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Assessing the relative importance of structural and locational effects on residential property values in Metropolitan Kuala Lumpur

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ABSTRACT

This paper assesses the relative importance of structural and locational attributes on residential property values in Metropolitan Kuala Lumpur. A computer-intensive algorithm known as LMG method was used in the analysis. Results suggest that Metropolitan Kuala Lumpur property values are mainly determined by the structural attributes which explain 62% of price variations, and the locational attributes explain only 17%. Results further suggest that floor area, two or more storeys, property types, property with freehold status, lot size, greater number of bedrooms, and two locational attributes i.e. closeness to city centre and closeness to forest are the most important variables affecting property values. The result of this analysis offers deeper understanding on how structural and locational attributes interact with property values in an urban setting, and could further increase the degree of objectivity of the professional valuer's in the predictive model.

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Structural attributes; locational attributes; residential property values; LMG method; Metropolitan Kuala Lumpur

1. Introduction

Residential property prices in Malaysia have experienced a significant rise over the last decade. The National Property Information Centre of Malaysia (2016) reported, between 2000 and 2016, the national average price for all type of houses rose from MYR 135,000 to MYR 320,000. Among states in Malaysia, residential properties in Kuala Lumpur have significantly outperformed the rest of the country, with prices averaging around MYR 772,000, whilst Perlis, the northernmost state in Peninsular Malaysia, on the other hand, exhibited the lowest, with an average price of around MYR 153,000 as shown in Figure 1 (National Property Information Centre of Malaysia, 2016).

In Malaysia today, generally, home buyers cite that property prices have reached a point of being extremely expensive, and they cannot afford to buy them. The issue is a lot more serious among young professionals in Kuala Lumpur who are faced with the growing concern of not being able to afford the generally expensive properties in and around the capital city (Chin, 2013). The issue of property affordability has become one of the biggest concerns

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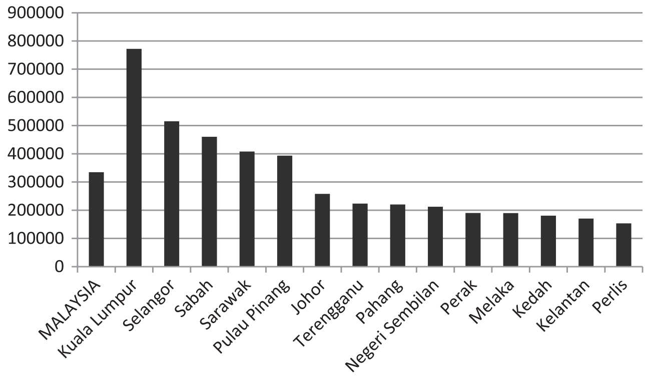

Figure 1. The average Malaysian house prices by state for 2016 (National Property Information Centre of Malaysia, 2016).

among general Malaysians over the recent years, especially for those who live in big cities such as Kuala Lumpur, Johor Bahru and George Town (Hashim, 2010).

While many discussions have taken place around the alarming phenomenon, there has been very limited in-depth study, particularly at a micro level, which is supported by empirical evidence that will offer a rationale behind the increase in property prices as witnessed in Kuala Lumpur. Several reasons that centre on modernisation of the city itself have been quoted as the inevitable cause for the increase in price. Modernisation of Kuala Lumpur has been taking place over the past 25 years or so, with significant developments of various business centres, erection of major building landmarks, reformed transportation networks, and the growth in the number of companies, business owners and traders. This quest for a modern Kuala Lumpur is aligned with the aim for Malaysia as a favoured nation within the global economy (Sirat & Ghazali, 1999). Furthermore, according to Sirat (2000), Kuala Lumpur has seen aggressive development since the early 1990s to ensure its position as a preferred location for global capital and thus, becoming a recognised city in the world of business and industry.

In short, it is a fair argument to support the notion of high property price in Kuala Lumpur over the years as due to the reasons cited above. This paper intends to go beyond those elements by discussing the contribution of structural (internal) and locational (external) factors which drive towards such scenario – the factors that are frequently discussed in previous studies in different cities (see, for instance, Anthony, 2012; Andersson, Jonsson, & Ögren, 2010; Jim & Chen, 2009; Oluseyi, 2014). To our knowledge, there have been very limited studies in Malaysia which discuss this issue (see Tan, 2012; Kam, Chuah, Lim, & Ang, 2016).

So far, extensive research has been done to explain the contribution of structural and locational attributes on residential property values in view of significant coefficients using linear regression analysis. This paper, however, interested to understand the extent to which each explanatory variable drives the prediction. Essentially, this paper interested to understand the contribution each explanatory variable makes towards explaining variance in the criterion. In other words, this paper basically interested to know which specific explanatory variable is important. To achieve that goal, we analyse the relative importance of structural and locational attributes in hedonic models.

Though the term relative importance often has numerous connotations, our use of the term relative importance in this paper refers to the definition given by Johnson and Lebreton (2004) where they define relative importance as "the proportionate contribution each predictor makes to R^2, considering both its direct effect (i.e. its correlation with the criterion) and its effect when combined with the other variables in the regression equation". Tonidandel and LeBreton (2011, p. 2) argue that although the relative importance makes no assumptions about either the statistical or practical significance, but information regarding a variable's contribution to predictable variance is useful when considering the practical utility of a variable.

In doing this, we deploy a computer-intensive algorithm known as the LMG method of the "relaimpo" package of R, which is based on the work of Lindeman, Merenda, and Gold (1980) and Grömping (2006). However, to our knowledge, there exists only one research, which employs this method to ascertain the factors affecting the residential property values (see Hiller, 2015). Whilst, this paper focuses on the LMG method to prove the share of determination, it is important to recognise other methods such as Random Forests (see Breiman, 2001) and relative weight analysis (see Fabbris, 1980; Johnson, 2000).[1] The LMG method was chosen and deployed, as it is a generally accepted method for such study. Additionally, it is a straightforward methodology to handle such set of data in arriving to informative outcome for observation.

To determine the relative importance of structural and locational attributes on residential property values, we use 4045 sales data of landed property within the Metropolitan area of Kuala Lumpur that is substantiated by property sales data over a selected period of years. Landed property is chosen in this study because this property category has seen the most significant impact in price increase over the years. The paper thus contributes to existing literature in two ways; by its focus on property market in a developing country setting and by considering relative importance of structural and locational attributes effects on residential property values.

The remainder of this paper is organised as follows. The paper begins in Section 2 by reviewing relevant literatures associated with factors affecting residential property prices. Section 3 presents property value estimation in which the use of the hedonic pricing model (HPM) is explained. Section 4 discusses the study area. Section 5 describes the modelling procedure. Section 6 presents the empirical findings and Section 7 concludes the analysis.

2. Previous literature

Residential property is a multidimensional heterogeneous commodity. The value of each residential property is strongly determined, not only by structural-specific characteristics such as property size, number of bedrooms, age etcetera, but also by adjacent significant locational (dis)amenities such as public transport, local school, shopping centre, local park, hospital and forest or landfill, flood risk and high voltage power transmission line. Over the past 40 years or so, numerous studies have been conducted to establish the relationship between these internal and external factors and residential property values.

2.1. Structural attributes

Values of residential properties are commonly related to their structural attributes (Chin & Chou, 2003). Empirical studies such as by Feng and Humphreys (2012), Tan (2012), McMillen (2008) and Fletcher, Gallimore, and Mangan (2000) indicated that the size of the property and number of bedrooms are positively related to the residential property values. This is because buyers with big families and those who can afford a better standard of living are willing to pay more for bigger space, particularly functional space (Chin & Chou, 2003). Studies carried out by Seo (2016) and Chiodo, Hernández-Murillo, and Owyang (2010) offer further understanding that the total area of the land positively affects the residential property values. There is also evidence for number of bathrooms which has a direct impact on residential property values as discussed by Oloke, Simon, and Adesulu (2013). Similarly, Ottensmann, Payton, and Man (2008) observed that the number of bathrooms is a dominant factor in determining the residential property values.

In estimating the effects of the age of buildings on residential property values, Seo (2016) and Yan, Delmelle, and Duncan (2012) gathered strong evidence that the age of buildings has a negative effect on the residential property values. This finding implies that the physical structure of the property normally depreciates over time, hence valued negatively by home buyers. The status of the property, leasehold or freehold, is another vital determining factor towards the residential property values (see, for instance, Iman, Hamidi, & Liew, 2009). The freehold status has a dramatic effect because freehold of a residential property means that one has an outright infinite ownership of the property and the land. Conversely, in the case of leasehold status, a majority of leasehold properties in Malaysia, for example, are granted only for up to 99 years. The certain level of uncertainty in the future of the leasehold properties makes it less favourable among property buyers.

Besides the attributes above, other researchers have claimed that the availability of garage, basement, air conditioning, swimming pool, fireplace and the number of storeys are significantly related to the value of a residential property (Feng & Humphreys, 2008; Kestens, Thériault, & Des Rosiers, 2006; Seo, 2016; Yu, Cho, & Kim, 2012). However, there have been relatively fewer studies on the effects of intangible attributes such as structural quality, property design and developer's reputation. This is due to the difficulty in quantifying objectively these attributes and to include them in the property estimation.

2.2. Locational attributes

The theory of property value formation examines location as a composite effect of a set of locational attributes (Kauko, 2003). The benefits of locational attributes are realised mainly in the form of externalities, hence they are collectively shared by a large number of people and houses (Kauko, 2003; Orford, 1999). In real estate parlance, externalities can be positive (beneficial) and negative (harmful). Hence, residential property values should reflect, at any point in space, the combined influence of positive and negative externalities associated with the proximity of nearby locational amenities. According to Dubin and Sung (1990) locational attributes are quantified through various measures such as proximity to significant nearby amenities, socio-economic class, racial composition, aesthetic attributes and pollution levels.

Among locational attributes, the relationship between public transport and property values has drawn some significant attention in the literature. Previous studies have shown that public transport displays both positive and negative externality effects towards the residential property value (see for example, Chen, Rufolo, & Dueker, 1997; Dziauddin, Powe, & Alvanides, 2015; Hess & Almeida, 2007; Mulley, 2014). Additional literature is surveyed in Smith, Gihring and Litman (Smith, Gihring, & Litman, 2006, 2009) and Ryan (1999). A study conducted by Dziauddin et al. (2015) on the effects of light rail transit (LRT) system in the Klang Valley, for example, revealed that buyers are willing to pay the premium price for properties located within close proximity to an LRT station. In contrast, Chen et al. (1997) found negative premiums on properties that are located adjacent to an LRT station in Portland, Oregon. They have attributed this to nuisance effects, including noise, safety, aesthetic and traffic.

The relationship between local school and property values has been widely studied in the literature. Similar with other locational amenities, a local school situated nearby residential areas is assumed to have both positive and negative proximity effects – the evidence from previous studies has proven this assumption (recent examples include Chiodo et al., 2010; Imberman, Naretta, & O'Rourke, 2015; Kane, Riegg, & Staiger, 2006; Owusu-Edusei & Espey, 2003; Owusu-Edusei, Espey, & Lin, 2007; Sah, Conroy, & Narwold, 2016). A study undertaken by Kane et al. (2006) showed that improved school quality contributed positively towards nearby property values. On the contrary, Sah et al. (2016) and Owusu-Edusei et al. (2007) found evidence of depressed values for properties which are located near public schools. Sah et al. (2016), for instance, claimed that properties located within 500 ft from a school sell for approximately 6.7% less than other properties in the same neighbourhood. They attributed this negative effect with greater street and pedestrian traffic, noise and light pollution, loitering and possibly vandalism and other minor criminal activities.

The existence of shopping centres has been recognised as one of the determinants of property value. A number of studies have been conducted to measure the impact of shopping centres on property values (see Des Rosiers, Lagana, Thériault, & Beaudoin, 1996; Sale, 2015; Tse & Love, 2000; Yu et al., 2012).These studies have established that proximity to shopping centres can have both positive and negative impacts on the value of surrounding properties. The positive impacts that are generated on property values can be attributed to good accessibility and improved convenience, whilst the potential negative impacts can be as a result of noise pollution and traffic congestion (Des Rosiers et al., 1996). A study carried out by Des Rosiers et al. (1996) in Quebec Urban Community concluded that the presence of shopping centre in the neighbourhood increases a property's value by 5%. Recent studies by Sale (2015) and Yu et al. (2012) have confirmed this finding that the proximity to shopping centre results in increase in the property value. On the contrary, a study conducted by Tse and Love (2000) in Hong Kong concluded that residential properties exhibit a negative price-distance relationship with shopping centres. The authors attributed the reasons for the adverse impact on nearby property of the shopping centres to traffic congestion and environmental problems.

Previous related studies have also shed light on the importance of woodlands or urban forests in determining the residential property values (see Kim & Johnson, 2002; Tyrväinen & Miettinen, 2000). These studies have confirmed that residential properties located closer to the nearest woodland or urban forest have increased in value. For example, a study undertaken by Kim and Johnson (2002) found that proximity to a forest raised property values by 7%. Similar findings were observed by Tyrväinen and Miettinen (2000) in the district of Salo, Finland where they found that property values decreased an average of 5.9% as the distance to the nearest forest increased by 1 km, and that prices were higher by an average of 4.9% for homes with a forest view.

In addition to this, previous studies have also revealed that parks do have a positive impact on property values (see Bolitzer & Netusil, 2000; Jim & Chen, 2006). For example, a research carried out by Bolitzer and Netusil (2000) by sampling 193 public parks and their surrounding areas. Outcome of analysis showed significant positive impact of those parks on the value of the nearby properties. Jim and Chen (2006) have arrived at similar conclusion where they found the view of parks increased residential property values in Guangzhou, China, by 7.1%.

Besides, there is a general consensus among most authors that closeness to the city centre is believed to be the dominant factor determining property values (see Ahlfeldt & Wendland, 2011; Ottensmann et al., 2008). For example, a study undertaken by Ahlfeldt and Wendland (2011) in Berlin, Germany has observed the increase of property values owing to closeness of the distance to the city centre.

Finally, researchers such as Chiang, Peng, and Chang (2015) identified hospital as one of the locational factors which contributes significantly towards property values. The results of the study carried out by Chiang et al. (2015) showed that residential properties located nearest to hospitals command a higher premium. On the contrary, Peng and Chiang (2015) found out that proximity to the nearest hospital in Taipei Metropolis, Taiwan would only be highly appreciated by home buyers in a "*close-but-not-too-close*" geographic location. They explained this finding as probably be due to negative externalities effect created by hospitals on the surrounding properties.

3. Property value estimation: the hedonic pricing model

Hedonic pricing model is a well-established method used in analysing a market for a single commodity with many attributes, such as residential properties. According to Rosen (1974) most house price studies are built within the context of hedonic house price regression model. The basic premise of HPM is that residential properties are a composite and heterogeneous good and, therefore, can differ in respect to a variety of attributes. These attributes will determine the value of those residential properties. For example, a unit of residential property located at the nearest significant locational amenities such as shopping centre perhaps is more valuable than a unit of residential property that is located further away from the amenity. This is due to the theory that the more accessible a property to a location, the higher its value becomes and, therefore, the former would be more expensive than the latter. In this case, for each property being considered, if an individual values living nearby a shopping centre, then price differentials would develop among the neighbourhood due to differences in distance from the shopping centre. These price differentials or propensity to pay are signals on the value that an individual place on living in a neighbourhood where shopping centre exists. In this case, HPM would capture the value of the shopping centres only if the benefit from the amenity accounts for those residential properties that are in the vicinity of a shopping centre.

While there are some limitations[2] with HPM, they remain useful because they allow us to determine the relevance of structural and locational amenities variables as influencing factors in the housing market. As Des Rosiers, Lagana, and Thériault (2001, p. 150) postulated, "the hedonic approach remains the most adequate tool for untangling the cross-influences between the numerous dimensions affecting property values and for establishing the implicit price of individual residential attributes".

This method was introduced by Court (1939) and later refined by Lancaster in 1966 on the basis of consumer behaviour theory, which argues that the characteristics of any commodity determine its price. It became well-known after Rosen (1974) developed a formal demand, supply and competitive equilibrium model.[3] Ordinary least squares (OLS) regression[4] is the common empirical method for estimating the HPM function. There are many studies employing HPM, however the ones by Malpezzi (2002), Chin and Chou (2003) and Sirmans, Macpherson, and Zietz (2005) worth a mention in this section for they provide a broad literature overview on the application of the method in the residential property value study.

There are two reasons which account for the use of HPM in the residential property value study (Powe, Garrod, & Willis, 1995). Firstly, this method is used to directly model a residential property value based on various attribute-level functions. Secondly, it is used to assume the coefficients of the estimated hedonic price function that reflects household willingness to pay (WTP) for discrete changes in these attributes. These coefficient values are particularly useful in deriving the marginal WTP for a unit enhancement at that attribute level. The marginal WTP is achieved by evaluating the partial derivative of the hedonic price function with respect to the attribute while holding all other variables at their mean values. This information can be useful to a number of market participants, including homeowners seeking to sell or renovate their properties, real estate agents who may be called upon to value individual components, real estate appraisers when estimating property values and real estate developers in understanding trends in homeowners' taste and preferences (Sirmans & Macpherson, 2003). The cross-sectional regression model traditionally shall be specified as follows:

$$Y_i = \beta_0 + \sum \beta_i X_i + \varepsilon_i \tag{1}$$

where the dependent variable Y_i is property price for observation i; X_i represents the value of factor for observation i; β_0 is the constant; β_i is the regression coefficient and ε is an error term.

4. Study area

Kuala Lumpur is not only the capital city of Malaysia but also the major financial and commercial centre, and home to hundreds of multinational companies, covering a total land area of 243 km^2. From 982,920 people in 1980, the population of Kuala Lumpur increased to 1.58 million people in 2010 (Department of Statistics Malaysia, 1980, 2010), with approximately 47% of the population in the 25–54 year-old bracket. These characteristics have made Kuala Lumpur a densely populated city in Malaysia. Although Kuala Lumpur is host to 1.58 million permanent residents, the city's total population swells to more than 2.5 million people during the day as workers, predominantly from the suburban and surrounding areas, travel to the city for work.

The demography of Kuala Lumpur population is made up of Malay ethnic group that contributes to 41% of the total, Chinese ethnic group stands at 39%, Indian ethnic group accounts for 9%, 1.6% are of other ethnic groups and the rest are Non-Malaysian citizens (Department of Statistics Malaysia, 2010). The gross domestic product (GDP) per capita at purchasing power parity (PPP) of Kuala Lumpur increased to MYR 55,951 (USD 18,218, with the FOREX rate at MYR 3.21or USD 1.00 in 2010) in 2010 from MYR 7497 (USD 2998, with the FOREX rate at MYR 3.21or USD 1.00 in 1980) in 1980 (Department of Statistics Malaysia, 1980, 2010). The labour force predominantly consists of technicians, trade workers, labourers and clerical and administrative workers accounting for approximately 69%; professionals and managers account for 18% of the workforce (Department of Statistics Malaysia, 2010).

The rapid growth of the population, employment, economic activities and services has resulted in an increase in demand for housing. Kuala Lumpur's housing market is generally varied across geographical areas, with the highest priced housing found in the central part (see Figures 2a and 2b). The central part of the city tends to offer larger and more expensive housing units compared to the southern and northern parts, although new developments are fast taking place around the urban fringe in all directions. For example, in 2010 terrace houses located in the central part recorded an average sold price of MYR 530,000 (USD 165,100), whilst terrace houses located in the southern and northern parts were sold at an average of MYR 330,000 (USD 102,800) and MYR 280,000 (USD 87,200), respectively (Department of Valuation and Services, 2010). The central area of the city, like other major cities in the world, is home to major landmarks such as the Petronas Twin Towers or KLCC; Malaysia's most famous department stores such as Suria KLCC Mall, Pavillion, Lot 10 and Star Hill, and major world-class hotels such as Mandarin Oriental, InterContinental and Traders Hotel, and, residences of Malaysia's royal families, ministers, upper middle and

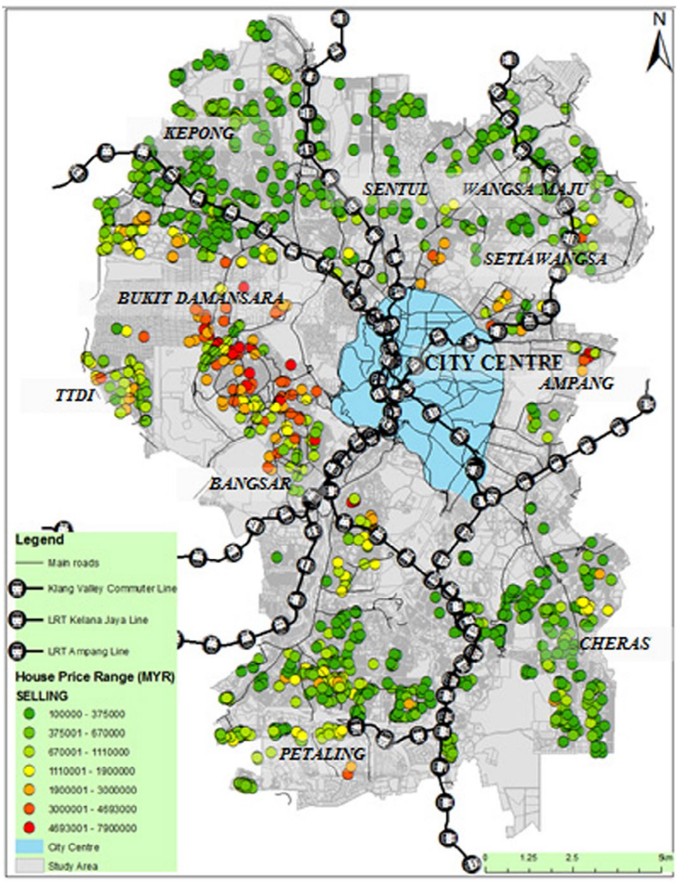

Figure 2a. Map of study area and spatial distribution of observations for 2009. Source: Author.

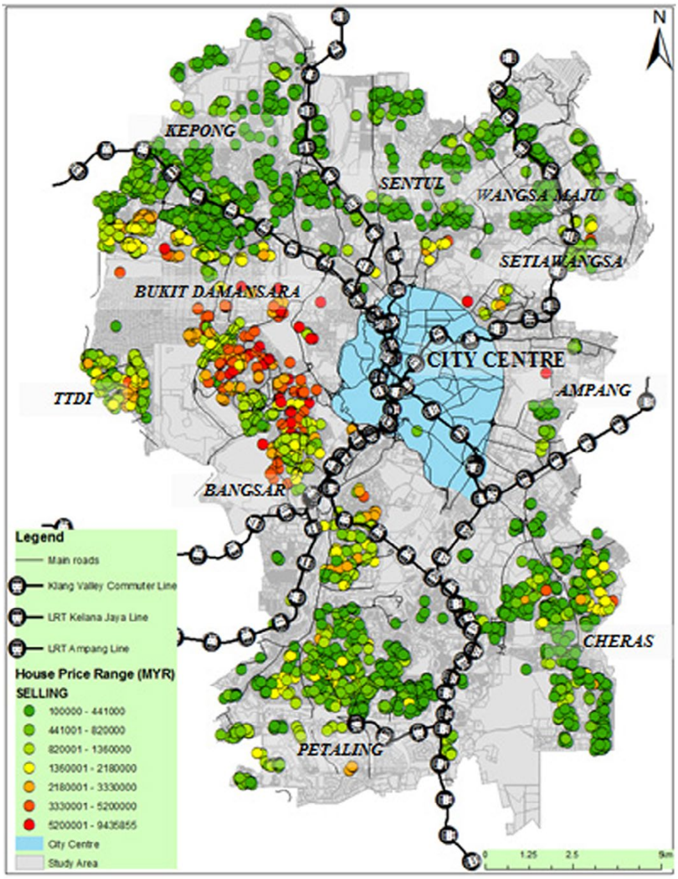

Figure 2b. Map of study area and spatial distribution of observations for 2010. Source: Author.

upper class families and expatriates (located in the city centre, Bangsar, Dutamas, Mont Kiara, KL Sentral, Bukit Damansara, Taman Tun Dr. Ismail and Bukit Tunku).

Apart from a slump during the Asian financial crisis in the late 1990s, the Kuala Lumpur housing market is generally vibrant. In recent years, residential property price appreciation has accelerated with a strong price increase. For instance, in 2010, the residential property price appreciation increased to 12%. Specifically, Kuala Lumpur bungalows were in top demand as it surged by 19%, followed by semi-detached that increased by 17%, high-rise buildings increased by 10% and terrace houses appreciated by 8%, which reflects the lack of new supply of residential properties in the capital (Commerce International Merchant Bankers Berhad, 2010).

5. Modelling of structural and locational effects on property values

5.1. Modelling approach

As previously discussed, property values are determined by the internal features of the house and the external factors such as locational attributes. The modelling approach of this paper relates the dependent variable of property price, Y, to vectors of internal and external factors as shown in Equation (2).

$$Y_i = f(S, L) \tag{2}$$

where S and L are, respectively, vectors of structural attributes associating to the property such as floor area, lot area etcetera and nearby significant locational attributes such as shopping centre, park etcetera.

5.2 Data acquisition

5.2.1. Property data

The residential property sales data used in this study were confined to the sales data of landed residential properties in the Metropolitan Kuala Lumpur housing market in the period of 2009 and 2010.[5] In total, 4539 units of residential property sales data, together with their physical characteristics, were gathered from the Department of Valuation and Services, Malaysia (Kuala Lumpur branch), an entity that is regarded as the most reliable government data source for residential property values. Filters were then applied to the data-set (for sales values of residential property, number of bedrooms and floor size) to eliminate outliers – generally beyond three standard deviations from the mean for key dimensions and suspected error in data entry. The outcome of this, we, therefore, eliminated sales values of residential property less than MYR 100,000 (USD 31,153) because we believe these sales values are not to be arms-length sales values in the Metropolitan Kuala Lumpur housing market. For the number of bedrooms and floor area parameters, we eliminated observations whose number of bedrooms are less than two and floor area of less than 46 m^2 because we believe these values are not representative number of bedrooms and floor area of landed properties in the Metropolitan Kuala Lumpur. Finally, from the original 4539 units, we were left with 4045 units of residential property sales data for the analysis.

Holding status (*FREEHOLD*) of the residential properties, floor size (*FLOORSIZE*), lot size (*LOTSIZE*), number of bedrooms (*BEDS*) and property type[6] such as semi-detached housing (*SEMIDETACHED*), developer's design bungalow house (*DEVELOPBUNG*), owner's design bungalow house (*OWNBUNG*), corner lot terrace house (*CORNERTRRD*), end lot terrace house (*ENDTRRD*) and intermediate terrace house (*INTERTRRD*) and town house (*TOWNHOUSE*) are the structural attributes of the property obtained from the data provider and they were used for the analysis. However, it is worth noting that two potentially important structural attributes were not available from the data-set i.e. property age and number of bathrooms.

5.2.2. Proximity to locational amenities data

To measure the distance for a given observation to the locational amenities, the geographical information system (GIS[7]) was used to position each observation accurately on a local map using geographical coordinates (latitude and longitude) obtained from Google Maps. The process of determining geographical coordinates from Google Maps was guided by housing address, land parcel number and size of land parcel for each observation obtained from Department of Valuation and Services Malaysia data-set. GIS and spatial analysis[8] were integrated into this study, and the integration was particularly useful because the proximity from a property to the locational amenities and proximity to the central business district

(*CBD*) was measured accurately using straight-line distance (measures *perceived* distance[9]). The distance in metres was measured along the shortest possible straight line by using near distance function available in ArcGIS software package.

In this study, PETRONAS Twin Towers or KLCC was assumed as the focal point of the CBD which control land values and subsequently property values. Other locational amenities include proximity to the nearest shopping centre (*SHOPCENTRE*), proximity to the nearest hospital (*HOSP*), proximity to the nearest park (*PARK*), proximity to the nearest forest (*FOREST*), proximity to the nearest primary school (*PRIMARYSCH*), proximity to the nearest secondary school[10] (*SECONDARYSCH*), proximity to the nearest high-performing primary school (*HP_PRIMARYSCH*) and proximity to the nearest high-performing secondary school (*HP_SECONDARYSCH*).[11]

Table 1 provides the summary statistics of dependent and independent variables employed in this paper. From the sample, residential property sales values range from MYR 100,000 (USD 31,152. 65) to over MYR 9 million (USD 2,803,738.32).The mean residential property sales values in our sample is MYR 832,676.87 (USD 259,400. 89). In terms of the floor size, the average residential property has a floor area of around 175 m^2 or 1750 ft^2. However, there are units with as low as 46 m^2 or 460 ft^2 to as large as 1300 m^2 or 13,000 ft^2.

In all regression-based analysis, some independent variables are usually multicollinear.[12] To manage this issue, the correlations among the independent variables used for the inclusion in the final models were detected by using Pearson's correlation coefficient and variance inflation factors (VIFs). Following Orford (1999) and Neter, Wasserman, and Kutner (1985), a Pearson's correlation coefficient that is above 0.8 and a VIF that is above

Table 1. Descriptive statistics of dependent and independent variables.

	Units	Mean	SD
PRICE	MYR	832,676.87	1,005,096.93
Ln Price (dependent variable)	MYR	13.19	0.87
SHOPCENTRE	Metre	1,386.54	845.81
HOSP	Metre	2,501.18	1,377.60
PARK	Metre	2,226.62	1,049.35
FOREST	Metre	2,249.35	1,463.53
PRIMARYSCH	Metre	642.93	370.95
HP_PRIMARYSCH	Metre	3,651.99	1,867.51
SECONDARYSCH	Metre	901.56	546.84
HP_SECONDARYSCH	Metre	4,544.99	1,899.99
CBD	Metre	8,145.09	2,292.04
CENTRAL	Dichotomous variable (0 or 1)	0.29	0.46
NORTH	Dichotomous variable (0 or 1)	0.44	0.50
SOUTH	Dichotomous variable (0 or 1)	0.26	0.44
FLOORAREA	Square metre	175.39	95.10
LOTAREA	Square metre	235.92	388.37
BEDS	Dichotomous variable (0 or 1)	0.48	0.50
STOREY	Dichotomous variable (0 or 1)	0.84	0.37
FREEHOLD	Dichotomous variable (0 or 1)	0.65	0.48
SEMIDETACHED	Dichotomous variable (0 or 1)	0.10	0.31
DEVELOPBUNG	Dichotomous variable (0 or 1)	0.06	0.23
OWNBUNG	Dichotomous variable (0 or 1)	0.04	0.19
CORNERTRRD	Dichotomous variable (0 or 1)	0.07	0.25
ENDTRRD	Dichotomous variable (0 or 1)	0.04	0.20
INTERTRRD	Dichotomous variable (0 or 1)	0.62	0.49
CORNERCLUSTER	Dichotomous variable (0 or 1)	0.00	0.04
ENDCLUSTER	Dichotomous variable (0 or 1)	0.00	0.03
INTERCLUSTER	Dichotomous variable (0 or 1)	0.01	0.11
TOWNHOUSE	Dichotomous variable (0 or 1)	0.06	0.23

10 indicate harmful collinearity. In this study, we eliminated pairs of independent variables that produce a correlation coefficient that is higher than 0.8 and VIF of 10 or higher from the final model.

6. Empirical results: Which attributes matter the most?

6.1. Hedonic pricing model

In estimating the structural and locational effects on residential property values, we explore several different functional forms. The final form of estimation that we use was a semi-logarithmic as shown in Equation (3).

$$\begin{aligned} lnY_i = {} & \beta_0 + \beta_1 FLOORAREA_i + \beta_2 LOTAREA_i + \beta_3 BEDROOMS_i + \beta_4 STOREY_i \\ & + \beta_5 FREEHOLD_i + \beta_6 SEMIDETACHED_i + \beta_7 DEVELOPBUNG_i \\ & + \beta_8 OWNBUNG_i + \beta_9 CORNERTRRD_i + \beta_{10} ENDTRRD_i + \beta_{11} INTERTRRD_i \\ & + \beta_{12} SHOPCENTRE_i + \beta_{13} HOSP_i + \beta_{14} PARK_i + \beta_{15} FOREST_i \\ & + \beta_{16} PRIMARYSCH_i + \beta_{17} HP\_PRIMARYSCH_i \\ & + \beta_{18} HP\_SECONDARYSCH_i + \beta_{19} CBD_i \\ & + \beta_{20} CENTRAL_i + \beta_{21} NORTH_i + \epsilon \end{aligned} \tag{3}$$

where *FLOORAREA* is the floor area of property in square metre; *LOTAREA* is the land area of property in square metre; *BEDROOMS* is property with four or more bedrooms; *STOREY* is property with two or more storeys; and *FREEHOLD* is property with freehold holding status. *SEMIDETACHED*, *DEVELOPBUNG*, *OWNBUNG*, *CORNERTRRD*, *ENDTRRD* and *INTERTRRD* are, respectively, dummy variables related to the property type namely semi-detached house, developer's design bungalow, owner's design bungalow, corner lot terrace house, end lot terrace house and intermediate lot terrace house.

SHOPCENTRE, *HOSP*, *PARK*, *FOREST*, *PRIMARYSCH*, *HP_PRIMARYSCH*, *HP_SECONDARYSCH* and *CBD* are, respectively, proximity to nearest shopping centre, hospital, park, forest, primary school, high-performing primary school, high-performing secondary school and central business district which were all measured in metre. Finally, *CENTRAL* and *NORTH* are dummy variables associated to the property located on the central and northern sides of Kuala Lumpur, respectively. Readers are advised that semi-logarithmic form was selected because it generally gives a better fit in terms of the R^2 criterion and intuitively interpretable.

Table 2 shows the results of HPM for this particular functional form, which includes the unstandardized coefficients (β), t-ratio, sig. and VIF. The model fits the data well with a considerable high goodness of fit (79%) in explaining the variation in the dependent variable, whilst the remaining 21% was captured by the error term, which is a good fit given the cross-sectional nature of the data. In addition, no harmful multicollinearity between independent variables in the final model was detected with the largest VIF standing at 7.3 as opposed to a suggested threshold of ten. All the explanatory variables were significant at the 95% level or 5% error margin allowed, and had the anticipated positive or negative signs except for hospital (*HOSP*), primary school (*PRIMARYSCH*), high-performing primary school (*HP_PRIMARYSCH*) and high-performing secondary school (*HP_SECONDARYSCH*) variables. As this is a semi-log functional form, the interpretation of the estimated coefficients relates to their proportional (or when multiplied by 100, their percentage) effect on price.

Table 2. Results of the hedonic pricing model ($n = 4045$).

	Coefficient (β)	*t*-ratio	Sig.	VIF
Intercept	11.6423	181.9	0.00	
FLOORAREA	0.00413	42.4	0.00	2.2
LOTAREA	0.00007	3.7	0.00	1.3
BEDROOMS	0.16117	10.7	0.00	1.5
STOREY	0.1523	8	0.00	1.3
FREEHOLD	0.18213	11.8	0.00	1.4
SEMIDETACHED	0.82012	24.1	0.00	2.8
DEVELOPBUNG	0.945	21.6	0.00	1.9
OWNBUNG	0.57534	14.2	0.00	2.3
CORNERTRRD	0.53653	15.6	0.00	2
ENDTRRD	0.38151	9.8	0.00	1.6
INTERTRRD	0.26597	10.2	0.00	4.2
SHOPCENTRE	−0.0001	−11.6	0.00	1.5
HOSPITAL	0.0001	12.4	0.00	3
PARK	−6E-05	−9.5	0.00	1.3
FOREST	−7E-05	−11.8	0.00	1.8
PRIMARYSCH	0.00009	4.9	0.00	1.2
HP_PRIMARYSCH	0.00005	5.7	0.00	5.9
HP_SECONDARYSCH	0.00011	20	0.00	2.9
CBD	−9E-05	−13	0.00	6
CENTRAL	0.61274	16.7	0.00	7.3
NORTH	0.22061	7.1	0.00	6.2

Notes: Goodness of fit: Adjusted $R^2 = 0.79$. All variables are significant at the 0.05 level ($p < 0.05$).

Our results show all structural attributes variables included in the final model generally meet the theoretical expectations. The size of the property measured by floor area (*FLOORAREA*) is highly significant, indicating that the floor area has a strong and positive effect on property values. Hence, *ceteris paribus*, every square metre increase in floor area increases the value of property by 0.14%. This finding is similar to other research findings as previously discussed. As expected, the effect of lot area (*LOTAREA*) on property values is also positive – for every square metre increase in lot area has led to an increase in property value by 0.007%. Furthermore, *ceteris paribus*, a property with four or more bedrooms (*BEDS*) commands a 16.1% price premium, whereas a property with two or more storeys (*STOREY*) and a property with freehold status (*FREEHOLD*) commands about a 15.2% and 18.2%, respectively, price premium. As for property-type attribute, its role is only to indicate the price for different types of housing in the study area. As one would expect, the price for bungalow or semi-detached property is higher than that of terrace property due the attributes that they possess.

In terms of locational attributes variables, we find proximity to the nearest shopping centre (*SHOPCENTRE*), park (*PARK*) and forest (*FOREST*) imposed a significant positive impact on property values. So, *ceteris paribus*, an increase of one metre closer to the nearest shopping centre adds 0.01%, to the nearest park adds 0.006% and to the nearest forest adds 0.007% to the property value, thus signifying a strong appreciation of home buyers for these locational amenities. The outcome of our model further indicates that the proximity to the CBD negatively impacts the property value, which confirms the theory of monocentric cities for Kuala Lumpur. The model also suggests that, if a property is located on the Central Side (*CENTRAL*) and the North Side (*NORTH*) of Kuala Lumpur which has the city's largest share of middle-income, upper middle-income and upper-income households, *ceteris paribus*, commands a higher price premium of about 61.2% and 22%, respectively, over similar properties located in other parts of Kuala Lumpur.

On the contrary, we find proximity to the nearest hospital (*HOSP*), primary school (*PRIMARYSCH*), high-performing primary school (*HP_PRIMARYSCH*) and high-performing secondary school (*HP_SECONDARYSCH*) imposed a significant negative impact on the property values. *Ceteris paribus*, an increase of one metre closer to the nearest hospital, primary school, high-performing primary school and high-performing secondary school leads to a decline in property value by 0.01, 0.009, 0.005 and 0.01%, respectively.

This significant negative relationship is clearly explained by previous findings in which negative impact attributable to these amenities was due to increased noise, traffic and parking congestion around the schools (Sah et al., 2016; Owusu-Edusei et al., 2007) and hospitals (see, for example, Peng & Chiang, 2015). Results based on a study in San Diego County, US by Sah et al. (2016) suggest that residential properties located near public schools suffer from a proximity penalty (nuisances of traffic congestion), rather than (benefit from) a proximity premium. We believe residential properties located near public schools in Metropolitan Kuala Lumpur indeed suffer from a proximity penalty because most parents are more likely to drive their children to school rather than walk or have their children take the school bus or public transport, thus reducing the proximity advantages and increasing nuisances of traffic congestion near schools. Although a high-performing secondary school (*HP_SECONDARYSCH*) is expected to affect residential property values positively, a study conducted by Owusu-Edusei and Espey (2003) and Owusu-Edusei et al. (2007) in Greenville, South Carolina, and Sah et al. (2016) in San Diego County found that a greater commuting distances to schools has a negative effect on the value of property.

In the case of our study, the average commuting distance to a high-performing secondary school is nearly five kilometres which is more than 20 times the mean for Greenville, South Carolina (Owusu-Edusei & Espey, 2003; Owusu-Edusei et al., 2007) and seven times the mean for San Diego County (Sah et al., 2016). This scale of distances is considerably greater. Similar results have also been observed by Peng and Chiang (2015) for proximity to the nearest hospital in Taipei Metropolis, Taiwan and they concluded that hospitals would only be highly evaluated in a *"close-but-not-too-close"* geographic location due to negative effect associated to hospitals.

6.2. Coefficients and relative importance

So far, we have gathered information about how strongly a set of explanatory variables in estimating the structural and locational effects on residential property values. Yet, our analysis cannot indicate which attributes matter the most since the explanatory variables possess various units of measurements. To overcome this, we consider the relative importance of structural and locational attributes by measuring the share of R^2 in our OLS-Models. According to Grömping (2006), there are four criteria for decomposing R^2. First, the model has to be decomposed into shares, which are in sum, the model variance (proper decomposition). Second, all shares have to be non-negative. Third, regressors with $\beta = 0$ should have zero share. Finally, a regressor with $\beta \neq 0$ should receive a non-zero share. In order to decompose R^2, we employ the computer-intensive LMG method of the "relaimpo" package of R as suggested by Grömping (2006). In principal, the contribution of all regressors to R^2 will be calculated by all possible ordering of each regressor. The first step of decomposing R^2 begins by generating the sequential[13] sums of squares of R^2 for each regressor $x_1, \ldots, x_p$ and it can be written as (Grömping, 2006):

$$SeqR^2(\{x_k\}|S_k(r)) = R^2(\{x_k\} \cup S_k(r)) - R^2(S_k(r)) \tag{4}$$

where S is a set of regressors, which is already included in the model; x_k represents additional regressors; k is an index of variables; p is the total number of variables and r is a tupel of indices $r = (r_1,\ldots, r_p)$ which describes the order of regressors. The sequences of all regressors will be used to assess the relative importance. The relative importance (LMG method) can be calculated by the following formula (Christensen, 1992):

$$\mathrm{LMG}(x_k) = \frac{1}{p}\sum_{j=0}^{p-1}\left(\sum\nolimits_{s\subseteq\{x_1,\ldots,x_p\}\{x_k\};n(s)=j} \frac{SeqR^2(\{x_k\}|S_k(r))}{\begin{pmatrix} p-1 \\ j \end{pmatrix}}\right) \tag{5}$$

where $n(S)$ is the number of variables included in the set of regressors S. Therefore, LMG is defined as the average contributions in models of different sizes. The order of the regressors in any model is a permutation of available regressors $x_1, \ldots, x_p$, which is denoted by the tuple of indices r. Following Johnson and Lebreton (2004), to assess the relative importance, it is important that the correlation between each variable to be low and that only significant variables are used.

Figure 3 shows share of relative importance of structural and locational attributes effects on property values from the LMG method. The results from the LMG method indicate that the most important factor in affecting the residential property values in Metropolitan Kuala Lumpur is structural attributes. Collectively, the structural variables garner 62% of price variations, and the locational variables attract only 17%. Specifically, results indicate that structural variables such as floor area (*FLOORAREA*), two or more storeys (*STOREY*), semi-detached (*SEMIDETACHED*), developers' design bungalow (*DEVELOPBUNG*), intermediate terrace (*INTERTRRD*), freehold holding status (*FREEHOLD*), lot area (*LOTAREA*) and four or more bedrooms (*BEDROOMS*) explain most of price variations.

Among these variables *FLOORAREA*, which is the floor area of property in square metre, has the highest explanatory power. This finding confirms the results of previous studies which indicate that the single most important variable in determining the residential property values is floor area. The probable explanation of this is that having a larger functional space particularly in a high-density area such as Metropolitan Kuala Lumpur is generally considered consistent with better quality accommodation and that buyers are prepared to pay for such attribute. Among locational variables, Central Side (*CENTRAL*) and forest (*FOREST*) explain most of price variations. This observation is consistent with general observation of previous studies in assessing the impact of closeness to the city centre effecting property price (see Ahlfeldt & Wendland, 2011; Ottensmann et al., 2008), whereas, the importance of forest is well supported by findings of Kim and Johnson (2002) and Tyrväinen and Miettinen (2000) who found that proximity to forest increased property values. Also, this is expected due to the fact that forest is scarce in Metropolitan Kuala Lumpur.

In summary, the paramount importance of property's structural attributes found in this study is in line with the study carried out by Ottensmann et al. (2008), Tan (2012) and Hiller (2015). Using a HPM and a sample of 8772 house sales data for Marion County (Indianapolis), Indiana in the US to measure the relationship between urban location and housing prices, they found that the contribution of locational attributes to the model produced only small increases in R^2 compared to structural attributes. Thus, they concluded that

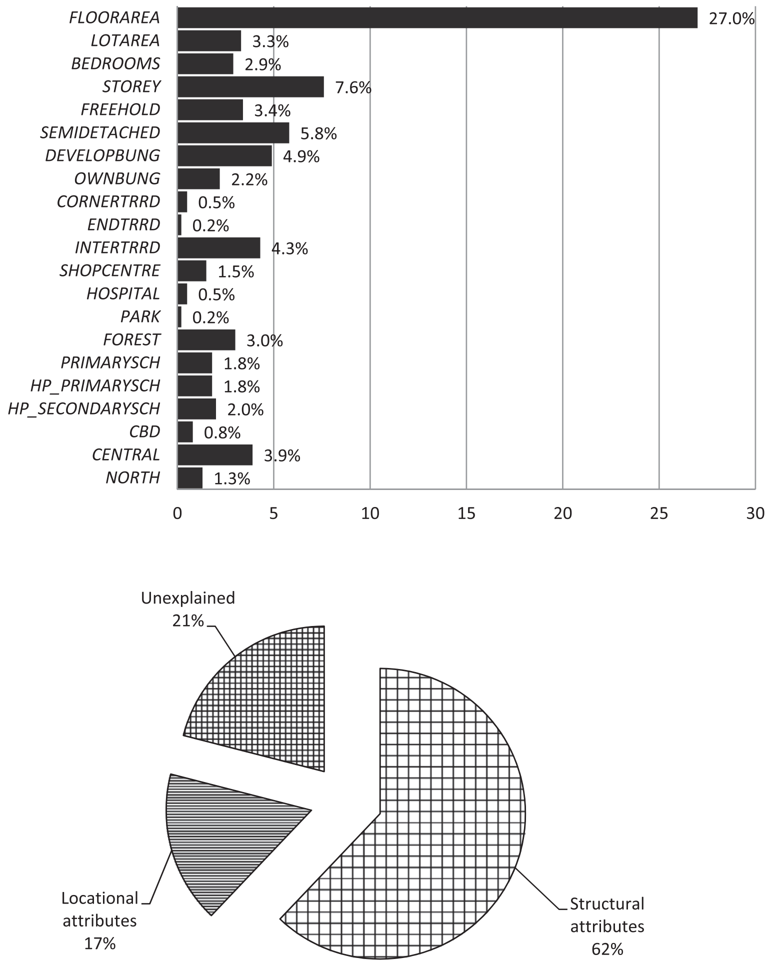

Figure 3. Shares of relative importance (LMG) for residential property values, OLS-Model.
Note: The R^2 with significant variables is 79%.

structural attributes are major determinants of residential property values. Similar results have been obtained by Tan (2012) where he examined the housing needs and preferences of first-time buyers in Kuala Lumpur with emphasis on certain attributes of a dwelling such as the number of bathrooms, bedrooms, living rooms, kitchen, among others. The study revealed that major preference is given to structural attributes i.e. number of bedrooms. More recently, a study carried out by Hiller (2015) in Münster, Germany using the relative importance approach drew the conclusion that structural variables explain most of the price variations (64.3%), whilst locational variables and time explain only 22.1% and 0.9%, respectively, when the depended variable is based on apartment prices.

Supporting the observation above, since the study only uses housing transaction data in the metropolitan city alone, the results indeed show large variations in the structural attributes compared to the locational attributes in the housing market of the studied area. This is predictably so since the high density and also the highly built up nature of the Kuala Lumpur market explains relatively smaller variations in locational attributes in the market compared to a more important impact of structural attributes of the properties.

7. Conclusion

This paper employed the LMG method to assess the relative importance of structural and locational attributes effects on property values, based on a sample of 4045 sales data of landed property within the Metropolitan Kuala Lumpur. Twenty-one different explanatory variables are used to estimate the relative importance for this market. The outcome shows that the value of a residential property in Metropolitan Kuala Lumpur over the period of 2009–2010 is significantly determined by the structural attributes compared to locational attributes. In short, floor area, two or more storeys, semi-detached, developers' design bungalow, intermediate terrace, freehold holding status, lot area and four or more bedrooms explain most of price variations.

The important observation above can be utilised as guiding principles by property developers in building future houses in Metropolitan Kuala Lumpur. Aligned to the findings, property developers should concentrate on building houses with maximised floor area, two or more storeys, property types, lot area, greater number of bedrooms and property with freehold status, as these are the key attributes demanded by the future property owners.

In the space of secondary property market, valuer, house agent or seller/owner could largely benefit from the findings. As a valuer, house agent or seller/owner, one would know that they could command higher premium selling price if their property has advantages in terms of structural attributes. They can perform the transaction in an informed manner as indicated by the outcome of this research. They may also want to regard the winning structural attributes cited above as their negotiating advantage. In enhancing the property price justification, two locational attributes i.e. closeness to city centre, and closeness to forest may increase the valuation as these two factors were highly appreciated in the findings.

It must be cautioned, in arriving to the final agreed property price, this outcome serves as a guide as Willis and Garrod (1993), and Lockwood and Rossini (2012) have demonstrated that considerable variation can exist in expert's estimation of the premium added to a property by a particular attribute.

While the findings are considered to be significant in assessing the discussed attributes, the study could have been more complete with the availability of other data points. Several potentially important independent variables were not available such as property age and number of bathrooms, and census-block level data on neighbourhood characteristics (for example, local crime rates) and socio-economic characteristics (for example, households' income, rate of unemployment, number of professionals and number of the unskilled). In addition, this study has not investigated the effects of disamenities (for example, proximity to landfill, flood risk and high voltage power transmission line) on property values. Therefore, we strongly recommend that future researchers include the abovementioned factors in their future studies.

In summary, this research has successfully unearthed and established the relative importance of structural and locational attributes in determining the residential property values in Metropolitan Kuala Lumpur. More importantly, major parts of the reasons behind the increase in property prices in the recent years are identified and rationalised.

Notes

1. A more extensive review of the methods is provided in Bi (2012) and Braun and Oswald (2011).

2. As has been argued in the literature, one of the limitations of HPM is that this method is found to be less sensitive to spatial variation, as the method assumes that the effect of locational amenities on residential property values is fixed across a geographical area. Fotheringham, Brunsdon, and Charlton (2002) postulate that the relationship between locational amenities and residential property values across geographical areas in a stationary fashion may not be representative of the situation in any particular part of the study area and may hide some interesting and important local differences in the determinants of residential property values.
3. For discussion of hedonic regression theory, see Freeman (1979b) and Kain and Quigley (1970a).
4. Ordinary least-squares (OLS) regression is a generalised linear modelling method that may be used to model a single response variable which has been recorded on at least an interval scale. The method may be applied to single or multiple explanatory variables and also categorical explanatory variables that have been appropriately coded (Hutcheson, 2011, p. 224).
5. Only 2009 and 2010 data were available for analysis and this was appropriate set of data since that was the period of economic recovery in Malaysia, witnessing vibrant property transactions in a stabilising property market.
6. Our sample consists of 421 (10.41%) units of semi-detached house, 160 (3.96%) units of developer's design bungalow house, 227 (5.61%) units of owner's design bungalow house, 275 (6.79%) units of corner lot terrace house, 172 (4.25%) units of end lot terrace house, 2505 (61.93%) units of intermediate terrace house, 6 (0.15%) units of corner lot cluster house, 3 (0.07%) units of end lot cluster house, 53 (1.31%) units of intermediate lot cluster house and 223 (5.51%) units of townhouse. Our sample thus captures over 90% of landed residential properties in the study area that are transacted in 2009 and 2010.
7. GIS can be defined as a branch of computer technology that deals with geographical information (Maguire, 1991); or alternatively as the set of computer-based decision support systems containing data, hardware, software and organisational for capturing, storing, managing, manipulating, analysing and visualising a special type of information, namely spatially referenced data (for alternative definitions of GIS, see Dueker, 1979; Burrough, 1986). An attempt to employ GIS in hedonic house price study has started in the US, but in the late 1990s, much attention has been given by UK researchers in employing GIS for the purpose of their research and now GIS has widely been employed in hedonic house price study. GIS has obtained greater attention from researchers because of its capabilities, particularly in handling and organising large spatial data sets from various sources.
8. Spatial analysis techniques have been defined as those "whose results are dependent on the locations of the objects or events being analysed" (Goodchild, Haining, & Wise, 1992). Bailey (1994) noted that spatial analysis is a general ability to manipulate spatial data into different forms and extract additional meaning as a result. Most importantly, spatial analysis involves the analysis of patterns in spatial data, relationships between patterns and other attributes, or the modelling of such relationships for the purpose of the understanding or prediction of certain phenomenon within the study region.
9. A household may perceive a locational amenity to be within a certain distance of the property, even though natural or man-made barriers may prevent a pedestrian from travelling along the shortest straight-line route to reach the locational amenity.
10. In Malaysia, primary school is intended for pupils aged 7–12, whilst secondary school is intended for pupils aged 13–18.
11. The identification of high-performing primary schools and high-performing secondary schools for this study is done based on the list produced by the Ministry of Education Malaysia.High-performing schools are defined as schools with ethos, character and a unique identity which enable the schools to excel in all aspects of education. These schools have strong and excellent work cultures and dynamic national human capital for holistic and continuous development in addition to being able to compete in the international arena, hence becoming the school of choice. There are six criteria were used to select high-performing schools; excellent academic achievement, towering personalities, national and international

awards, linkages with institutions of higher learning, strong network and nationally and internationally benchmarked.

12. Multicollinearity exists when two or more of the predictors in a regression model are moderately or highly correlated. There are six ways to deal with highly correlated predictors when developing a linear regression model; manual variable selection (i.e. the variance inflation factor or VIF), tree-based automatic variable selection, regression-based automatic variable selection (i.e. stepwise regression methods), variable reduction via principal components analysis or PCA, variable reduction via partial least squares or PLS and parameter estimation via "shrinkage" methods.
13. Sequential means that the regressors are entered into the model in the order they are listed. The sequential sums of squares of all regressors do sum to the model sum of squares (Grömping, 2006).

Disclosure statement

No potential conflict of interest was reported by the authors.

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