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HEDONIC REGRESSION ANALYSIS IN DETERMINING THE EFFECT OF GREEN ON HIGH RISE RESIDENTIAL

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Abstract

In predicting house price, there are many influential variables, and each variable is identified as a price determinant. Theoretically, variables are divided into categories, namely locational and neighbourhood attribute, structural attribute, time attribute, and environment attribute. Green element is one of the attributes as describe under environment category. The attribute is important as other variables which significantly explained how people willing to pay intangible variable. The relationship between property price and attribute needs to be examined to understand the influence of the green element on property price. Thus, this research attempts to demonstrate the independent variables correlated to the house price, including the green variable, by using hedonic regression analysis. Hedonic regression analysis is a well-known approach in determining the relationship between two or more variables. Green element represents the green-rated obtained by the housing scheme as evidence that the building possesses sustainable characteristics. The cost of green is relatively high than a conventional building. A dataset of 934 house price transactions with 14 variables was analysed. From the analysis, it is concluded that green has a significant effect on the house price. The result was interpreted by the β coefficient of 0.065 explained in hedonic regression analysis. It signifies that green can add premium to the house price. House price results from multiple determinants represented by house attributes and the findings confirm that one of the environment attributes do give effect on the house price in Malaysia property market.

***Keywords**:* House price, green, house variables, hedonic regression analysis

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INTRODUCTION

From the global statistic, the leading sectors for carbon dioxide (CO2) emission are electricity and heat sector followed by transport, manufacturing and construction and building sector (Historical GHG Emission, 2020). In Malaysia, building sector significantly contributes 4.10 million tonnes of CO2 emission. As to date, residential sector in Malaysia still leading as the largest number by volume and value.

Green building has been introduced in Malaysia since 2009 with the establishment of Green Building Index (GBI). Today, up to 579 projects have been certified by GBI, the green building rating system which is initiate by PAM's Architect (GBI, 2021). The establishment of green rating system and the incentive given by the government are moving towards promoting sustainable development in order to reduce the impact of physical development on environment (Green Buildings and Townships Working Group, 2020).

GBI possess same objective as other well-known rating system, BREAM, LEED, Green STAR and Green Mark, their establishment in relation to promoting sustainable development. Each rating system have its own rating criteria according to the local context as it is much easier to incorporate the climate. Every rating system is unique and its effect toward local context is different. Thus, exploring the effect of this rating system on in the local context is significant.

The main objective of this paper is to assess whether green element, as measured by the GBI rating system, has an impact onto the price of housing market in Malaysia. Typically, the correlation between independent and dependent variables can be tested using regression (Yusof & Ismail, 2012). Hedonic price model has been used extensively in measuring the green effect on property price. Thus, the relationship between green and house price can be interpreted in hedonic regression analysis using dataset of sale transaction with information such as floor area, age of building, number of bedrooms, location, and green status.

LITERATURE REVIEW

Factors Affect Price

The housing market is inextricably linked to a country's economic wellbeing. Demand fluctuations would have an impact on growth in other economic sectors. In understand the demand, various factors were discussed and studies. There are significant amount of previous research discussing the factors or attributes that affect house price. The factors contribute and become the determinant of house price. Generally, these factors can be divided into four main categories namely locational and neighbourhood attributes, structural attribute, time-related attribute and environment attribute (Abdullah et al., 2016; Rashid et al., 2017; Kamarudin et al., 2008; Yusof & Ismail, 2012).

The location attribute is well known since there is a popular phrase: 'location, location, location'. Location is more than locality of the property. Furthermore, locational and neighbourhood attributes refer to the location of the property such as proximity to school, amenities, transportation and town and they also indicate the surrounding such as view of the building (Thanaraju et al., 2019, Abdul Lateef et al., 2018; Oloke et al., 2013; Kiel & Zabel, 2008). Structural attribute is another important factor that is related to the physical condition of the property. Among the factors are size of the building or floor area, age of the building, floor level, number of bedrooms and bathrooms and facilities of the building (Kamal et al., 2016) .

Next, time-related attribute is the date when the sales of the property take place. Typically, new or recent transaction will indicate increment of price as compared to the old transactions (Fesselmeyer, 2018). For this research, time attribute is represented by year of transaction for the unit of house. Finally, the environment attribute is one of category which significantly influence the property price. It can be interpreted as environment characteristics of property, where the green element was discussed. To assess the greenness of building, green rating system was introduced as one of the tools. In green rating system, there are few categories of rating such as platinum, gold, silver and certified (GBI, 2021). In other words, green element is associated with green certification, or some literature mentioned energy efficiency. Many previous studies revealed the positive impact of green-rated on residential property price (Zhang et al., 2017; Taltavull et al., 2017; Evangelista et al., 2019).

Hedonic Price Model

The first introduction of basic hedonic pricing framework is by Rosen (1974), where price can be explained by a package of goods characteristic. Hence, hedonic regression becomes a discovered preference technique to evaluate demand or value of good. The model of hedonic pricing in measuring real estate economics is widely used. It has given significant impact towards the exploration of variables on property price explicitly.

The hedonic price model has been extensively used to demonstrate the correlation between property characteristics and price. It becomes popular especially in relation to housing properties. Most of the published research studied on the effect of green such as energy efficiency or green certification use this modelling technique in their method (Taltavull et al., 2017; Fuerst & Warren-Myers, 2018; Fesselmeyer, 2018; Evangelista et al., 2019; Fuerst et al., 2016).

The formulation of prediction model using hedonic pricing is the price relation to its characteristic. The price of house in simple hedonic regression model can be expressed as follows:

$$\gamma = \propto + \beta\kappa 1 + \beta\kappa 2 + \beta\kappa 3 + \cdots.$$

Where the **Y** is the sale price per unit of house, each **K** is set of house characteristic and $\propto$ and β is the vector of parameter to be estimated. The hedonic weights allocated by each variable and finally equivalent to this characteristic's overall contribution to the property sales prices (Rosen, 1974).

METHODOLOGY

The research paper exploits a dataset provided by National Information Centre (NAPIC) of condominium transaction in Penang over the time between 2016 and 2020. The variables available for each property include year of completion, occupancy rate, floor area, floor level, number of bedrooms, location described as town or Mukim, date of transaction, tenure, and price. Additional information such as green certification was extracted from GBI website, security, facilities, and view of the building from site inspection and Google Maps, and developer ranking as listed in The Edge website. Figure 1 showed the study area of Timur Laut District on Penang Island. The area was selected because according to GBI list, Penang ranked top 3 with most projects certified by GBI which is the indicator of green building. Furthermore, about 60% of the total project certified in Penang is housing, and most condominiums certified by GBI are in the district.

Figure 1: The map of Timur Laut District on Penang Island
Source: www.pegis.penang.gov.my

To test and analyse the effect of green certificate on house price, 934 database that were used involved GBI certified condominium and non-certified condominium. The sale transaction price is a secondary data of resale property (exclude sale from developer) to ensure that the price is representative of the

actual market and not influenced by any marketing or selling point. Summary of the description of the variables are provided in Table 1.

To estimate the contribution of each characteristic using regression analysis, there are two hedonic specifications: the first is the fully linear model, and second is the logarithmic-linear model or log model. The log model can be semi-log or log model. Logarithmic scale is more preferred due to its the skewness of data towards large value. Thus, using log scale can display the numerical data in better way. In Table 1, numerical data were transformed into log scale, while category data transform into dummy variable to incorporate qualitative data into regression. A total of 14 variables were transform.

Table 1: Description of variables for Case Study area

	Variable	Overview	Transformations
Dependent Variable (DV)	Price per Square Metre	Price divide floor area	log
Independent Variable (IV)	Town	Georgetown and Other Town/mukim	dummy
	Year	Year 2020, 2019, 2018, 2017, 2016	dummy
	Interest	Freehold and Leasehold	dummy
	Floor size	Floor area of unit in SM	log
	Number of rooms	Number of rooms	-
	Floor level	Level of unit	log
	View	Seaview, Hillview and Town view	dummy
	GBI certificate	GBI certified - 1, Non-GBI -0	dummy
	Facilities of scheme	Full facilities and semi-facilities	dummy
	Security	Single and double gated	dummy
	Occupancy rate	Rate above 75% and below	dummy
	Developer	Developer 30 and no ranking	dummy
	Age	Age of building	log

Sources: Author's research (2021)

RESULTS AND DISCUSSION

This section explains the result from the analysis using regression function. The descriptive analysis was summarised in Table 2. The table showed mean, median, standard deviation, minimum and maximum value of each variable. Transaction price and price per square metre indicate a minimum value of RM230,000 and RM2036 respectively and a maximum value of RM4,550,000 and RM14,507 respectively. The range of value is high for both variables, and this implies that the data should be presented in log form for better result. It is also being applied

to the other 4 variables: number of rooms, floor level, floor size of unit condominium and age of the building.
In exploring the relationship between price and house characteristic, price of house such as the condominium dependent variable is in square meter and the rest of the list become the independent variables for price determinant.

Table 2: Descriptive statistic for sale price and condominium characteristics

	N	Minimum	Maximum	Mean
PRICE PER UNIT	934	230000	4550000	988828.73
PRICE PER SQ M	934	2036	14507	6413.30
GEORGETOWN	934	0	1	.26
OTHER TOWN	934	0	1	.32
2020	934	0	1	.22
2019	934	0	1	.29
2018	934	0	1	.14
2017	934	0	1	.13
FREEHOLD	934	0	1	.91
FLOOR AREA SQ M	934	40.69	1001.00	155.9856
NUMBER OF ROOMS	934	1	5	3.38
FLOOR LEVEL	934	1	42	14.97
HILLVIEW	934	0	1	.34
SEAVIEW	934	0	1	.42
GREEN -GBI	934	0	1	.15
FACILITIES	934	0	1	.55
SECURITY	934	0	1	.04
OCCUPANCY	934	0	1	.62
DEVELOPER	934	0	1	.37
AGE OF BUILDING	934	3	33	9.87
Valid N (listwise)	934			

Sources: Author's research (2021)

There were a few tests and assumption that should be met before the regression analysis. The correlation analysis was carried out to check the correlation between independent variables. All 14 variables showed that there was no correlation in more than 0.80 among the independent variables.

Next, the data as illustrated in graph (Figure 2) below show normal probability plot and random pattern in scatterplot. These meet the assumption that all data are normally distributed and there is no outlier. This is also supported by the VIF value for each variable below 10 and tolerance value more than 0.1 which indicates no multicollinearity issue exists.

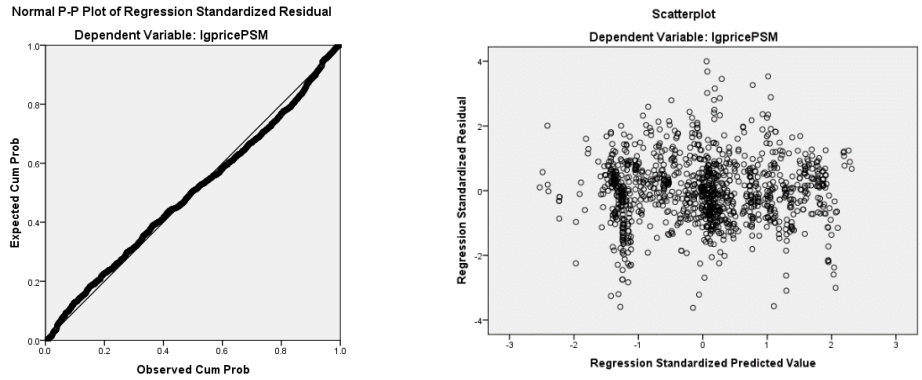

Figure 2: The normal plot and scatterplot of variables
Sources: Author's research, 2021

Table 3: The model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.600[a]	.360	.347	.2253281

b. Dependent Variable: LOGPRICE PSM

Sources: Author's research (2021)

Table 4: The model coefficients

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	26.111	18	1.451	28.570	.000[b]
Residual	46.457	915	.051		
Total	72.568	933			

a. Dependent Variable: LOGPRICE PSM

Sources: Author's research (2021)

The hedonic regression results for 934 of sale transaction data are presented in Table 3. The model has relatively good overall fit after it is revised with the R2 at 0.360 and that explains the variables is 36% of the total variance of the condominium price. According to Cohen (1988), R2 below 0.1 is very small, between 0.1 to 0.30 is small, between 0.3 to 0.5 is moderate and above 0.5 is high. A result of R2 0.360, is at moderate level and acceptable. It also indicates that other variables which are not included may have also affected the price.

Statically, most independent variables show significant coefficients. The p-value in Table 4 shows that the model with green-GBI rated is significant.

Table 5: The model

Independent variables	Unstandardized Coefficients		t	Sig.
	B	**Std. Error**		
(Constant)	9.084	.105	86.147	0.000
GEORGETOWN	.067	.029	2.322	.020
OTHER TOWN	.097	.022	4.346	.000
2020	-.131	.024	-5.523	.000
2019	-.077	.023	-3.347	.001
2018	-.051	.027	-1.847	.065
2017	-.058	.026	-2.226	.026
TENURE	.022	.029	.745	.456
NUMBER OF ROOMS	-.003	.014	-.197	.844
HILLVIEW	-.056	.026	-2.131	.033
SEAVIEW	.155	.023	6.651	.000
FACILITIES	-.167	.020	-8.374	.000
SECURITY	.176	.039	4.529	.000
OCCUPANCY	-.077	.018	-4.304	.000
DEVELOPER	.180	.017	10.535	.000
GREEN -GBI	.065	.033	1.987	.047
LOGSIZE	-.080	.020	-3.979	.000
LOGLEVEL	.016	.010	1.564	.118
LOGAGE	.007	.019	.393	.694

a. Dependent Variable: LOGPRICE PSM

Sources: Author's research (2021)

Table 5 shows the $\propto$ and β coefficient value. Green-GBI variable indicates +0.065 coefficients. Other variables such as developer and security indicate high coefficient value of 0.180 and 0.176 respectively. All the transform variables that were included in the model together with the log form variable, i.e floor size, floor level and age of building. A linear combination form to explain β coefficient is as follows.

LN (Price per square metre) =
9.084 +0.067(GEORGETOWN) +0.097(OTHERTOWN) -0.131(Y_2020)
-0.077(Y_2019) -0.051(Y_2018) -0.058(Y_2017) +0.22(TENURE)
-0.003(ROOMS) -0.056(HILLVIEW) +0.155(SEAVIEW)
-0.167(FACILITIES) +0.176(SECURITY) -0.077(OCCUPANCY)
+0.180(DEVELOPER) +0.065(GREEN-GBI) -0.080(LOGSIZE)
+0.016(LOGLEVEL) +0.007(LOGAGE)

From this regression analysis, the selection of the **GBI certificate** variable suggests the positive sign of the variable. This shows evidence of support by other literature (Evangelista et al., 2019)(Li Zhang et al., 2017)(Jayantha & Man, 2013)(Fesselmeyer, 2018)(Limao Zhang et al., 2018) in which the discussion reported that there are differences in prices if the property is green or GBI certified increased. The beta coefficient is 0.065 and this associates with the p value. Therefore, the model obviously shows there is a statistically significant change in value if the property is located at Timur Laut District if it is certified green. Out of the 18 control variables entered in the model, 13 variables were statistically significant. Further, it can be defining trough t values of the independent variables.

CONCLUSION

This paper analyses the green certificate effect on condominium price in Timur Laut District in Penang Island. The analysis uses database which comprises of a combination of several data including information from condominium transaction sale data. The data was compiled and extracted by NAPIC, and it is to be used for the purpose of valuation and research related to property. NAPIC is an organisation responsible to promote and provide information on property market in Malaysia.

From the analysis done, it is found that green certification relatively gives an impact on property price. The percentage of premium if compared to non-certified building is about 6.5 per cent. The result is supported by a valuer who also estimated about 5-10 of price increment if condominium in Penang is green (Abdullah et al., 2018). Hence, the effect might vary according to the locality. Property market as well as green building should be explored differently in their local context. Even though most of the time green building is associated with high cost of construction, but the value of green is not only about cost. It represents the market, the demand, and the economics of the property. Value can be influenced by other factors. With more incentive, knowledge and promotion given by the government, green development can become the upcoming trend and demand.

Specifically, the contributions of these findings can be explained in several contexts. First, this research adds “green” into the residential hedonic pricing literature especially from the perspective of local context. It is estimated that green can become a common consideration in the hedonic research paradigm. Next, this study encourages additional research on the effects of green development on housing sector. The results of this research indicated a positive and statistically significant premium for transactions with green as a housing feature. The findings from this study are parallel with most of green effect studies done previously. The biggest challenge here is to educate public on the awareness of sustainability and green development. Empirical studies have shown

significant number of green effects towards price and value. But green is more than that.

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