THE INCLUSION OF SPATIAL ELEMENTS IN HOUSE PRICE INDEX CONSTRUCTION

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ABSTRACT

Price of residential property plays a very important role in the economics of developed countries. It is an essential factor for individual or household to decide on selling and buying properties and to invest in the direct property market. Of these reason, the Valuation and Property Services Department (VPSD) has constructed the Malaysian House Price Index (MHPI). The purpose of its establishment is to monitor the changes of real estate price from one period to another and assists in formulation of economic policy. However, there is no other house price index that could be used as a comparison to the existing MHPI. Besides, the MHPI did not encounter spatial elements that can describe the exact location of property. To fill in the gap, this study aim to construct a house price index by incorporating spatial elements. An alternative house price index called as the Hypothetical House Price Index (HHPI) is constructed. Method used in the construction of HHPI is the hedonic method. Three difference models of HHPI are available which each of them composed of different spatial elements used as variable. Spatial elements included in this study are sub districts dummy, distance of house to city centre and absolute location of property. Results have shown that the inclusion of absolute location of property helps to explain the exact location of houses. Other than that, it has produced a house price index with better price movements as compared to model that did not encounter the absolute location of property as the explanatory variables. This study has revealed the significance of considering new variable of property absolute location in estimating the property prices, hence helps in producing an accurate house price index.

Keywords: *House price index, hedonic method, spatial elements.*

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INTRODUCTION

Property prices play a significant role in understanding the dynamic of real estate market. Property such as houses that represents a bundle of attributes however is a bit complex than other products or goods. The importance of property prices in understanding the complexity of real estate market has lead to the construction of real estate price index. The real estate price index is normally used to monitor the changes of house prices from period to another. Netzell (2010) supported that real estate price index is used to monitor the real estate cycle and relationship between real estate markets. This price indicator has become an important tool to parties that have interest in real estate market.

Gourieroux and Laferrere (2009) noted that parties such as investors, financial institution, researchers, policy maker or developers depend on price index for a specific purpose. Policy maker for instance use the house price index prior to formulation of economics as housing market contribute to GDP significantly. They rely on the property price signals to do a decision making. The application of real estate price index can also be seen from the perspective of investors. Basically, price index is used to benchmark and monitor the equity investment. Besides, it is also used to make comparison with other alternative. Longford (2009) posited that house price index play a significant role in individual decision whether to buy or to sell a property.

Most developed countries have produced a house price index due to the significant of housing market to an economy. Such countries include UK and US in which the price index has been established for the past 40 years. Lim and Pavlou (2007) noted the application of house price index in UK is seen as early as 1973. It was first produced by the mortgage providers and recently it is produced by the government sector, the Land Registry. The house price index produced by the government sector is known as the Land Registry House Price Index, whilst the one that is produced by the private sector are the Halifax House Price Index and Nationwide House Price Index.

On the other hand, in US house price index is constructed due to the needs in monitoring real estate price changes. For instance, US Federal Housing Finance Agency introduced house price index to measure the movement of house prices for single family. Besides, Freddie Mac House Price Index (FMHPI) was introduced since 1975 in order to measure the house price inflation. In Malaysia, the effort to produce house price index started in 1993 while the production of house price index began in 1997 (Norhaya et al., 2008). The house price index known as Malaysia House Price Index (MHPI) was introduced by the Valuation and Property Services Department (VPSD).

Tan (2011) explained that the construction of MHPI comprise price indices for 13 states and 2 federal territories. The purpose of its establishment is to monitor the changes of real estate price from one period to another and assists in formulation of economic policy (Norhaya et al., 2008). Method used to construct the MHPI is the hedonic method which it is a widely used price index construction method in US and UK (Norhaya et al., 2008 and Bourassa, Hoesli & Sun, 2006).

Since real estate prices indices are important, therefore it should posses some quality in order to provide an accurate measurement of house price movements (Bourassa et al., 2006). Recently there are growing interests in improving methodological aspect of real estate price index. Studies by Quigley (1995) and Vries et al. (2009) used various techniques in order to develop reliable property price index. There are few methods that can be used to construct the price indices. One of the widely used methods is the median price method.

However, this type of method is said biased due to the heterogeneity nature of residential property. Therefore, methods that involved controlling different quality of housing characteristics is needed to ensure the reliability of price indices. Methods that have the ability to handle the heterogeneity issue are the hedonic method, the repeat sales approach and the hybrid method (Case & Szymanoski, 1995). Among these three methods, hedonic method has drawn a particular attention and widely research.

The hedonic method is based on the hedonic hypothesis; products or goods are valued according to their respective characteristics (Rosen, 1974). In real estate market, house is an example of a product and its characteristics can be categorized into three parts; the structural, the accessibility and the neighbourhood (Malpezzi, 2002). Bourassa et al. (2006) noted two approaches are available in constructing house price index based on the hedonic method. First is by performing a separate regression for each time period and the estimated implicit prices should be applied to a standardized bundle of attributes. Second is by including time dummy variables as part of the model.

Although the hedonic method is used widely, Long, Paez & Farber (2007) noted that the application of hedonic method in modelling house price index may lead to spatial effects. Spatial effects exist in the property data when one property influenced other in term of the market price, resulting to autocorrelation in a model outcome. Spatial autocorrelation is a type of spatial effect. Its existing can be seen in the cross-sectional data (Anselin, 1999). As explained by Anselin (1999), spatial autocorrelation is defined as the coincidence of value similarity with locational similarity. This situation can be explained in which, houses located in same place tend to have a similar house prices.

Intuitively, houses located close to each other tend to have similar values because they exhibit similar characteristics. For instance, terrace houses with three bedrooms cluster together in one area and terrace houses with six bedrooms cluster together in another area. This situation can be seen from the development concept in Malaysia where particular type of house mainly clustered together in one housing scheme and this further reinforce the spatial autocorrelation problems. As the distance between properties increase, spatial autocorrelation between properties will decrease.

Therefore, to construct the real estate price index by adopting the hedonic method, spatial data must be considered. Distance, location and topology arrangement are example of spatial data (Gerkman, 2010). In real estate market, location played a very important role in contributing to the property prices. Even so, it is difficult to measure the locational factor of property in the quantitative form. The complexity to identify locational factors could bring problems to the validity of the multiple regression analysis (MRA) model (Gallimore, Fletcher & Carter, 1996).

The importance in determining a precise geographical location for property is due to the characteristics of house that affect its price. It is spatially-related in the form of locational hierarchy (Kiel & Zabel, 2008). Recent studies show that location of property is measured according to its distance with the nearest central business district (CBD), distance of the properties to the sub-markets and distance of the properties to the nearest public facilities (Gallimore et al., 1996). On the other hand, studies done by Gelfand et al. (2004) and Ting (2008) have incorporated the geocoded data; coordinate (x, y) of property and it has show that the variable is significant in house price modelling.

METHODOLOGY

DATA BACKGROUND

This study constructed three hypothetical house price indices (HHPI). The constructed price indices are based on transaction data of residential property located in Kuala Lumpur area. The data is originated from a government organization, National Property Inforation Centre (NAPIC). A total of 5,365 transaction data of double-storey terraced houses are available. The data is compiled in annual files and it contained transaction data from year 2005 to 2012. During the data cleaning process, some of the data are eliminated due to the inconsistencies and missing values. Observations with missing values and points which do not meet the mathematical control limit are removed from the data. As a result, only 2,000 transaction data are available to be used in the price indices modelling. Each price index is constructed using difference number of observations as each models contained of different outliers. Property details such as transaction price, address, sub-district, date of transaction, year built, lot area, building area and owner-specific characteristic are available. The hypothetical house price index is constructed in a quarterly basis. Thus, 30 quarters of price indices are available which it started from Q1: 2005 to Q2: 2012.

METHOD TO CONSTRUCT THE HOUSE PRICE INDEX

This study adopts time-variant approach of hedonic method in the construction of HHPI. The hedonic method is a multiple regression based method. It composed two types of variable; the response variable and the explanatory variable. Transaction price of house is used as the response variable whilst house characteristics as the explanatory variable. House characteristics can be divided into two. These are physical and locational characteristics. Basically, all house characteristics includ in this study are obtained in the data given by NAPIC. Physical characteristics used as variable are listed in Table 1 below:

Table 1: Physical characteristic of property

Physical characteristics	Description
Size	i. *Lot area*: Size of land on which the house resides ii. *Built-up area*: Overall building size.
Age	Age of building is used to represent the depreciation of the building. It is measured by taking the difference between the building transaction year and its completion year.
Bedroom	It represents number of bedroom available in a house. It is expected that the increase of bedrooms' number will increase the property prices.

Locational characteristic is another important attributes contribute to the house price. Kiel and Zabel (2008) noted that house prices are spatially related in the form of location hierarchy. As the focused of this study is to include the spatial elements in price index modelling, therefore three difference locational characteristics are included. Details of locational characteristics used as explanatory variables are listed in Table 2 below:

Table 2: Locational characteristics of property

Locational characteristics	Description
Sub-districts	Numbers of sub-districts available in Kuala Lumpur area are five. However, in this study only three sub-districts are used. These are: i. Sub-district Batu ii. Sub-district Kuala Lumpur iii. Sub-district Petaling
Property linkage	Property linkage is used to describe the proximity or accessibility to specific externalities. This study used distance to the nearest city centre to represent the property linkage. It is measured in kilometres (km).
Absolute location	Absolute location is represents by the property coordinates (*x, y*). This study used Universal Transverse Mercator (UTM) system that describe the coordinate as ($x_{Easting}, y_{Northing}$).

Modelling the house price index

The house price index is modeled by using multiple regression technique. It is given as:

$$Y_i = \alpha + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots + \beta_k X_{ki} + \varepsilon_i \qquad \text{(eq. 1)}$$

Where $i = 1, 2, \ldots, n$ (n = number of observations), Y_i = house price for ith transaction, $\beta_1,\ldots, \beta_i$ = determined coefficient parameter, β_{ki}, k represent the previous mentioned property characteristics which $k= 1, 2,\ldots k$.

The basic multiple regression model as shown in equation (1) is used to construct the HHPI. Three different models; HHPI Model I, HHPI Model II and HHPI Model III are constructed. Each model composed of different locational characteristics used as variables. The locational characteristics available to describe property location are sub-district dummy, distance to city centre and coordinates ($x_{Easting}, y_{Northing}$) of property. Sub-district dummy and property linkage are widely used locational characteristics in property price modelling studies. On contrary, less study include coordinates ($x_{Easting}, y_{Northing}$) of property as a locational characteristic. In order to see the significance of considering the coordinates ($x_{Easting}, y_{Northing}$) of property in property price modelling, this study attempts to include it as one of the explanatory variables.

As mentioned earlier, this study is based on the time-variant approach of hedonic method. Thus, time-dummy variable is included in the HHPI models. Functional form of log-log model is applied, so that the estimated coefficient result can be interpreted in percentage. The dependent variable of transaction price is in log transformation and selected continuous variables are also transformed into log. It is to be highlight here that dummy variables and other types of variables that contain zero and negative values in this study cannot be logged.

The HHPI models constructed in this study are as shown below:

HHPI Model I

$$logPrice_i = \alpha + \beta_1 logLotArea + \beta_2 logBuiltArea + \beta_3 Age + \beta_4 Age^2 + \beta_5 Bedroom + \sum_{k=1}^{K=3} \beta_{ki} subdistrict + \beta_7 Distance + \sum_{k=1}^{K=30} \beta_{ki} Time + \varepsilon_i \quad \text{(eq. 2)}$$

HHPI Model II

$$logPrice_i = \alpha + \beta_1 logLotArea + \beta_2 logBuiltArea + \beta_3 Age + \beta_4 Age^2 + \beta_5 Bedroom + \sum_{k=1}^{K=3} \beta_{ki} subdistrict + \beta_7 Distance + \beta_8 x_{Easting} + \beta_9 y_{Northing} + \sum_{k=1}^{K=30} \beta_{ki} Time + \varepsilon_i \quad \text{(eq. 3)}$$

HHPI Model III

$$logPrice_i = \alpha + \beta_1 logLotArea + \beta_2 logBuiltArea + \beta_3 Age + \beta_4 Age^2 + \beta_5 Bedroom + \beta_6 x_{Easting} + \beta_7 y_{Northing} + \sum_{k=1}^{K=30} \beta_{ki} Time + \varepsilon_i \quad \text{(eq. 4)}$$

Where α represent the constant value of a model, β_i (i = 1, 2,…, n) represent the coefficient for each parameter used k represents the number of parameters in each variable, i represents the number of observation (i = 1, 2,…, n) and ε is the error terms.

RESULT AND DISCUSSION

THE DESCRIPTIVE ANALYSIS

This section discussed the result of models constructed. The descriptive statistics of dependent and independent variables for each HHPI models are as shown in Table 3 below:

Table 3: Descriptive statistics of the HHPI models

Variables	Mean	Standard deviation	Minimum	Maximum
HHPI Model I				
Dependent variable				
-Transaction price (RM)	590367.9	182067	297000	1100000
Independent variables				
-Lot area (sq. m)	182.293	54.26724	130	497
-Built area (sq. m)	179.8225	30.02583	148	400
-Age (year)	18.07514	12.05381	1	44
-Age^2 (year)	471.8852	429.9356	1	1936
-Bedrooms	3.648225	.6505838	3	6
-Distance (km)	12.71924	3.104321	3	23
Number of obsevations	1211			
HHPI Model II				
Dependent variable				
-Transaction price (RM)	568609.5	186099	290000	1100000
Independent variable				
-Lot area (sq. m)	180.6112	52.98094	130	497
-Built area (sq. m)	179.3499	29.84369	148	400
-Age (year)	18.8759	11.93183	1	44
-Age^2 (year)	498.566	430.668	1	1936
-Bedrooms	3.631277	.6444174	3	6
-Distance (km)	12.79627	3.064998	3	23
-Easting (km)	798.2748	4.879945	791.11	805.76
-Northing (km)	346.0135	5.55623	338.11	357.91

Number of observations	1394			
HHPI Model III				
Dependent variable				
-Transaction price (RM)	561551.8	178986	290000	1090000
Independent variables				
-Lot area (sq. m)	179.8018	51.89143	130	497
-Built area (sq. m)	179.3499	29.84369	148	400
-Age (year)	18.34846	11.96946	1	44
-Age^2 (year)	479.8238	428.3522	1	1936
-Bedrooms	3.645385	.6468508	3	6
-Easting (km)	798.2759	4.896971	791.11	805.76
-Northing (km)	345.9202	5.536983	338.11	357.84
Number of observations	1300			

From table above, it can be seen that number of observations used in each model is different. This is because; each models contained of different outliers. Number of observations for HHPI Model I, HHPI Model II and HHPI Model III are 1,211, 1,394 and 1,300 respectively. Range of transaction price of houses used in this study is from RM 290, 000 to RM 1, 100, 000. For lot area attributes, the minimum and maximum sizes are 130 sq. m and 497 sq. m. On the other hand, built area comes with minimum size of 148 sq. m and maximum size of 400 sq. m.

Building age is also encountered in the HHPI models as it will affect the house prices. The increase of building age normally will decrease the house prices. The minimum and maximum building age used is 1 year and 44 years. Although the maximum building age is 44 years, most of the houses used are around 18 years. This is explained from the mean value shown in the table. Other than that, numbers of bedrooms also help to explain the house prices. As the focus of this study is to construct a house price index for double-storey terraced houses, thus the range of bedrooms available in each house are from three to six. The mean value for number of bedrooms is 3.60. This indicates that average number of bedrooms for observations used in this study is around four.

Distance of house to the nearest city centre is used to describe the locational characteristic of houses. The minimum distance is 3 km and its maximum value is 23 km. The farther away the houses from city centre, the lower the house price. Most houses used in HHPI Model I and HHPI Model II are located around 13 km away from the city centre. For HHPI Model III, coordinate ($x_{Easting}, y_{Northing}$) of houses is used to explain the location of houses. Majority of houses used are located at coordinate (798.28, 345.92).

THE EMPIRICAL ANALYSIS

The empirical analysis is run based on the ordinary least square (OLS) estimator. This analysis is conducted to ensure the validity of constructed HHPI models. Results of the empirical analysis for all HHPI models are shown in Table 4 below:

Table 4: The empirical analysis for HHPI models

Models	**Model 1**		**Model 11**		**Model III**	
Diagnostic test						
R^2	0.5938		0.8171		0.6840	
Adjusted R^2	0.5810		0.8118		0.6750	
F-statistic	46.35		155.05		75.93	
***p*-value (F-statistic)**	0.0000		0.0000		0.0000	
Estimated error variance	0.0552		0.8614		0.0594	
Breusch-Pagan/Cook-Weisberg	0.0515		0.9248		0.1379	
No. of observations	1211		1394		1300	
Variables	*Coefficient value*	*p-value*	*Coefficient value*	*p-value*	*Coefficient value*	*p-value*
Log (Lot area)	0.6223	0.000	0.6358	0.000	0.5799	0.000
Log (Built area)	0.6066	0.000	0.5319	0.000	0.4784	0.000
Bedroom	0.0312	0.001	0.0379	0.001	0.4714	0.000
Age	-0.0393	0.000	-0.0291	0.000	-0.0080	0.000
Age^2	0.0006	0.000	0.0004	0.000	0.0001	0.137
Distance	-0.0478	0.000	-0.0465	0.000		

$x_{easting}$			0.0617	0.000	0.0628	0.000
$y_{northing}$			0.0442	0.000	0.0388	0.000
Sub-district						
Batu (base)	-	-	-	-		
Kuala Lumpur	0.3332	0.000	0.2102	0.000		
Petaling	-0.0502	0.003	-0.0994	0.000		

The R^2 value for HHPI Model I, Model II and Model III as shown in table above are 0.5938, 0.8171 and 0.6840 respectively. The highest R^2 value is represented by HHPI Model II. The additional of coordinates ($x_{Easting}$, $y_{Northing}$) in HHPI Model II help to increase the value of R^2. It indicates that around 81% of the house prices are contributed from house characteristics used as variables.

Results produced by the heteroskedasticity test; Breusch-Pagan/Cook-Weisberg test, have shown that all models fail to reject the null hypothesis of constant variance. With significance level higher than 5%, the result indicates that residuals are homoskedasticity. To ensure the residuals of models and independent variables are not correlated, diagnostic test on zero correlation assumption are conducted. Results produced indicate that residuals and independent variables for all models constructed in this study are not perfectly correlated.

The normality assumptions test indicates that all HHPI models are normally distributed. Besides, *p-value* as shown in table helps to indicate the significance of explanatory variables with the property prices. All of the *p-value* results are less than 5%. It shows that all explanatory variables used are significant and contribute to the property prices. Positive and negative signs show in the coefficient value for each variables used also show similar result produced by past studies in the same area. Results produced by the diagnostic test and hedonic regression have shown that all models constructed are valid and fit.

THE HYPOTHETICAL HOUSE PRICE INDEX

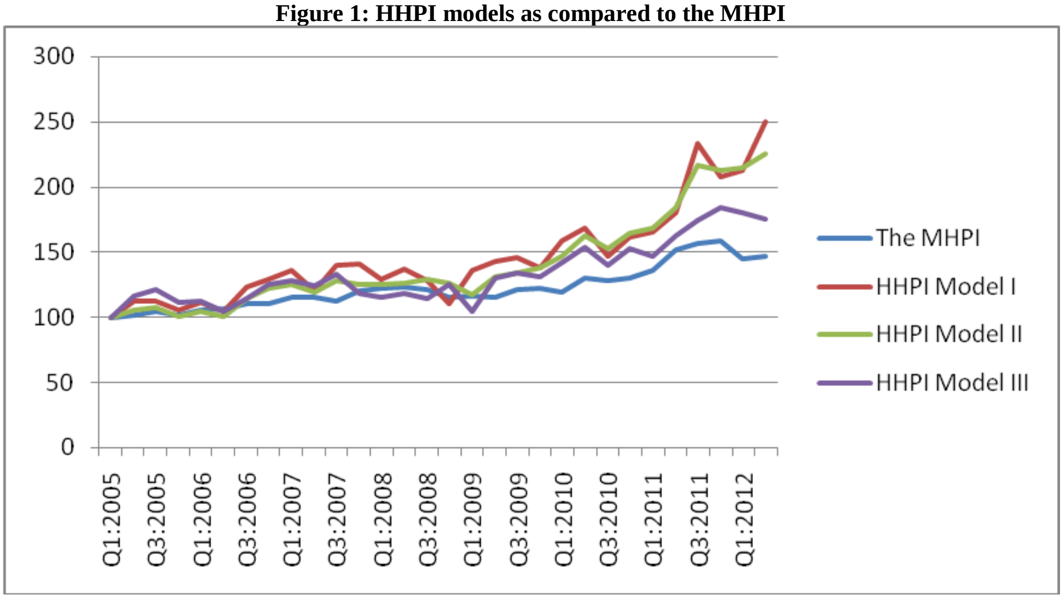
Based on the coefficient value of time dummies produced by the hedonic regression, the HHPI are constructed. Details of the coefficient value are shown in Table 5. As this study constructs house price indices in a quarterly basis, 30 quarters or price indices are available. The index begins from Q1: 2005 to Q2: 2012. Quarter 1: 2005 is used as the base period for all HHPI. MHPI for Kuala Lumpur area is used as a benchmark to compare the value of price index.

Table 5: Coefficient value of time-dummies

	HHPI Model I		HHPI Model II		HHPI Model III	
	Coefficient value	*p-value*	*Coefficient value*	*p-value*	*Coefficient value*	*p-value*
Time-dummies						
Q1	-	-	-	-	-	-
Q2	0.1174	0.011	0.0532	0.081	0.1543	0.000
Q3	0.1188	0.010	0.0739	0.018	0.1952	0.000
Q4	0.0571	0.263	0.0131	0.688	0.1139	0.009
Q5	0.1094	0.023	0.0460	0.153	0.1182	0.006
Q6	0.0469	0.321	0.0108	0.725	0.0457	0.272
Q7	0.2129	0.000	0.1386	0.000	0.1405	0.001
Q8	0.2595	0.000	0.2011	0.000	0.2252	0.000
Q9	0.3085	0.000	0.2285	0.000	0.2543	0.000
Q10	0.1886	0.000	0.1776	0.000	0.2166	0.000
Q11	0.3388	0.000	0.2539	0.000	0.2863	0.000
Q12	0.3448	0.000	0.2267	0.000	0.1746	0.000
Q13	0.2607	0.000	0.2263	0.000	0.1439	0.002
Q14	0.3141	0.000	0.2373	0.000	0.1717	0.000
Q15	0.2499	0.000	0.2610	0.000	0.1379	0.001
Q16	0.1059	0.076	0.2381	0.076	0.2237	0.000
Q17	0.3062	0.000	0.1634	0.000	0.0478	0.375
Q18	0.3613	0.000	0.2756	0.000	0.2664	0.000
Q19	0.3761	0.000	0.2930	0.000	0.2991	0.000
Q20	0.3244	0.000	0.3238	0.000	0.2726	0.000
Q21	0.4645	0.000	0.3860	0.000	0.3547	0.000
Q22	0.5228	0.000	0.4877	0.000	0.4321	0.000
Q23	0.3874	0.000	0.4226	0.000	0.3392	0.000

Q24	0.4831	0.000	0.4975	0.000	0.4251	0.000
Q25	0.5029	0.000	0.5220	0.000	0.3865	0.000
Q26	0.5899	0.000	0.6125	0.000	0.4884	0.000
Q27	0.8460	0.000	0.7714	0.000	0.5598	0.000
Q28	0.7323	0.000	0.7535	0.000	0.6125	0.000
Q29	0.7524	0.000	0.7665	0.000	0.5898	0.000
Q30	0.9152	0.000	0.8135	0.000	0.5642	0.000

Figure 1: HHPI models as compared to the MHPI



The respected Figure 1 above shows the HHPI patterns produced by using the constructed models. All HHPI models are compared with the existing house price index; MHPI produced by the VPSD. The MHPI, HHPI Model I, HHPI Model II and HHPI Model III are represented by the blue line, red line, green line and purple line respectively. HHPI Model III shows the most similar pattern with MHPI. The index value produced by the model did not contradict too large from MHPI. On contrary, index value produced by HHPI Model I and HHPI Model II show quite large deviation from the MHPI. A large difference of house price indices are seen started from Q3: 2011 to Q2: 2012 which the HHPI values exceed 200. This situation is contradicted with MHPI value which is less than 200.

The dissimilarity between the constructed HHPI models and MHPI might arise due to the difference data set used in the construction of house price index. Data set used in this study mainly focused on double-storey terraced houses. Besides, the difference in the price indices may arise due to the house characteristics used as the explanatory variables. Some variables such as house type, building quality and tenure type used to construct MHPI are not available in the data set used in this study. The shortage of house information is due to the limitation of data provided by NAPIC.

Dissimilarity of approach used in constructing the house price index may also affect the index values. This study is based on time-variant index approach. On contrary, MHPI is based on exact-hedonic approach. By adopting the time-variant approach, time-dummies variable is included in the hedonic equation. It helps to capture variation of house prices in each time period within a single equation.

CONCLUSION

Past studies have shown the importance of house price index for various parties especially the banking institution. The main application of house price index is to monitor price changes from period to another. In Malaysia, MHPI is the only available house price index. Parties that have interested in real estate market can only monitor the price changes based on MHPI. A comparable house price index is not available for them to compare the accuracy of price index. This research has filled the gap by constructing HHPI as an alternative to the existing MHPI.

As the concern of this study is to incorporate spatial elements in the house price index, three different models of HHPI are constructed. Results produced from the empirical analysis conducted show that the inclusion of coordinate ($x_{Easting}, y_{Northing}$) has improved the accuracy of house price index. It can be seen from the price index movement pattern produced by HHPI Model II and HHPI Model III. The movement patterns for both models are better as compared to HHPI Model I that only based on sub-districts dummy and distance to nearest city centre as locational variables. Besides, the significance of the house coordinate can be seen through the R^2 value produced by the models. The inclusion of house coordinate has increased the value of R^2. This indicates that the coordinate of house contribute to the house price.

Results produced from this study have shown the significance of considering house coordinate in property price modelling as it helps to improve the accuracy level of house price index. This study has highlighted the importance of house coordinates in real estate market to data provider such as VPSD or NAPIC. It is hoped that these institution can provide details of house coordinate in order to improve the accuracy in house price index modelling. Besides, the constructed HHPI is hoped to be as one of the alternative for parties that have interested in real estate market to monitor the house price changes.

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