p-value = 0.479404 > 0.05. Hence, H_0 is failed to reject and this concludes that WARDPRICE is not relevant in explaining house price.

3.3.1.2. Joint significance test

The p-value and the critical value of the F-distribution are used for a joint significance test.
$H_0 : \beta_0 = \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = 0$ (i.e. all variables are not jointly relevant to explain house price).
H_1 : Otherwise.

Testing the joint significance of a subset of variables in a regression model is accomplished by generalizing the F-test of overall significance to:

$$F^* \sim F_{1-\alpha,k-1,n-1} \text{ and } A.R = [0, F_{1-\alpha,k-1,n-1}], \text{ where:}$$

- R is the R-squared;
- k is the number of parameters;
- n is the number of observation;
- $F_{1-\alpha,k-1,n-1}$ is the F-distribution.

After running the regression of house price on six variables and testing for the significance of the coefficient, calculations yields $F^* = 74.52$ and A.R $= [0, 2.214]$, implying $F^* \notin$ A.R. Therefore H_0 is rejected.

Besides, p-value of F-statistic of variable is smaller than α (2.2e-16 < 0.05), so H_0 is rejected. Hence, the variables AREA, BEDRMS, BATHS, ASAP, WARDPOP and WARDPRICE are jointly relevant to explain house price.

It can be seen that $\mathbb{R}^2$ (R-squared) $= 0.858$, it means in the regression, AREA, BEDRMS, BATHS, ASAP, WARDPOP and WARDPRICE explain 85.8% of District 7's house price. The goodness of fit of the model is rather good. In the join significance test, the result given is six variables are jointly relevant to explain house price, however, in the individual significant test, the two variables which are ASAP and WARDPRICE have no statistically significant meaning with house price. Hence, the multiple regression after removing two variables which are not significant (ASAP and WARDPRICE) is as follows:

$$\text{PRICE} = \beta_0 + \beta_1\text{AREA} + \beta_2\text{BEDRMS} + \beta_3\text{BATHS} + \beta_4\text{WARDPOP} + \text{u}.$$

```
Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  2.303e+10  1.190e+09  19.349  < 2e-16 ***
AREA         4.136e+07  7.558e+06   5.473 5.48e-07 ***
BEDRMS      -7.184e+08  9.499e+07  -7.563 7.52e-11 ***
BATHS       -2.319e+08  9.298e+07  -2.494 0.014786 *
WARDPOP      8.192e+04  2.186e+04   3.748 0.000345 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 967200000 on 76 degrees of freedom
Multiple R-squared:  0.8565,    Adjusted R-squared:  0.8489
F-statistic: 113.4 on 4 and 76 DF,  p-value: < 2.2e-16
```

Figure 3.2: Multiple regression with four variables (AREA, BEDRMS, BATHS, WARDPOP)

3.3.2 Test for heteroscedasticity

The auxiliary regression:

$$\hat{u}_i = a_1 + a_2\text{AREA} + a_3\text{BEDRMS} + a_4\text{BATHS} + a_5\text{WARDPOP} + a_6\text{AREA}^2 + a_7\text{BEDRMS}^2 + a_8\text{BATHS}^2 + a_9\text{WARDPOP}^2 + a_{10}\text{AREA} * \text{BEDRMS} * \text{BATHS} * \text{WARDPOP} + v_i.$$

Here v_i is a normally distributed disturbance term independent of u_i.
$H_0 : a_2 = a_3 = a_4 = a_5 = 0 \rightarrow \hat{u}_i = a_1$. There is homoscedasticity in the model.
$H_1 : H_0$ false. There is heteroscedasticity in the model.

```
        studentized Breusch-Pagan test

data:  ReturnReg
BP = 18.989, df = 19, p-value = 0.4576
```

Figure 3.3: Breusch-Pagan Test conducted on R

After running Breusch-Pagan test, it is observed that p-value = 0.4576 > 0.05. Hence, H_0 is accepted and this research concludes that there is homoscedasticity in the model.

3.3.3 Test for multicollinearity

```
              AREA     BEDRMS      BATHS    WARDPOP
AREA     1.0000000  0.1214834  0.1829282 -0.1356163
BEDRMS   0.1214834  1.0000000  0.7832158 -0.7184542
BATHS    0.1829282  0.7832158  1.0000000 -0.6467865
WARDPOP -0.1356163 -0.7184542 -0.6467865  1.0000000
```

Figure 3.4: Correlations of 4 significant variables
(AREA, BEDRMS, BATHS, WARDPOP)

```
> vif(ReturnReg)
    AREA   BEDRMS    BATHS  WARDPOP
1.037913 3.240699 2.735727 2.152160
```

Figure 3.5: VIF of 4 significant variables
(AREA, BEDRMS, BATHS, WARDPOP)

From figure 3 and figure 4, we can see that four independent variables AREA, BEDRMS, BATHS and WARDPOP do not have strong and perfect correlation to the others. For instance, the case of the number of bedrooms of the house and the number of bathrooms (0.7832). It means that the more bedrooms the house has, the more tendency it has more bathrooms. Calculating VIF of 4 variables helps us figure out that there is no multicollinearity in our regression model because they are all below 5.

3.3.4 Test for assumption of normality

The Jarque-Bera (JB) is used for testing the assumption of normality in the residual. Based on R, the regression is done:

$$\log(y_i) = \beta_0 + \beta_1 \log(x_1) + \beta_2 \log(x_2) + \beta_3 \log(x_3) + \beta_4 \log(x_4) + u_i.$$

```
        Jarque Bera Test

data:  ReturnReg$residuals
X-squared = 0.82274, df = 2, p-value = 0.6627
```

Figure 3.6: Jarque Bera test conducted on R

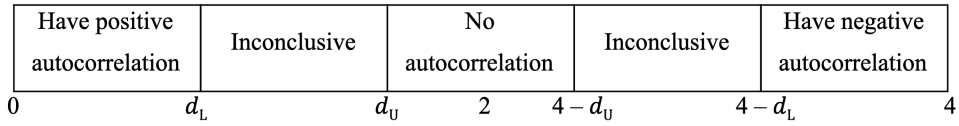
H_0 : the model is normally distributed.
H_1 : H_0 false.
Jarque-Bera (JB) = 0.82274 and p-value of variable = 0.6627 > 0.05. In this case, we would fail to reject the null hypothesis that the data is normally distributed.

3.3.5 Test for autocorrelation

```
        Durbin-Watson test

data:  ReturnReg
DW = 2.1817, p-value = 0.7817
alternative hypothesis: true autocorrelation is greater than 0
```

Figure 3.7: Durbin-Watson test conducted on R



According to figure 7, Durbin-Watson (D-W) = 2.1817. For k = 4 (number of variables), n = 81 (number of observation), $d_L = 1.534, d_U = 1.743$ (Durbin-Watson table for $\alpha = 0.05$).
Hence, D-W belongs to $[d_U, 4 - d_U]$ which means that there is no autocorrelation in this model.

3.3.6 Multiple Regression model

From the above tests, the multiple regression model for District 7's house price is as follow:

$$\text{PRICE} = 2.303 \times 10^{10} + 4.136 \times 10^{7}\text{AREA} - 7.184 \times 10^{8}\text{BEDRMS} - 2.319 \times 10^{8}\text{BATHS} + 8.192 \times 10^{4}\text{WARDPOP}.$$

Chapter 4

RESULTS & FINDINGS

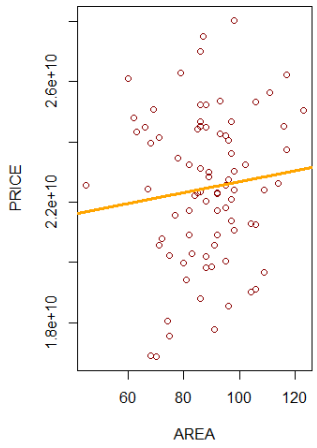


Figure 4.1: Scatterplot of Price vs Area

With $\beta_1 = 4.136 \times 10^7$, it could be concluded that the two variables PRICE and AREA have positive correlation. According to the plot, the higher the size of the house is, the higher its price is. The result is logical to reality as the first thing that Vietnamese people consider whenever buying or renting any property is its size. Houses with an appropriate size and optimal acreage satisfy different home buyers' demand. Especially with the explosion of cosmopolitans nowadays, the city's land resource is ultimately exploited even in the suburban area. In fact, this is also a cultural belief that Vietnamese people always wish to have big houses as a symbol of wealth. Big houses could enable space and comfort for the family. Therefore, it is not surprising that this variable has significant influence on leading to high house price.

Normally, we would think that if we increase the number of bedrooms or bathrooms, the price of the house will increase, so is our regression model an unreasonable one?

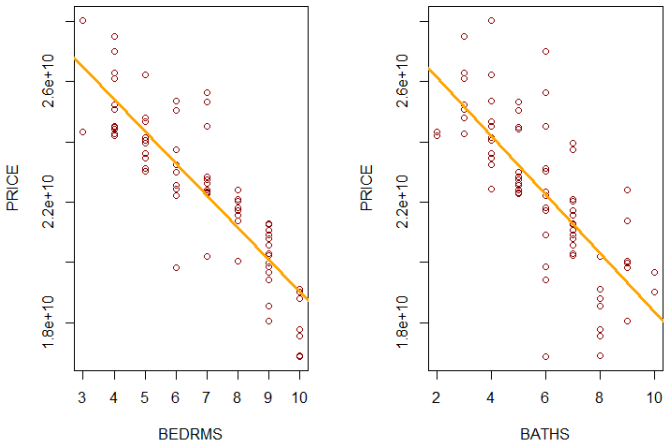


Figure 4.2: Scatterplot of Price vs Bedrooms (left) and Price vs Bathrooms (right)

However, if we consider more deeply, we will be able to explain that: If we consider the effect of each explanatory variable on house price, assume that we do not change the usable area and number of bathrooms, the multiple regression model says that, if we add one more bedroom, on average, the price of the house will decrease by $\$7.184 \times 10^8$. The problem is that house's owners divide an unchangeable area into multiple bedrooms. As a result, each bedroom will become narrower and buyers do not like doing so. They will be willing to pay a lower price to buy that house. Likewise, if the number of bathrooms is increased by one while the number of bedrooms and house's area remain the same, the price of the house will decrease by $\$2.319 \times 10^8$.

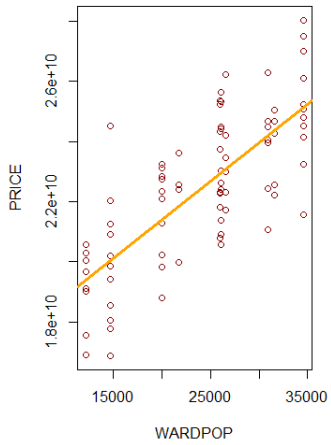


Figure 4.3: Scatterplot of Price vs Ward's population

With $\beta_1 = 4.136 \times 10^7$, it could be concluded that the two variables PRICE and

WARDPOP have positive correlation. According to the plot, the more crowded the ward is, the higher its house price is. The result is logical to reality because Vietnamese people always think that the places having a large number of people living in will have much more utilities, shopping malls, entertaining activities, etc. Those things will add more tangible value to the house and lead to the increase in the house price in those wards.

Moreover, we could calculate errors from the estimated price and price provided in Chotot. The formula is: (PRICEEST-PRICE)/PRICE, which gives the following histogram:

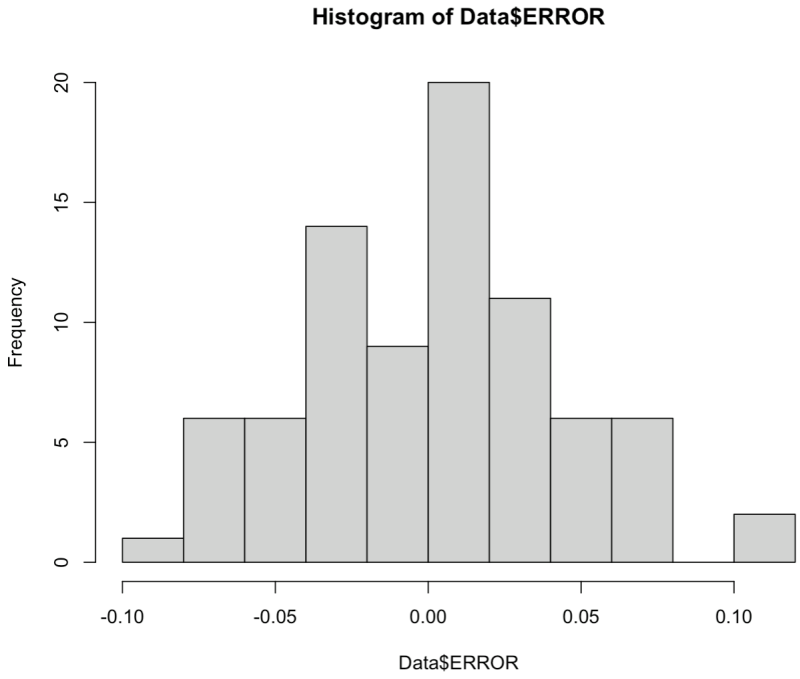


Figure 4.4: Error Histogram

Overall, the absolute value of these errors are less than 15%. Another interesting point we could exploit is that the positive errors indicate under-priced houses, which we should suggest investors as a major bargain.

Chapter 5

CONCLUSIONS

As a result of model by testing different variables that affects to house price in District 7, Ho Chi Minh City, a positive relationship is found between house price and the size of the house as well as the population of the ward whereas the number of bedrooms and bathrooms in a house has a negative relationship with the house price. We hope that based on our research, real estate investors as well as ordinary buyers can apply the model to make strategic decisions about buying a house in district 7, Ho Chi Minh City.

Further quantitative research on house price in this city should be conducted with typical variables should be conducted in other to make the result more convincible. Research on the same field with a different focus such as economic factors is also necessary to contribute to the limited literature. As mentioned before, there is a shortage in the study on house price in a specific district in Ho Chi Minh city currently whereas real-estate is a developing sector in the economy of this city and our country as a whole. Therefore, it needs more attention from both local and international economists and researchers. Besides, more data on social economics of each family should be collected. Furthermore, research on house price in the same context with macroeconomic attributes is also in need. Further research should have a focus on other districts in Ho Chi Minh City such as District 1, District 3, District 5, District 10, which are also central districts of this city.

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