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Lease Decay and the Prices of Private Residential Properties in Singapore

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Singapore's residential properties sold mainly on 99-year and freehold leases are useful for studying how changing leases and age affect property values. This paper uses the hedonic model to analyze the effect of lease decay on transaction prices for non-landed, private residential 99-year leasehold properties. The results find a negative effect of lease decay on the transaction price, or more specifically, a 1% increase in the remaining lease increases prices by 1.46%. The effects of decay differ between freehold and leasehold properties, thus implying that age has negative effects on freehold property prices but positive effects on leasehold prices. The results show that older properties could increase in value after controlling for the physical decay effect.

Keywords

Lease Decay, Residential Property, Age-House Price Correlations, Age Decay

1. Introduction

Real estate has held high significance and status in Singapore's socio-political and economic environment. As property maintains its appeal through wealth creation and growth prospects, in the long run, Singaporeans hold property ownership in high regard due to the value of property as an asset.

The majority of Singapore's residential properties have a 99-year leasehold tenure. As such, it is essential to understand how the property value changes as the 99 years elapse. In contrast to freehold property which lasts in perpetuity, leasehold property owners have an additional concern regarding the expiring lease. Properties will be returned to the state once the lease expires. Thus, owners of private leasehold residential property derive value from the resale market by selling the property with its remaining lease, thus making it a depreciating asset (Agarwal and Foo, 2019). The primary authority that governs land titles in Singapore is the Singapore Land Authority (SLA). The SLA is a statutory board under the Ministry of Law and optimizes land resources for socio-economic development in Singapore. There are two ways for developers to obtain residential plots in Singapore. The first is through government land sales, typically sold with 99-year lease tenures on vacant parcels of land. The second is through the collective sale of existing properties. This collective sale is conditional on an 80% majority of the project agreeing to the sale and the subsequent development subject to approval by the planning authorities. Owners of leasehold properties may also dispose of their property before the lease expires via a collective sale to developers, who will then request a lease- top up to 99 years from the SLA. Collective sales are also the only avenue for developers to acquire freehold land.

However, Singapore is a considerably young city, and no private residential leaseholds have expired their term yet. The oldest properties in Singapore are approximately 50 years where some have been sold en bloc for redevelopment. Therefore, the analysis performed on transaction prices per square foot (psf) will not contain data for the entire lifecycle of the 99-year lease. Instead, this study will identify factors that can explain for and show the transaction price trend.

Models in previous research work, such as the bid rent theory (Alonso, 1964) and the hedonic price model (Rosen, 1974), have shown that the value of a property is not merely dependent on physical value but also the land value which is derived from the location and amenities that surround the property. As such, the effect of the balance lease on 99-year leasehold property prices in Singapore is analyzed before and after adding other infrastructure and unit attribute factors.

Comparing the effects of decay for both freehold and leasehold tenures would be relevant to investors in deciding which property title to purchase. Age is used instead of the remaining lease for leasehold properties since there is a proportionally inverse relationship between the remaining lease and the age of a leasehold property.

Theoretically, a freehold property is worth more than a leasehold property ceteris paribus. However, when the location and accessibility factors are accounted for, and decay in terms of age for both types of properties, there is potential for decay to have a similar or less influence on transaction prices for leasehold compared to freehold properties. This paper will be particularly significant to investors with limited capital who have to choose between investing in a freehold or leasehold property in a particular region.

This paper aims to achieve three objectives:

1. To examine the effect of lease decay on 99-year leasehold non-landed private properties in Singapore with and without the variables of unit area and infrastructure;
2. To analyze how the effect of age decay affects 99-year leasehold, non- landed, private properties; and
3. To compare the difference of the effect of age decay on leasehold and freehold properties in Singapore.

In this study, we observe that unit area and infrastructure significantly affect the price and reduce the price elasticity between the remaining lease and price for leasehold properties. After age variables are included, the price elasticity between the remaining lease and price increases more and age variables have a positive effect on price. On the other hand, age variables negatively affect prices for freehold properties.

This paper is organized as follows. Following the introduction is a review of the existing literature in Section 2. The data and research methodology are presented in Section 3, and the regression results are covered in Section 4. Some concluding remarks appear in the final section.

2. Literature Review

The service life of a building is the period during which a building or its parts meet performance requirements (ISO 15686-1, 2000), while the economic life of buildings refers to the period where costs and benefits are weighed to make decisions regarding design and management (Bradley and Kohler, 2007). Baum (1991) advocates that the revenue and opportunity costs are the most pertinent when deciding on building obsolescence. Building obsolescence stems from redundancy due to the inability of the building to serve its original purpose (Johnson, 1996). Not merely by its physical interpretation, obsolescence can be propelled by economic, social, and legal factors as well as political and technological developments (Mansfield, 2000; Thomsen and Van der Flier, 2011). This is often followed by redevelopment or refurbishment of the site. As such, refurbishment due to obsolescence often occurs earlier than refurbishment caused by deterioration (Aikivuori, 1996).

Properties in the Jiang Bei and Da Dukou districts in the Chongqing municipality of China have an average construction life of 38 years due to political reasons and other external factors rather than the construction quality of the building (Liu et al., 2012). As buildings deteriorate with use, the costs of maintenance rise, and asset recovery diminishes. The economic life of the building is the point where the equivalent annual cost, determined by the annual asset recovery cost and the annual operation cost, is at its lowest (Wang and Wang, 2015). Should the structural reliability and comfort meet the requirements of the existing users of the building, it can continue to be used, but this is seen to be economically unreasonable.

Using proxies that reflect the impact of these obsolescence factors, Langston (2011) derives a model to predict the useful life of a building by discounting them from its estimated physical life. While some contend that only the most influential factors matter, Langston (2011) maintains that all factors are interconnected, and accounting for all of them would give the best sense of the whole.

Several works have analyzed the influence of decay and present the life cycle of a building as its capacity to perform over time (Markus et al., 1972; Miles et al., 2007). Based on Markus et al. (1972), obsolescence is elucidated by referring to the increasing difference between the increasing expectations of building users and the deterioration in building performance (Iselin et al. 1993). Exogenous factors such as the neighborhood environment and the availability of even more attractive options have become highly related to obsolescence as the expectations of users increase over time due to economic prosperity and technological advancements (Wassenberg et al., 2007). Refurbishments and redevelopment have thus become requirements to meet user demands for performance.

Depreciation follows an exponential trend with younger properties having a larger depreciation effect, thus reflecting the relative ratio of land value to building value in the total value of a property (Bokhari and Geltner, 2018). Furthermore, real depreciation is mainly caused by changes in fundamental property value due to the progressive loss in potential revenue of a property as the building becomes obsolete. Bokhari and Geltner (2018) also identify properties that are less affected by depreciation in cities with low supply elasticity and space constraints.

Numerous studies have been conducted to identify the determinants of land value. Emo et al. (2013) state that locational factors such as access to transportation, amenities, and the neighborhood environment are the main variables, while Uju and Iyanda (2012) argue that non-locational factors, namely the time of purchase, hold more significance.

The determinants of land value rely on the willingness of consumers to pay for structural, locational, and neighborhood attributes of a property (Gwamna et al. 2015), following the bid rent theory (Alonso, 1964) and the hedonic price model (Rosen, 1974) which account for land utility, attributes, and accessibility to the user. In particular, Rosen (1974) primarily focuses on the proximity to the central business district (CBD) as home occupiers who live near the CBD would pay less for transportation to access amenities in the neighborhood. However, the houses would have a higher value due to this positive externality and tend to be structurally smaller than those further away from the CBD (Rosen, 1974). Furthermore, competition for space in the city center leads to overcrowding and congestion, which are negative externalities (Gwamna et al., 2015). Rosen (1974) regresses property values on the identified determinants, and their coefficients account for the hedonic prices of these factors. It is found that even in polycentric cities, the land values are still centered around the nearest CBD through the monocentric effect (Muth, 1969; Mills, 1972).

It is difficult to develop a precise model that can determine transaction prices of residential properties because of the sheer number of parameters involved and the subjective preferences or priorities of the seller and buyer (Gustafsson and Wogenius, 2014). Such information is difficult to obtain and measure. Hence, explaining differences in transaction prices with few pertinent and significant parameters is highly important.

Floor area is supported in various studies in the literature as a significant factor that influences real estate prices (Wilhelmsson 2002; Mirasyedi 2006; Selim 2008; Yusof and Ismail 2012; Amca 2016), along with the property age (Wilhelmsson 2002; Bin 2004; Yusof and Ismail 2012; Randeniya et al. 2017). While numerous studies conclude that the distance to the city center influences property prices (Wen et al. 2005; Yusof and Ismail 2012; Ayan and Erkin 2014), Randeniya et al. (2017) do not find this factor to affect sale prices. However, age may have a positive effect on price if redevelopment values increase faster than the decline in the utility of the existing property (Ayan and Erkin, 2014).

The Singapore government, like many others, chooses to lease most of the limited land supply rather than selling most of them as freehold. The lessee would be disinclined to perform multiple upgrades to the asset or redevelop the asset because they lose the benefit of the upgrade once the lease expires. However, the option to upgrade or redevelop a property is valuable, which justifies the lower price of leased assets compared to freehold in a high rental growth environment (Capozza and Sick, 1991).

The ability of a development to attract investments depends on its surroundings, which are external to the building itself (Frieden, 1961). According to Bourne (1969), residential construction in Toronto, Canada, follows growth trends in the previous years. It has a negative relationship with the age of the existing buildings, which means that the physical obsolescence of existing buildings does not prioritize redevelopment. Bourne (1969) also finds that accessibility through transport infrastructures and favorable zoning policies has a positive relationship, while there is no significant relationship with the distance from the city center.

Land prices increase with proximity to arterial roads and the CBD due to the cluster of high-quality amenities and businesses in that area, which makes it attractive for further developments (Haider and Miller, 2000). Traffic conditions can have both positive and negative effects, with the former providing accessibility while the latter causing noise pollution (Kim et al., 2007; Levkovich et al., 2016), and hence have contrasting effects on redevelopment potential (Cheshire and Sheppard, 1995; Bowes and Ihlanfeldt, 2001). Furthermore, proximity to good schools also increases the probability of redevelopment (Jud, 1985). Therefore, this study focuses on infrastructure variables due to their influence on prices to study how these variables might also influence lease decay.

Land development and redevelopment in Singapore depend on government planning policies and economic factors within the country. Although the government controls the land bank in Singapore through statutory boards, these developments are often undertaken by mutual effort and cooperation of the public and private sectors to construct the urban environment. Zhou et al. (2017) find that a higher pre-development floor area ratio leads to less likelihood of redevelopment in China as the government seeks to balance development throughout the urban areas. This ideology is similar to Singapore in terms of allowable plot ratio. A larger existing plot ratio is less likely to be increased, and hence there will be less incentive for redevelopment. Redevelopment follows the desirability of land as reflected by land prices. Hence, the likelihood of redevelopment is often affected by the factors that influence land prices, such as site, location, neighborhood characteristics, and policies. This study contributes to the existing literature by examining the effects of lease decay on residential property prices in Singapore and comparing the effects of age decay between freehold and leasehold properties.

3. Data and Research Methodology

Three levels of comparisons are made in this study:

1. The effect of lease decay in Singapore before and after the addition of surrounding infrastructure and unit area as variables
2. The effect of age on leasehold properties in Singapore
3. The difference in the effect of age decay for leasehold and freehold properties in Singapore

To the best of our knowledge, this is the first study that attempts to understand the difference in decay between leasehold and freehold properties in Singapore.

The data for the empirical study consist of transactions of non-landed private residential properties of freeholds and 99-year leaseholds from January 1995 to May 2019, excluding executive condominiums and en bloc transactions. They were taken from the Real Estate Information System (REALIS). This dataset contains information such as tenure, unit area, postal sector and transaction date. The remaining lease is derived from the given tenure and date of transaction. Transacted price psf acts as the dependent variable in this study as this paper seeks to study the effect of variables on property value.

To gather information on the current infrastructure in the surroundings of each development and its proximity to the CBD, a geographic information system QGIS is used to measure distance and count points within a specified buffer of 1000 meters (m). Locations of Mass Rapid Transit (MRT) stations in Singapore are taken from the QGIS Singapore Database, and the road networks are taken from Data.gov.sg (Data.gov.sg, 2019).

Age is the main variable of interest as this paper looks at the effect of age decay on leasehold properties instead of the remaining leases for comparison with freehold properties. Age is derived from the raw data by subtracting the completion year of the property from its sale year. When the building is incomplete or has an unknown transaction date, the transactions are removed from the data along with those sold on the year they were completed (i.e. age = 0). The variable that accounts for the effects of age is grouped into several buckets to capture transactions of units that are between 1-10, 11-20, 21-30, 31- 40, and 41 or more years in age (Age1.10, Age11.20, Age21.30, Age31.40, and Age41, respectively) where properties between 1 to 10 years in age (Age1.10) are taken as the base case.

The CBD of Singapore is identified in this study as the Raffles Place MRT, and infrastructure data in this study are based on 2019 conditions within a 1000 m buffer from each property: Number of MRT Stations, Length of Expressway Roads, Number of Expressway Roads, Length of Expressway

Slip Roads, Number of Expressway Slip Roads, Length of Major Roads, and Number of Major Roads.

A summary of the raw variables for the leasehold and freehold data is shown in Tables A-1 and A-2. It can be observed that prices for freehold properties are generally higher than those of leaseholds although the range of prices is rather similar. Freehold properties are also slightly older, with an average age of 9.99 years compared to 9.74 for leasehold properties. Based on the average distance, more freehold properties are located closer to the CBD as compared to the leasehold properties, and freehold properties are also seen to have a larger area as observed from the average of 1491 compared to 1309 in leasehold properties.

This study utilizes hedonic modeling and estimation as hedonic regression recognizes that heterogeneous goods, in this case, non-landed private residential properties, can be described by their attributes. The value of a property is generally equal to the sum of the structural value and the land value; these characteristics of the property cannot be sold separately (de Haan and Diewert, 2013). Hence, the value of individual characteristics cannot be independently observed; instead, economic influences on property price implicitly determine the marginal contributions of each characteristic to the property value.

The hedonic model assumes that the transaction price of a property, "P", is a function of the identified attributes that affect property value, where "ε" is a random error term associated with all of the variables. The initial model that identifies the effect of lease decay is:

$$\ln(P) = a + \beta_1 R_m + \beta_2 Q + \beta_3 D + \beta_4 P_s + \varepsilon \tag{1}$$

where

P: Price psf of transacted unit

R_m: ln of the remaining lease

QQ: Quarter of sale, Q11995 = 1

D: ln of the distance to Raffles Place MRT

P_s: Postal sector

The coefficient terms are the parameters of interest that indicate the effect of therespective variables on the price. To account for some of the error term "ε", additional factors such as unit area and infrastructure are added to the equation based on studies that show that the property value can also be derived from its location and amenities (Alonso, 1964; Rosen, 1974).

$$\ln(P) = a + \beta_1 R_m + \delta + \omega_1 A_r + \sum_{x=1}^{7} \rho_x I_x + \varepsilon \tag{2}$$

where

$\delta\delta$: $\beta_2 QQ + \beta_3 D + \beta_4 P_S$

A_r: ln of the area of a transacted unit

$\rho_x I_x$: Infrastructure (Number of MRT Stations, Expressways, Expressway Slips and Major Roads, Length divided by 1000 m of Expressway, Expressway Slip and Major Road) within a 1000 m radius

To benchmark the effect of lease decay against freehold properties, age is included as a comparable variable between the two tenures. Hence the revised equation for leasehold transactions includes discrete age dummies with properties 10 years and less in age as the base:

$$\ln(P) = a + \beta_1 R_m + \sum_{x=1}^{4} \theta_x Ag_x + \gamma + \varepsilon \quad (3)$$

where

$\theta\theta_x Ag_x$: Age dummies where properties are divided into buckets –11-20, 21-30, 31-40, and over 40 years in age

γ: $\delta + \omega_1 A_r + \sum_{x=1}^{7} \rho_x I_x$

With the dependent variable of natural log price psf, the coefficients of the independent variables input into the equation are compared across tenure to identify the effects of age on price and how it differs from that of freehold properties with the influence of the additional variables of infrastructure and area of unit transacted.

4. Results and Analysis

4.1. Lease Decay

The regression results in Table 1 (Basic column) show that the variables identified significantly impact price. It can be seen from the coefficient of ln.rm that a 1% increase in the remaining lease will result in a 1.62% increase in price. This reflects that a property with a longer lease will have a higher value, thus following the theory that a longer remaining lease will allow the owner or investor to have increased value from that additional year of utility.

Adding unit area and infrastructure to the results improves the R-squared of the model to 0.762 compared to 0.745 (Table 1). With the addition of the variables, the effect of lease decay becomes less prominent as a 1% increase in the remaining lease above the mean results in a 1.46% increase in price (1000 m column), which is less than the initial 1.62%. This implies that the effects of area and infrastructure variables inflate the effects of the remaining lease on price before they are singled out into their variables. The current elasticity of 1.46 is closer to the true value. Apart from the number of MRT stations, major roads, and lengths of expressway within 1000 m, the infrastructure variables have a negative effect on price. This indicates that in the case of Singapore, the negative externalities, such as noise and congestion, of having too much infrastructure around the property outweigh the benefits of accessibility (Kim et al., 2007; Levkovich et al., 2016).

Table 1 Lease Decay in Singapore

Leasehold	Singapore			
Variables	Basic		1000m	
	coefficient	t-value	coefficient	t-value
Intercept	0.339***	5.21	2.14***	28.2
ln.rm	1.62***	150	1.46***	133
Quarter	0.0145***	365	0.0139***	349
ln.distance	-0.177***	-24.6	-0.113***	-14.5
ln.Area			-0.194***	-70.4
MRT.Count.1000m			0.00923***	5.32
Ex.L.10.1000			-0.00346*	-2.15
Expressway.Count.1000m			-0.0132***	-10.1
ES.L.10.1000			0.0423***	17.2
ES.Count.1000m			-0.00730***	-17.0
Major.L.10.1000			-0.0197***	-16.7
Major.Count.1000m			0.00404***	9.24
Multiple R-squared	0.746		0.762	
Adjusted R-squared	0.745		0.762	

Notes: Signif.. codes: '***' 0.001, '**' 0.01, '*' 0.05, '.' 0.1, ' ' 1. ^postal sector variable found in full results (Table A3/A4, available upon request)

4.2. Separating Lease Effects from Age Effects

The age variable is divided into several buckets: 1-10, 11-20, 21-30, 31-40, and 41 or more years in age (Age1.10, Age11.20, Age21.30, Age31.40, and Age41, respectively), where properties between 1 to 10 years in age (Age1.10) are taken as the base case. Table 2 compares the models before and after separating the age effect.

Observing the results from the Lease Decay column in Table 2, where the coefficient, 1.46, for ln.rm is the elasticity of price for the remaining lease, a 1% positive change in the remaining lease is associated with a 1.46% positive price change. All variables in this model are significant, although the expressway length within 1000 m has a lower significance of 0.05.

When considering the Lease and Age Decay column, the coefficient of ln.rm is increased to 1.90. In other words, a 1% positive change in the remaining lease is associated with a 1.90% positive price change. This is a larger effect than the initial model without age, where the price elasticity for the remaining lease is lower at 1.46%. This greater elasticity in price with the remaining lease could be balanced by the positive effects captured in the age variables. There are increasing effects on price as the age of the property increases based on the coefficients from the age variables with Age11.20. Age21.30, Age31.40 and Age41 being 0.0496, 0.0638, 0.328 and 0.327 respectively. In other words, older properties transact at higher premiums than newer properties. This phenomenon could be due to the decay effects captured in the ln.rm variable, which may reflect the possible redevelopment or collective sale potential of the projects. The results are particularly significant for properties between 31-40 years old with a coefficient of 0.328, which is an over five-times increase in magnitude compared to properties between 21-30 years old with a coefficient of 0.0638.

Table 2 Lease and Age Effects in Leasehold Properties

Variables	Lease Decay		Lease and Age Decay	
	coefficient	t-value	coefficient	t-value
Intercept	2.14***	28.2	0.188	1.59
ln.rm	1.46***	133	1.90***	81.6
Age11.20			0.0496***	16.0
Age21.30			0.0638***	10.2
Age31.40			0.328***	32.2
Age41			0.337***	15.8
Quarter	0.0139***	349	0.0139***	349
ln.distance	-0.113***	-14.5	-0.120***	-15.5
ln.Area	-0.194***	-70.4	-0.193***	-70.6
MRT.Count.1000m	0.00923***	5.32	0.00803***	4.67
Ex.L.10.1000	-0.00346*	-2.15	-0.00222	-1.39
Expressway.Count.1000m	-0.0132***	-10.1	-0.0131***	-10.2
ES.L.10.1000	0.0423***	17.2	0.0388***	15.9
ES.Count.1000m	-0.00730***	-17.0	-0.00681***	-16.0
Major.L.10.1000	-0.0197***	-16.7	-0.0178***	-0.0178
Major.Count.1000m	0.00404***	9.24	0.00259***	5.92
Multiple R-squared	0.762		0.767	
Adjusted R-squared	0.762		0.766	

Notes: Signif.. codes: '***' 0.001, '**' 0.01, '*' 0.05, '.' 0.1, ' ' 1. ^postal sector variable found in full results (Table A4/A5, available upon request)

Apart from an expressway length within 1000 m, the other variables are highly significant. The Lease and Age Decay model is also shown to be a slightly better fit with an adjusted-R squared of 0.766 compared to 0.762 without age variables.

4.3. Comparing Decay between Leasehold and Freehold Properties

After analyzing the effects of age decay on price for leasehold properties, a comparison between leasehold and freehold is made to see the effects of age differences. Freehold and leasehold properties are similar apart from their tenures which captures the difference in utility due to length of ownership. The impact of age has been captured for both age variables. The primary institution in Singapore that determines leasehold and freehold land is the SLA. For comparison with freehold properties, the remaining lease variable properties with freehold tenure should be infinite. However, the natural log of infinity is infinity. Therefore, the remaining lease for freehold properties is substituted with a very large value of "9999" such that the natural log of the remaining lease for freehold properties would be reflected as "ln(9999)" for regression purposes. Table 3 shows the results for decay in leasehold properties compared to freehold properties.

The variable ln.rm in the Freehold column is reflected as "NA" due to the projects being assigned the same value for the remaining lease (Table 3). We can observe in Table 3 that the coefficients for the freehold age variables are all negative, which show that freehold properties are transacted at a discount compared to when they are new (up to 10 years in age). These results indicate that the age variables for freehold and leasehold properties may capture different effects other than their physical depreciation. Where the freehold properties follow the intuition that older properties transact at a discount compared to newer ones, leasehold properties show the opposite effect. This difference could be due to the decay effects captured within the ln.rm variable for leasehold properties. A 1% increase in the remaining lease corresponds to a 1.90% increase in price, which leaves the age variables to capture other effects. With the variable of the remaining lease being inapplicable to freehold properties, the decay effects can only be captured in the age variables, thus resulting in negative coefficients.

It is also observed that the discount effect of the age categories for freehold properties is inconsistent with increase in age. The coefficients of Age 11.20, Age 21.30, Age 31.40 and Age41 are -0.146, -0.241, -0.160 and -0.288 respectively. One possible cause of freehold properties transacting at a smaller discount between 31-40 years in age is the general age in which sentiment for collective sales is higher. It is difficult to disentangle the age-dependent effects for the two types of tenures. However, the contrasting effects between the two tenures make it clear that some positive effects are indeed associated with older properties apart from merely the physical decay effect.

The effects of other variables are largely similar for leasehold and freehold properties apart from the number of expressways within 1000 m, which is significant for leasehold properties at a coefficient of -0.0131 but not for freehold properties as observed from the significant codes. The length of expressways within 1000 m is insignificant for properties of both tenures.

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Table 3 Decay Effects in Leasehold and Freehold Properties

Variables	Leasehold		Freehold	
	coefficient	t-value	coefficient	t-value
Intercept	0.188	1.59	7.75***	54.9
ln.rm	1.90***	81.6	NA	NA
Age11.20	0.0496***	16.0	-0.146***	-65.7
Age21.30	0.0638***	10.2	-0.241***	-68.0
Age31.40	0.328***	32.2	-0.160***	-23.2
Age41	0.337***	15.8	-0.288***	-12.9
Quarter	0.0139***	349	0.0111***	299
ln.distance	-0.120***	-15.5	-0.0167*	-2.15
ln.Area	-0.193***	-70.6	-0.110***	-44.0
MRT.Count.1000m	0.00803***	4.67	0.0165***	8.81
Ex.L.10.1000	-0.00222	-1.39	0.0017	1.17
Expressway.Count.1000m	-0.0131***	-10.2	-0.00263.	-1.77
ES.L.10.1000	0.0388***	15.9	0.0124***	5.13
ES.Count.1000m	-0.00681***	-16.0	-0.00410***	-7.79
Major.L.10.1000	-0.0178***	-0.0178	-0.0336***	-28.5
Major.Count.1000m	0.00259***	5.92	0.000287***	0.704
Multiple R-squared	0.767		0.713	
Adjusted R-squared	0.766		0.713	

Notes: Signif.. codes: '***' 0.001, '**' 0.01, '*' 0.05, '.' 0.1, ' ' 1. ^postal sector variable found in full results (Table A5/A6, available upon request)

The effects of other variables are largely similar for leasehold and freehold properties apart from the number of expressways within 1000 m, which is significant for leasehold properties at a coefficient of -0.0131 but not for freehold properties as observed from the significant codes. The length of expressways within 1000 m is insignificant for properties of both tenures.

5. Concluding Remarks

This paper shows that adding area and infrastructure variables significantly impacts the decaying lease effects for leasehold and freehold properties in Singapore. As the lease and age effects are separated for leasehold properties, we note that the price elasticity of the remaining lease is increased, and the variables of age for leasehold properties are found to all positively affect the price. However, age has negative effects on freehold property prices.

The effect of lease decay in Singapore has a negative impact on price as a 1% increase in the remaining lease will result in a 1.62% increase in price after accounting for the time fixed variable, quarter of sale, and location variables, distance to CBD, and postal sector. This shows that properties with a longer lease will have a higher value, following the theory that a longer remaining lease will allow the owner or investor to have increased value from the additional year of utility. However, an expanded model shows that area and infrastructure are also significant variables to be considered when analyzing the effect of lease decay on price through a larger adjusted R-square of 0.762 compared to 0.745 in the first model. The lease decay effects become less prominent as a 1% increase in the remaining lease above the mean results in a 1.46% increase in price after adding these infrastructure variables.

Age is added as a variable to the remaining lease to separate the effects of age and lease decays in leasehold properties. The model is a slightly better fit with an adjusted R-squared of 0.767 compared to 0.762. The effect of lease decay has an increasingly negative impact on price as a 1% increase in the remaining lease results in a 1.90% increase. In contrast, all categories of the age variables are shown to positively affect price. This likely indicates that the negative effects of age and lease have been captured in the remaining lease variable. A significantly positive effect on price is observed from Age21.30 at a coefficient of 0.0638 to Age 31.40 at 0.328. Potential reasons that increase in age to positively affects price could be due to speculations on redevelopment or collective sales potential of the projects, which may be largely taking effect after the property passes 30 years in age.

Upon a comparison of leasehold transactions with freehold transactions island- wide, it is observed that the effect of age variables on price is negative for freehold properties, whereas they are the opposite for leasehold properties. As previously mentioned, lease and age decay effects are likely captured in the remaining lease variable for leasehold properties. On the other hand, freehold properties would not be subject to lease decay, and thus all negative and positive effects are captured within the age variables. The coefficient of -0.160 on Age31.40 for freehold properties shows a decrease in the effect of age on price compared to the coefficient of -0.241 on Age21.30. This supports the reasoning that the sentiment of collective sales or redevelopment potential is higher for properties that pass 30 years in age. It is important to note that how the age variables affect properties of different tenures is complex as they may also capture other inherent unobservables. Yet, the contrasting effects of age between the leasehold and freehold properties distinctively show positive effects associated with the aging of the property apart from merely decay effects.

After running the regressions on a 500 m, 700 m, and 1000 m radius, the results show that the models with a 1000 m radius are better with a higher R-squared. The 1000 m is set as the limit for walkable distance when considering the number of MRT stations. Furthermore, the radius of 1000 m provides the most data since there is a lack of infrastructure in the north and west regions for smaller radii, thus resulting in the regression returning 'NA' results.

There are limitations as to how much this regression model can reflect the situation in reality as this study relies on retrospective transaction data, and any future transactions may not necessarily follow the same trend of past transactions. Attempts are made to include more variables into the model, such as supply elasticity of land based on the availability of white sites across the years of 1995 to 2019, as an indicator of potential future developments in the regions. However, this data could not be acquired. Additionally, data on transportation infrastructure used in this study are based on recent developments since there is a lack of data on the development of transport infrastructure by year. Hence, an in-depth analysis of how transport infrastructure affects older transactions and how this affects the effects of age and lease on these properties cannot be thoroughly analyzed.

The inclusion of supply elasticity for the different postal sectors is a potential variable to be explored in future studies. By including the available land for development, the supply side of real estate would be accounted for and is likely to produce a more comprehensive model for determining price and the effect of the variables. This paper has shown the dynamics of infrastructure and the potential to further explore how it affects lease decay in the future. Studies that delve further into the collective sales and redevelopment potential of properties could also be considered to dissect further the effects associated with the increased age of a property. There is no universal way to think about lease decay, and other variables which are found to be significant could also play a role in deciphering the effects of lease and age decays on price. While this study can be particularly relevant for investors with limited capital, the importance of predicting real estate prices and lease decay remain a prominent consideration for developers and homeowners in Singapore. Therefore, further research into the effects of lease decay would be highly relevant to the industry and should be pursued as more properties in Singapore approach lease expiry.

References

Agarwal & Sing (2019). Aging and Decaying Leases of Residential Properties. Retrieved from https://ireus.nus.edu.sg/2019/04/06/aging-and-decaying-leases-of-residential-properties/

Aikivuori, A. (1996) Periods and Demand for Private Sector Housing Refurbishment, Construction Management and Economics, 14(1), 3-12

Alonso, W. (1964). Location and Land Use: Toward a General. East-West Center Press.

Amca F (2016) Real estate appraisal and an application at center of Denizli. Master’s Thesis, Pamukkale University

Anderson, S. (2013). A history of the past 40 years in financial crises. Retrieved from https://www.ifre.com/story/1291951/a-history-of-the-past-40-years-in-financial-crises-0d xjlzsrcx

Ayan E, Erkin HC (2014) Hedonic modeling for a growing housing market: valuation of apartments in complexes. Int J Econ Fin 6(3):188–199

Baum, A. (1991), Property Investment Depreciation and Obsolescence, Routledge

Bin, O. (2004). A prediction comparison of housing sales prices by parametric versus semi-parametric regressions. Journal of Housing Economics, 13(1), 68-84.

Bokhari, S., and Geltner, D. (2018). Characteristics of depreciation in commercial and multifamily property: An investment perspective: Characteristics of depreciation in commercial and multifamily property. Real Estate Economics, 46(4), 745-782. doi:10.1111/1540-6229.12156

Bourne, L. S. (1969). Location factors in the redevelopment process: a model of residential change. Land Economics, 45(2), 183-193.

Bowes, D. R., and Ihlanfeldt, K. R. (2001). Identifying the impacts of rail transit stations on residential property values. Journal of Urban Economics, 50(1), 1-25.

Bradley, P., and Kohler, N. (2007). Methodology for the survival analysis of urban building stocks. Building Research and Information, 35(5), 529-542.

Capozza, D., and Sick, G. (1991). Valuing long-term leases: The option to redevelop. The Journal of Real Estate Finance and Economics, 4(2), 209. doi:10.1007/BF00173125

Cheshire, P., and Sheppard, S. (1995). On the price of land and the value of amenities. Economica, 247-267. Data.gov.sg. (2019). National Map Line. Retrieved from https://data.gov.sg/dataset/national-map-line

de Haan, J. and E. Diewert (2013), "Hedonic Regression Methods", in Handbook on Residential Property Price Indices, OECD Publishing, Paris, https://doi.org/10.1787/9789264197183-7-en.

Emo, F. I., Oni, A. O., and Egolum, C. C. (2013). Prioritizing Residential Land Value Determinants in Onitsha, Nigeria. International Journal of Academic Research in Business and Social Sciences, 3(3), 201-213.

Frieden, B. J. (1961). Locational preferences in the urban housing market. Journal of the American Institute of Planners, 27(4), 316-324.

Gustafsson A, Wogenius S (2014) Modelling apartment prices with the multiple linear regression model. Thesis, KTH Royal Institute of Technology SCI School of Engineering Sciences

Gwamna, E. S., Yusoff, W., Zahari, W., & Ismail, M. F. (2015). Determinants of land use and property value. Advanced Science Letters, 21(5), 1150-1153.

Haider, M., and Miller, E. J. (2000). Effects of transportation infrastructure and location on residential real estate values: application of spatial autoregressive techniques. Transportation Research Record, 1722(1), 1-8.

Haron, Nuzul and Liew, Cindy. (2013). Factors influencing the rise of house Price in Klang Valley. International Journal of Research in Engineering and Technology. 2. 261-272. 10.15623/ijret.2013.0210039.

Harvey, J., and Jowsey, E. Urban Land Economics (2004). Hampshire: Palgrave Macmillan Ltd.

Iselin, D. G., Lemer, A. C., and National Research Council (U.S.) . Committee on Facility Design to Minimize Premature Obsolescence. (1993). The fourth dimension in building: Strategies for minimizing obsolescence. Washington, D.C: National Academy Press.

ISO 15686-1. (2000). Buildings and constructed assets-Service life planning: Part 1: General principles.

Jiang, L., Phillips, P. C., & Yu, J. (2014). A new hedonic regression for real estate prices applied to the Singapore residential market. SSRN Electronic Journal. Retrieved from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2533017

Johnson, A. (1996) Rehabilitation and Re-use of Existing Buildings, in Building Maintenance and Preservation: A Guide to Design and Management (Second Edition), E.D. Mills (editor), Architectural Press, Oxford, 209-230

Jud, G. D. (1985). A further note on schools and housing values. Real estate economics, 13(4), 452-462.

Kim, K. S., Park, S. J., and Kweon, Y. J. (2007). Highway traffic noise effects on land price in an urban area. Transportation Research Part D: Transport and Environment, 12(4), 275-280.

Langston, C. A. (2011). Estimating the useful life of buildings. In Proceedings of the 36th Annual conference for Australasian Building Educators Association (AUBEA) (pp. 418- 432). AUBEA.

Levkovich, O., Rouwendal, J., and Van Marwijk, R. (2016). The effects of highway development on housing prices. Transportation, 43(2), 379-405.

Liu, G., Xu, K., Zhang, M., and Zhou, T. (2012). A Study on the Life-Span of Demolished Buildings: Based on the Investigation of Demolished Buildings in Chongqing [J]. Urban Development Studies, 10.

Mansfield, J.R. (2000) Much Discussed, Much Misunderstood: A Critical Evaluation of the Term "Obsolescence", The Cutting Edge 2000, London: RICS Research Foundation

Markus, T. A. (Ed.). (1972). Building performance. John Wiley and Sons.

Grace-Martin, K. (2022). Should You Always Center a Predictor on the Mean? Retrieved from https://www.theanalysisfactor.com/center-on-the-mean/

Miles, M. E., Berens, G. L., Eppli, M. J., & Weiss, M. A. (2007). Real Estate Development: Principles and Process, 4. Utgave. Urban Land Institute, Los Angeles.

Mills, E. (1972). Studies in the Structure of Urban Economy. The Johns Hopkins University Press, Baltimore.

Mirasyedi A (2006) An investigation of factors affecting the housing prices case of Üsküdar. Master's Thesis, Istanbul Technical University

Muth, R. F. (1969). Cities and Housing University of Chicago Press. Chicago, IL.

Ong, T.S. (2013). Factors affecting the price of housing in Malaysia. Available on the Internet: http://www. globalbizresearch. com/images/files/73848_JEIEJB_% 20Tze% 20San, 20.

Randeniya TD, Ranasinghe G, Amarawickrama S (2017) A model to estimate the implicit values of housing attributes by applying the hedonic pricing method. Int J Built Environ Sustain 4(2):113–120.

Rosen, S. (1974). Hedonic prices and implicit markets: product differentiation in pure competition. Journal of political economy, 82(1), 34-55.

Selim H (2009) Determinants of house prices in Turkey: hedonic regression versus artificial neural network. Exp Syst Appl 36(2):2843–2852. https://doi-org.libproxy1.nus.edu.sg/10.1016/j.eswa.2008.01.044

Shiller, R. J. (2008). Derivatives markets for home prices (No. w13962). National Bureau of Economic Research.

Thomsen, A., and Van der Flier, K. (2011). Understanding obsolescence: a conceptual model for buildings. Building Research and Information, 39(4), 352-362.

UCLA Statistical Consulting (n.d.). HOME. Retrieved from https://stats.oarc.ucla.edu/other/mult-pkg/faq/general/faqhow-do-i-interpret-the-sign-of-the-quadratic-term-in-a-polynomial-regression/

Uju, I. V., and Iyanda, S. T. (2012). Comparative analysis of the determinants of residential land values. Chinese Business Review, 11(2).

URA. (2019). MASTER PLAN. Retrieved from https://www.ura.gov.sg/maps/?service=MP

Wang, J., and Wang, R. (2015, November). Research on economic life of building based on the principle of equipment renewal. In 3rd International Conference on Management Science, Education Technology, Arts, Social Science and Economics. Atlantis Press.

Wassenberg, F., Van Meer, A., and Van Kempen, R. (2010). Strategies for upgrading the physical environment in deprived urban areas: examples of good practice in Europe. Retrieved from https://repository.tudelft.nl/islandora/object/uuid:7ccaa37b-206e-4dc7-b0ed-7d2d01b5d79e?collection=research

Wen, H.Z., Jia, S.H., Guo, X.Y. (2005). Hedonic price analysis of urban housing: an empirical research on Hangzhou, China. J Zhejiang Univ Sci 6A(8):907–914

Wilhelmsson M (2002). Spatial models in real estate economics. Housing Theory Soc 19(2):92–101

Yusof A, and Ismail S (2012). Multiple regressions in analysing house pricevariations. Communications of the IBIMA, DOI: http://www.ibimapublishing.com/journals/CIBIMA/cibima.html

Yusof A, Ismail S (2012). Multiple regressions in analysing house price variations. Communications of the IBIMA, DOI: http://www.ibimapublishing.com/journals/CIBIMA/cibima.html

Zhou, T., Zhao, R., and Zhou, Y. (2017). Factors influencing land development and redevelopment during China's rapid urbanization: Evidence from Haikou city, 2003– 2016. Sustainability, 9(11), 2011.

Zhu, M.(2018). Singapore's public transport system among best in the world: McKinsey report. Retrieved from https://www.channelnewsasia.com/news/singapore/singapore-public-transport-system-among-best-in-the-world-10637978

Appendices

Table A1 Summary Statistics, Leasehold

Singapore	Unit Price psf	Remaining Lease	Age	Distance	Area	Number				Length		
						MRT	Expressway	Expressway Slip	Major	Expressway	Expressway Slip	Major
Min	119	48	1	331	344	0	0	0	0	0	0	0
Max	4799	98	47	18510	22529	5	11	55	42	8870	11145	15578
Average	859	85.2	9.74	9274	1309	1.01	1.76	6.67	7.33	2324	1601	5183
Total Number of Transactions: 79191												

Table A2 Summary Statistics, Freehold

Singapore	Unit Price psf	Age	Distance	Area	Number				Length		
					MRT	Expressway	Expressway Slip	Major	Expressway	Expressway Slip	Major
Min	136	1	346	258	0	0	0	1	0	0	1061
Max	5001	53	18031	34477	5	10	56	44	8141	11447	14427
Average	1033	9.99	6686	1491	0.815	1.57	7.57	10	2241	1157	5906
Total Number of Transactions: 77270											