A Review of Property Attributes Influence in Hedonic Pricing Model

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Abstract

The property attributes – physical, neighbourhood and location attributes – are incorporated into Hedonic Pricing Models (HPM) to determine property prices or evaluate the relative contribution of each attributes to the property prices. However, the findings of most studies on the influence of the property attributes on prices have been diverse. The directionality and quantum of influence are not static rather dynamic. Therefore this paper reviewed previous hedonic pricing models studies and summarise the influence of property attributes on price. The review found that the magnitude and directionality of the property attributes influence on prices are not uniform but rather diverse depending on the property type, situations and consumer preference. The divergence of findings was found to be more common in the physical attributes and location attributes. The findings on neighbourhood attribute are relatively more uniform. This is because most of the neighbourhood attributes are both positive or negative externalities, and deals with the overall society rather than a single property. The review shows that most of the hedonic pricing model applications are in the housing market with fewer applications in the commercial property market. The paper recommends more application of the hedonic pricing model in the commercial property market.

Keywords
Hedonic pricing model, physical attributes, neighbourhood attributes, location, real estate

1. Introduction
Properties are real estate assets which are physical structures (Lecomte, 2019) whose ownership gives the holder the right of enjoyment, possession, letting and disposal. The property market involves the transaction of properties in terms of letting, buying, selling, mortgaging and auctioning as the case may be. The property market performs a strategic role to the individuals, institutions and the economy in general. To the individuals, the property market provides them with the avenue to have their shelter and accommodation, a source of income to those that let their properties and provides employment opportunities to the teaming members of the populace. For instance, in Malaysia alone, about 1.4 Malaysian are employed in property-related jobs (Ling, Almeida, Shukri, & Sze, 2017). The property also serves as the greatest household's wealth as well as their dominant liability (Campbell, 2012; Usman & Lizam, 2016). The property market, unlike other markets, is imperfect. Properties are heterogeneous, unique and distinct. No property is identical with another at least in their locational position. Properties are thinly or rarely traded, have a cyclical market with relative information asymmetry, illiquid, have a high cost of transaction and relocation (Aliyu, Sani, Usman, & Muhammad, 2018; Wiley, 2017). These characteristics make the property market price largely uncertain and volatile (Hardin III, Jiang, & Wu, 2017).

Real estate property is a bundled commodity. It is made up of many components that cumulatively make-up the final product – residential properties, commercial properties, hotel properties, industrial properties, agricultural properties, recreational properties, etc. The property bundles are broadly grouped into three attributes – the

physical attributes, the neighbourhood attributes, and the location attributes (Leishman, 2001; Li, He, Xu, Wang, & He, 2013; Tian, Peng, Wen, Yue, & Fang, 2020; Hamza Usman, Lizam, & Adekunle, 2020; Wu, Wei, & Li, 2020; Zhang, Zhou, & Hui, 2020). The property attributes play a vital role in the marketing and pricing of real estate asset. Each property has a unique feature which distinguishes it from each other. The features are capitalised into their prices using the hedonic pricing model.

Hedonic Pricing Model (HPM) is a revealed preference method used to model property prices as a function of property attributes. The model based on Rosen (1974)'s seminal works, hedonic prices and implicit market, considered property price as the sum of implicit prices of property attributes. Hedonic pricing model considered price as a composite of interrelated property attributes including physical characteristics of the property, neighbourhood attributes, and location features. The physical attributes of the property involved the tangible elements of the property. These are tangible assets that are inherent within the property itself. For instance, it includes lot size, building area, age, number of room and toilets, building height, building type, property condition, and tenure. This attribute is reported in the literature to have a diverse range of influence on property prices (Abidoye & Chan, 2017; Wen, Gui, Zhang, & Hui, 2020). The neighbourhood attributes, on the other hand, are either tangible or intangible elements that are not peculiar to a particular property but to all the properties within a particular neighbourhood. Examples of such attributes are public facilities and amenities, security, serenity etc. The neighbourhood attributes are considered a significant component of the hedonic price model (Holt & Borsuk, 2020; Keskin, 2008; Wilhelmsson, 2004; Wu, Wei & Li, 2020; Zhang, Zhou & Hui, 2020). Location is the discrete position of a property relative to other properties, facilities, amenities, utilities, and services. Location is reported in HPM literature as one of the most significant determinants of property prices.

The influence of the property attributes on prices using the hedonic pricing model has been reported with diverse findings. While some studies found a positive relationship with price in some variables others found a negative relationship with the same variables. Therefore, this paper reviews the influence of the property attributes influence on property prices and compare the findings. The rest of the paper is structured as follows: Section 2 provides information on the hedonic pricing model. Section 3 reviewed the theoretical underpinning behind the HPM. The property attributes are reviewed in section 4 and section 5 concludes the paper.

2. Hedonic Pricing Model

The hedonic pricing model is a revealed-preference model that explain property prices based on their attributes (Yang, Wang, Zhou, & Wang, 2018). In the hedonic model, the property is considered as a composite good which is made up of its components. Thus the property price is the function of its characteristics which are priced simultaneously. Property is a heterogeneous good with bundled characteristics. The hedonic price modelled the implicit (shadow) prices of these bundle characteristics such that inferences can be made regarding their relative contribution to the property prices (Yu & Levy, 2017). The implicit price also indicated the amount a consumer is willing to pay (willingness to pay) for each property characteristics (Yang et al., 2018; Yu, Pang, & Zhang, 2017).

According to Seo, Salon, Shilling, & Kuby (2018), Hedonic price model is used to estimate the "economic value of nonmarket goods" by disaggregating the price of the good into the prices of its constituent characteristics, including the "non-market" features. When applied to real estate, the hedonic price model disaggregates the property price into the prices of the property's distinct characteristics known as implicit prices. The distinct property characteristics that make up the property are its physical characteristics, the neighbourhood characteristics and locational characteristics (Andres & Calvo, 2017; Dai, Bai, & Xu, 2016; Das, Smith, & Gallimore, 2017; Deng, Ma, & Nelson, 2016; Gnagey & Tans, 2018; Liou, Yang, Chen, & Hsieh, 2016; Mohammad, Graham, & Melo, 2017; Sevtsuk & Kalvo, 2018). The hedonic price thus takes the following form as expressed in equation 1.

$$P = f(S, N, L) \qquad (1)$$

Where,
P = Property price
S = Structural (physical) characteristics
N = Neighbourhood characteristics
L = Locational characteristics

3. The theoretical underpinning

The hedonic price principle has been used since the early nineteenth century. This can be seen in the work of Court (1939) in the field of consumer and marketing. The principle was based on the idea that heterogeneous goods can be described by their features. Such goods are a bundle of characteristics that cumulatively make up the good. The seminal work of Rosen (1974), hedonic price and implicit market, lay the formal theoretical foundation for the application of hedonic price model in property market modelling (Francke & van de Minne, 2018). The theory explains that property value is a revealed preference which measures the value of non-market goods based on the utility of specific features and people's willingness to pay (Yu, Pang, et al., 2017). One of the nature of property is heterogeneity with different distinct characteristics including property's inherent features, neighbourhood characteristics and location (Dai et al., 2016; Fell & Kousky, 2015). According to the theory, the implicit utility derived from the property characteristics make up the utility derivable from the property as a bundle. In other words, the theory considers property as a bundle of characteristics such as the property physical feature and location. Such individual characteristics cannot be sold independently of the property. Thus, the demand and supply for the individual property characteristics determine the marginal contribution (willingness to pay) to the aggregate bundle price (Francke & van de Minne, 2018).

The theory of hedonic prices provides that the market price of a good or service can be disaggregated into constituent non-market characteristics that provide utility to the buyer. The theory assumes consumers do not buy the product characteristics separately in the market but the implicit market for the characteristics in the form of willingness to pay for the individual characteristics within the final market price (Munro & Tolley, 2018). The theory assumes that goods are differentiated thus making it a revealed preference method such that the obtained price of a good is a combination of implicit prices of the constituent attribute (Cao, Swallow, & Qiu, 2017). Property hedonic price is the combination of the implicit prices of the property's physical, neighbourhood, and location characteristics (Yu, Zhang, & Pang, 2017).

4. The Property attributes

Properties are heterogeneous bundle that have physical, neighbourhood, and location attributes. The influence of these attributes on property prices is reviewed in the following subsections.

4.1 Physical attributes

Property physical attributes are structural characteristics that are inherent to the property. These are features that their presence, number, and condition, or otherwise affect the price of the property. Properties are building structures constructed to serve the purpose of residence, commercial space or industrial use. Such buildings have their structural components and characteristics that made up the property. These are called the physical attributes which are internal to the property itself. The physical attributes of the property may include its size, age, year of transaction, bedrooms, toilets, living room, ceilings, floors, height, type, swimming pool, security post, servant quarters, garage, etc.

Different studies use hedonic price modelling to estimate the relative marginal contribution of the physical attributes to the property prices. Findings from these studies are varied and diverse. For instance, while Dziauddin et al. (2014), Taylor et al. (2016) and Yang et al. (2018) found the number of bedrooms to positively affect residential property prices, Dai et al. (2016) and Yu, Zhang, et al. (2017) found a negative influence of bedrooms on property prices. Other studies did not find a significant relationship between the number of bedrooms and property prices. Taylor et al. (2016) found both linear and squared number of rooms to affect residential property prices positively. The number of rooms is attributable to the residential properties only. Rooms are expected to impact property prices because they provide privacy and shelter needs of the occupant. The divergent result may be due to differences in the study area and consumer preference. For instance, a large household family may have a higher demand for room and would be more likely to pay a higher implicit room price than the low household family. Thus, studies in high density areas are likely to produce significant positive relationship between number of rooms and property prices.

Another important property feature is its size. The size could be in form of lot size, building size or plot size. Larger properties are expected to give consumers more utility than the smaller properties. Various studies found a positive relationship between property size and its prices (Dai et al., 2016; Dziauddin et al., 2014; Taylor et al., 2016; Yang et al., 2018). Property price is expected to diminish as its ages. Thus, the relationship between property age and price is mostly found to be negative (Fell & Kousky, 2015; Núñez-tabales, Rey-carmona, & Caridad y Ocerin, 2016). However, the negative relationship between age and property values may not be continuously linear. Taylor et al. (2016) found cubed property age to be positively related to price even though the same study found a significant negative relationship with linear and squared age.

Other property physical attributes such as the year of the transaction, the property type, the availability of servant quarters, swimming pool, security post, ceiling, door, bath and height were found to have a significant relationship with property prices (Abdullahi, Usman, & Ibrahim, 2018; Dziauddin et al., 2014; Yang et al., 2018). Summary of some recent findings on the impact of physical attributes on property prices is presented in table 1.

Table 1. Summary of some recent findings on physical attributes

Authors	Dziauddin et al. (2014)	Fell & Kousky (2015)	Dai et al. (2016)	Núñez-tabales et al. (2016)	Taylor et al. (2016)	Yu, Zhang, et al. (2017)	Abdullahi et al. (2018)	Yang et al. (2018)
Property type	Res.	Com.	Res.	Com.	Res.	Res.	Res.	Res.
Size	+	+	*	+	2			+
Room	+		-		2	-	+	+
Age		-	-	-	1	-		-
TRSC							+	
CND			*				+	
Living							*	
BQ							+	
Pool							+	
Ceiling							*	
Sec. post							+	
Door							+	
Height		-						+
Type	+							

+ Significant positive relationship
- Significant negative relationship
* No significant relationship
$+^2$ significant positive relationship and significant squared positive relationship
-2 significant negative relationship and significant squared negative relationship
$+^3$ significant positive cubed relationship

4.2 Neighbourhood attributes

These are environmental amenities or disamenities that their presence or otherwise affect property prices. Neighbourhoods are spatial enclosures within which social and economic interaction and activities take place. The intensity of these interactions vary from place to place and is important to the lives of the populace. The benefits or otherwise of the amenities and interaction can be capitalised into property prices because consumers consider, in addition to physical attributes, the neighbourhood in their property purchase decision. This is because the neighbourhood offers the residence the comfort, security, social interaction and family life. These benefits also come with certain negative externalities that may affect the mentioned benefits negatively.

Property neighbourhood attributes also include public services such as hospitals, schools, airport, etc., which exert a positive impact on proximate property prices. However, these public infrastructures may exert a negative impact on property prices due to possible nuisances such as pollution, noise, vibration (Yang et al., 2018). Various studies investigated the impact of neighbourhood attributes on property prices with different and diverse findings. In many hedonic price models, studies control for the neighbourhood effect of population density, employment density, income, shopping density, and presence of schools, hospitals, bus stop, sport and cultural centres, and a range of numerous positive and negative externalities. The presence of positive externalities such as rail system, improved transportation networks, etc., are expected to give price premium to the property. However, the negative externalities such as the presence of contaminated areas, noise, pollution, radiations, flooding, nuisance, etc., are expected to cause price discount to the property prices.

Various studies found population density and employment density to affect property price positively (Yang et al., 2018; Yu, Pang, et al., 2017; Yu, Zhang, et al., 2017). This finding shows that a higher population and employment density indicates higher demand for properties and therefore is compounded into the price as a premium. However, Taylor et al. (2016) found a negative relationship between employment density and residential property prices. Income was also found to positively influence property prices (Taylor et al., 2016; Yu, Pang, et al., 2017; Yu, Zhang, et al., 2017). Higher-income relaxes consumer's budget constraint thereby increasing their demand power. The presence of public services was found to have a positive impact on property prices (Yang et al., 2018). However, the presence of such services may have both positive and negative impact on property prices. For instance, Dai et al. (2016) found the presence of rapid rail transit transfer station to have a negative impact on property prices within 200m radius but have a positive impact on the prices afterwards. A summary of recent findings on the impact of neighbourhood attributes on property prices is presented in table 2.

Table 2. Summary of recent finding on neighbourhood attributes

Authors	Fell & Kousky (2015)	Dai et al. (2016)	Taylor et al. (2016)	Núñez-tabales et al. (2016)	Yu, Zhang, et al. (2017)	Yu, Pang, et al. (2017)	Yang et al. (2018)
Property Type	Commercia	Residential	Residentia	Commercia	Residentia	Commercia	Residenti
Population density	+		+		+	+	+
Employment density			-		+	+	+
Income			+		+	+	
Shopping density							+
School							+
HSP							+
Bus stop		+					+
S&C centre							+
Race						*	
+EXT	+	+		+			
-EXT		+	-				

Note:
+ Significant positive relationship
- Significant negative relationship
* No significant relationship
+EXT = Positive externalities
-EXT = Negative externalities
HSP = Hospitals
S&C = Social and cultural

4.3 Location attribute

Location is regarded as the most important determinant of the property price. This is the reason why a popular real estate parlance 'location, location, location' is used to symbolize the importance of location on property prices (Heyman & Manum, 2016; Orford, 2017; Özyurt, 2014). The essence of this is driven from the fact that property prices are location specific and vary across space. Property locations are static, immovable and distinct such that none is spatially the same with another (Wyatt, 2010). Such spatial distinctiveness wields substantial impact on property prices with the consequent consideration to all property market participants (Orford, 2017). Location is associated with neighbourhood, amenities, social ties, and many environmental factors, with their related externalities, that cumulatively wield enormous impact on property price. For instance, specific spatial point of property influences its access to other land uses, other properties. The location also determines the proximity, level and quality of amenities which could affect satisfaction with property locality (Can, 1998; Pace, Barry & Sirmans, 1998).

The role of location in property market modelling stems from the early urban economic theories which are based on the trade-off between accessibility and space relative to Central Business District (CBD) (Alonso, 1964; Ibeas, Cordera, Dell'Olio, Coppola & Dominguez, 2012). Properties with higher accessibility attract higher

prices due to accessibility premium relative to the urban systems and activities (Chiarazzo, dell'Olio, Ibeas, & Ottomanelli 2014; Muth, 1969). With the availability of many urban sub-centres and improved transportation network, the polycentric nature of many cities has diminished the role of CBD in the property market but increased the suburban centres' influence (Ahlfeldt, 2011; Ahlfeldt & Wendland, 2013; Trujillo, 2016). The polycentric city theory is useful in property market research since properties are heterogeneous with an imperfectly competitive market. Consumers are assumed to be rational and utility maximising while commercial firms are profit maximising which influence how they trade-off accessibility and transportation cost. With numerous occupation centres, the linear access-space model does not capture the reality of modern cities. Thus, property prices vary across space based on the available externalities (Bujanda & Fullerton Jr., 2018; Clark & Pennington-cross, 2016; Pryce, 2013; Seo, Salon, Kuby, & Golub, 2019).

The locational characteristic of the property market, therefore, makes it an important feature to property valuers when modelling the real estate market. The major issue of concern is now not on whether the location is important but rather on how to incorporate it into property market analysis. The hedonic pricing model considers property price as a function of its physical attributes, neighbourhood features and location. The utilisation of the hedonic model in property modelling is based on the seminal work of (Rosen, 1974) on hedonic prices and implicit markets. Since then, several works empirically modelled property market including commercial properties (Abdullahi et al., 2018; Basu & Thibodeau, 1998; Das et al., 2017; Deryol, 2019; Fell & Kousky, 2015; Fitzgerald, Hansen, Mcintosh, & Slade, 2019). Although the incorporation of physical and neighbourhood attributes into the hedonic model is relatively straight-forward, the incorporation location factor into the hedonic model is rather difficult, subjective and implicit (Abdullahi *et al.*, 2018; Effiong, 2015; Ogunba, 2013). The traditional implicit locations modelling in hedonic models mostly come in two ways. Firstly, location dummies are used to control the neighbourhood effect on commercial property prices (Deryol, 2019; Fell & Kousky, 2015; Raposo & Evangelista, 2017).

The second method of implicitly modelling location into the commercial property market in the hedonic model is using the approximate distance between the subject commercial property to other spatial landmarks such as highways, CBDs, airports, rail stations, bus terminals, highway exits and other positive and negative externalities that have an impact on property prices (Abdullahi *et al.*, 2018; Bujanda & Fullerton Jr., 2018; Clapp, 2003; Pace *et al.*, 1998; Seo, Salon, Kuby, & Golub, 2019).

Location attribute in the hedonic price modelling is the spatial position of the property in relation to other property price influential factors. In real estate, location is mostly considered as the most influential determinant of property prices to the extent that real estate practitioners use the proverbial statement that the "three most important determinants of real estate prices are 'location, location, location'" (Nitsch, 2007). Properties are located on space and interact with other spatial features of the urban area such as places of work, CBD, rail lines, rail stations, parks, airports, schools, hospitals, seas, institutional buildings, and high ways.

Urban location theory provides that property prices decrease with distance to the urban centres (Alonso, 1964). This theory is mostly used to evaluate the impact of property location with respect to other spatial features with the property prices. Similarly, the price premium and discounts associated with property location is evaluated using the hedonic pricing model. Various studies evaluated this locational impact on property prices. For instance, CBD, rail lines, commuting time, hospital, school, bay, sea view, forest, institutional buildings, and parks have distance decay (Dai et al., 2016; Dziauddin et al., 2014; Fell & Kousky, 2015; Yang et al., 2018; Yu, Zhang, et al., 2017). This implies that property price decrease with distance to the other essential spatial features locations.

Other studies, instead of using distance decay to measure the impact on location, use accessibility to other spatial features locations. For instance, access to Bus Rapid Transit (BRT), highway and forest areas were found to have a significant positive effect on property prices (Fitzgerald et al., 2019; Yu, Pang, et al., 2017). A summary of some recent findings on the effect of location on property prices is presented in table 3.

Table 3. Summary of some recent finding on properties location attributes

Authors	Location	Comm. time	Distance to											Access To		
			Com	Hospital	Prison	School	CBD	Rail	INS	Park	Airport	Sea Lake	Bay	FRST	Highway	BRT
Taylor et al. (2016)							-							+		
Abdullahi et al. (2018)	+															
Yu, Zhang, et al. (2017)		-					-	-							+	
Yang et al. (2018)							-	-			+	-	-			
Yu, Pang, et al. (2017)							-	-		-					+	+
Fitzgerald et al. (2019)				-	*	-	*				-				+	
Núñez-tabales et al. (2016)	+															
Dziauddin et al. (2014)		-	-	+		+	-	-	-			-		-		
Fell & Kousky (2015)												-			*	
Dai et al. (2016)			*	-		-	-	-								-

+ Significant positive relationship
- Significant negative relationship
* No significant relationship
Comm. = Commuting
Com. = Commercial areas
INS = Institutional buildings
BRT = Bus Rapid Transit
CBD = Central Business District
FRST = Forest

5. Conclusion

Property is a bundled commodity consisting of its attributes which are capitalised into prices by hedonic pricing model. It assumes unitary equilibrium and models property prices as the function of the property attributes. The property attributes are broadly grouped into three – the physical attributes, the neighbourhood attributes, and the location attributes. Most hedonic pricing models incorporate these attributes to determine property prices or evaluate the relative contribution of each attribute into the property prices. However, the findings of most studies on the influence of the property attributes on prices have been diverse. The directionality and quantum of influence are not static rather dynamic. Therefore this paper reviewed previous hedonic pricing models studies and summarise the influence of property attributes on price.

The review found that the magnitude and directionality of the property attributes influence on prices are not uniform but rather diverse depending on the property type and situations. The divergent result may be due to differences in the study area and consumer preference. For instance, a large household family may have a higher demand for room and would be more likely to pay a higher implicit room price than the low household family. Thus, studies in high-density areas are likely to produce a significant positive relationship between the number of rooms and property prices. The divergence of findings is more common in the physical attributes and location attributes. The findings on neighbourhood attribute are relatively more uniform. This is because most of the neighbourhood attributes are both positive or negative externalities, and deals with the overall society rather than a single property. Similarly, the review shows that most of the hedonic pricing model application is in the housing market with fewer applications in the commercial property market. The paper recommends more application of the hedonic pricing model in the commercial property market. Further researches that systematically review each element of the property attributes are equally recommended. The paper contributed to the literature on hedonic pricing modelling.

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