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Are Green Buildings worth more because they cost more?

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Abstract

Since the introduction of the Green Mark Scheme in Singapore in January 2005, more than 440 projects have been awarded the Green Mark Award. Of these, 114 are residential projects, and the majority of which have been launched, pre-sold and resold. Recent studies on the impacts of green on property values seem to indicate a positive correlation between property value and the green mark award although some have been inconclusive. Given that most new residential developments in Singapore are pre-sold with prices being determined by developers, we are able to scrutinize if the premium for green properties is developer induced or market driven. It is only natural that developers would need to account for the higher costs of green construction and homebuyers would not need to be aware of green features. Hence they may not be willing to pay a premium for it. We analyse the transaction prices of green mark certified residential condominium and apartment projects matched with non-green mark projects between January 2005 and June 2010 in Singapore using a geo-statistical model to test whether green mark does fetch a premium at presale. We also analyse some resale transactions after the projects have been completed and determine if green mark condominiums fetch a premium because they are better maintained and provide direct benefits to occupiers. Our findings seem to suggest that green mark residential properties do fetch a premium and that the premium increases for the higher level of awards among presale transactions. However, for resale housing transactions, the evidence that green mark properties sell for a premium against resale transactions is weak, implying that homebuyers may not be willing to pay for a green premium. This is despite that the green mark certification may help to ensure better maintenance and provide cost savings to the owners. The development of green building, to certain degree, reflects a developer's social responsibility.

Key words: green buildings, property values, price premium

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1. Introduction

Globally, buildings are responsible for an estimated 30 to 40% of all primary energy use, greenhouse gas emissions, and waste generation (United Nations Environment Programme (UNEP, 2008). The Intergovernmental Panel on Climate Change (IPCC) identifies buildings as having the single largest potential of any sector for the reduction of greenhouse gases: the capacity to reduce projected emissions by 29 % by the year 2020 (IPCC, 2007). The United Nations Framework Convention on Climate Change (UNFCC) has also been actively encouraging industrialised countries to stabilize its greenhouse gas emissions. As a result, it is evident that governments and other international organizations have been actively encouraging the reduction of the environmental impact of the real estate sector. These include the introduction and implementation of mandatory certification in an increasing number of countries.

Singapore's Green Mark Scheme was introduced in January 2005, whereby buildings can be rated the award of Platinum, Gold^{PLUS}, Gold or Certified depending on the type of green features incorporated in the buildings. Green Mark certified buildings generally consume less energy, provide a better living environment and should contribute to the overall reputation of the property. These positive externalities should translate into a price premium. In Singapore, given that residential projects are typically pre-sold and therefore priced by developers we hypothesize that in all likelihood they would have priced in the premium. This is especially since most of the green mark certified projects are yet to be completed and the original buyers have not had time to live in these green buildings to appreciate their benefits. We therefore postulate that if there is a price premium for green labels, then this is likely to be developer induced rather than market driven. Green mark features do require additional costs in the region of 1-3% as compared with a non-green mark project. Developers would naturally pass the additional costs to buyers. Fuerst and McAllister (2011) argue that green certification would increase production costs so that supply is more inelastic ad investors would command price premiums to compensate the costs. However, we do note that as more and more new developments attain the Green Mark certification, there should be an increasing awareness in the market such that buyers would be able to differentiate between green and non-green. This knowledge could then be priced into the transactions in the future. We also analyse re-sale transactions after the green residential projects have been completed to test if indeed there is a market driven premium for the green mark.

Developers are motivated to develop green buildings if there are any economic returns from the green building development (Deng et al 2011) or if they value social responsibility stimulated by government initiatives (Fitzsimmons 2007). Current literature has found conflicting evidence on the economic returns of green buildings, underpinned by the alternative explanations (Ries et al 2006; Miller et al 2008; Eichholtz et al 2009; Deng et al 2011; Fuerst and McAllister 2011). Sampling, methodology and measurement may have contributed to the conflicting results (Muldavin 2008). However, we are suspicious that the price differentials between green and non-green buildings are cost driven rather than market driven. Social responsibility rather than economic returns perhaps motivates the development of green building.

The paper is organized as follows. Section 2 presents the Green Mark Scheme, the criteria for certification and the different awards. This is followed by a review of recent research on the impact of green on property prices. Section 4 discusses the research hypothesis and methodology. Section 5 describes the sample data and presents the findings of the analysis. The last section provides the implications, conclusions and recommendations for further research.

2. Singapore's Green Mark Scheme

The Building and Construction Authority of Singapore (BCA) introduced the Green Mark Assessment system in January 2005 as a system to be used for rating the level of green in buildings. It is supported and authorized by the National Environment Agency (NEA). Under the assessment framework for new buildings, developers and design teams are encouraged to design and construct sustainable real estate which can promote energy and water efficiency, protect the natural environment as well as enable cleaner indoor environments. The use of greenery is also strongly encouraged as this will help to enhance the overall environment. The criteria adopted by the BCA Green Mark scheme for new residential buildings cover these five areas: *(1) Energy Efficiency (2) Water Efficiency (3) Environment Protection (4) Indoor Environmental Quality, and, (5) Other Green Features.* Of these, Energy Efficiency is the most critical as it accounts for half of the total marks in the assessment. With regards to existing buildings, building owners and operators are advised to enable operations to be sustainable in order to reduce adverse impacts on the environment as well as occupant health over the entire building life cycle.

Buildings are required to have an assessment every three years so as to ensure that the Green Mark building continues to be well-maintained. The assessment process involves a pre-assessment briefing to the project team to enable better comprehension and evaluation of Green Mark's requirements and the certification level required. Actual assessment would thereafter be carried out to verify the appropriate reports and documents to validate the previously assessed certification level. With reference to the figures below, points are awarded for various types of energy-saving practices a building accommodates. In this regard, buildings are awarded their respective awards depending on their scores: *Platinum* (85 points and above), *Gold*^{PLUS} (80 to <85 points), *Gold (*70 to <80 points) or *Certified Rating* (55 to <70 points). Apart from achieving the minimum points in each rating scale, the project has to meet all pre-requisites, and score a minimum of 50 % of the points in each category, with the exception of the Innovation category.

To encourage owners and developers to build new green buildings and retrofit existing buildings with green features, various financial and non-monetary incentives are provided by the government. Given the overarching goal of having 80% of all buildings in Singapore to the green by 2030, incentives have been introduced to expedite the process. These include a sum of SGD$500 million for greening all public buildings to the Gold^{PLUS} standard, and another remaining SGD$100 million for cash incentives to building owners to retrofit existing buildings to be more energy efficient. In addition,

developers who build Green Mark Gold^{PLUS} buildings will get an extra 1% of gross floor area (GFA) that is allowed under the Master Plan gross plot ratio, capped at 2500sqm, and Platinum buildings get an extra 2% GFA, capped at 5000sqm. Obviously, these incentives will have an impact on the financial feasibility of developing new green buildings and retrofitting existing buildings.

3. Past Studies

Although there have been a rising number of research papers on the impact of green on property values recently, the empirical findings are far from conclusive. Miller, Spivery and Florance (2007) conducted a study "Does Green Pay Off" using a sample of 550 Energy Star rated buildings and 318 LEED rated buildings obtained from the CoStar database which provides information on office property in the United States. They find that the average LEED impact on sales price per square foot was 9.94%, while the Energy Star impact on sale price is 5.76%. Fuerst and McAllister (2008) define three main drivers of price differences between certified and non-certified buildings – (1) certified buildings offer benefits to occupiers in relation to business productivity, image and occupancy costs, (2) due to these occupier benefits, certified buildings can result in steeper rents and lower holding costs for investors, and (3) certified buildings may require a lower risk premium. Applying the hedonic regression analysis method, a sample of 110 LEED, 433 Energy Star and several thousand of comparable buildings are analyzed. Findings from the analysis show that in comparison to buildings within the vicinity, certified buildings have a rental premium and are more highly rated in terms of their environmental implications. In other words, the more environmentally friendly the building is, the higher the rental premium. In addition, based on a sample of transaction prices for 292 Energy Star and 30 LEED-certified buildings, a 10% and 31% price premium was found respectively compared to non-certified buildings within the vicinity.

In Eichholtz, Kok and Quigley (2009), an analysis of the economic values of certified green buildings in the US based on a sample of 10,000 subject and control buildings is carried out. The locational attributes of Energy Star and LEED-rated office buildings are matched with their respective characteristics and the following results are obtained. A building with an Energy-star certification rented for an estimated 3% more per square foot; the difference in effective rent is estimated to be six percent. The increment to the selling price may be as much as 16%. A 10% decrease in energy consumption leads to an increase in effective rent of about 20 basis points and an increase in value of about 2%, over and above the rent and value premium for a certified building. The monetary value of the link between energy savings and asset values suggests that the intangible effects of the "green label" (i.e. certified green) – beliefs about worker productivity or improved corporate image are also important in determining the value of green buildings. However, the evidence suggested only a premium for the Energy Star rated building, whereas Leed-certificated buildings did not fetch rental premium.

Chegut, Eichholtz and Quigley (2010) evaluate the impact of the EcoHomes (the green building rating scheme in the UK) on property value and found that the green mark scheme can fetch a premium of 8% on property value and 16-20% on rent.

Deng, Li and Quigley (2011) analyze the economic returns to energy-efficient investments in Singapore's housing market. This is a preliminary study where it aims to estimate the economic impact of the Green Mark Scheme on Singapore's residential sector. A total of 62,434 transactions were analyzed, and a two-stage research design was used in its empirical analysis. In the first stage, a hedonic model is used which includes fixed effects for each of the 656 individual projects. In the second stage, the fixed effects estimated for each project are regressed on the locational attributes of the projects, as well as Green Mark controls. The results show that the economic returns to green building are significant.

Prior to these studies, there have been other sporadic studies done, but without significant evidence with regard to the effect of green on property values. Furthermore, most of these cover non-residential real estate. This is usually attributed to the difficulty of quantifying green mark awards as well as to the fact that pertinent information such as transaction prices are not easy to obtain, or otherwise incomplete. In the context of Singapore, research on the effects of the Green Mark scheme is at the incipient stage. Findings from this and other studies are therefore preliminary and might differ given the low level of awareness amongst buyers.

4. Research Hypotheses and Methodology

We hypothesize that first, green buildings may fetch a premium at presale because developers need to cover the additional costs incurred for the green features; and, second, the green premium at resale is unlikely to be as significant as the one at presale because homebuyers may not be aware of the green features (the green features hardly appear in any sales' advertisements in Singapore). This is despite that the green buildings are better maintained and that they incur lower maintenance cost especially in energy consumption.

To test the hypotheses, we need to compare the value differences between two otherwise identical housing units: one with green mark and one without green mark. However, the difficulties are that firstly, the green mark scheme only started in 2005 with a limited sample of transactions for green apartments as compared with the large number of transactions in the whole private housing market. Secondly, hedonic function is typically used to estimate premium by controlling the rest of the hedonic factors with dummy variables being used to quantify the green mark factor. However, a dummy variable typically represents multiple factors that may affect the housing price. These two problems tend to cause inaccurate coefficient estimation in a conventional hedonic function.

We take three measures to solve the problems. First, we carefully select the samples, hoping that each green development is matched with an otherwise identical non-green development. Second, we adopt an advanced geo-statistical hedonic model in order to

estimate the coefficients more accurately. Third, for presale data, we estimate the green premium against yearly data. This is to minimize the temporal effect as well as to investigate if the premium varies over time. We suspect that the premiums may increase over time as people become more aware of green mark benefits. For resale data (small sample size), we estimate the green premium against all year data due to limited data available.

To match a green mark project with a comparable non-green mark project, we take the following steps. For the first step, for each green mark development, we carefully select one comparable non-green mark development, meaning that the two developments are identical except for the green mark. The following rules are adopted to find a matching development. The sequence below shows the order of importance: same district; same tenure, if it is not available in the same district, we find one from the nearest district; same or similar in age; same or similar in the size of the development; the number of units in a development and similar in the unit transaction price

After controlling the sample, a geo-statistical model is adopted to estimate the hedonic function. The advantage of geo-statistical model is that it can effectively capture spatial information to reduce spatial correlations. Hence, the estimated coefficients are more accurately (smaller standard errors) and robust (Tu et al 2004). However, due to the computation burden, we can only process 2800 sample. Hence, a random sampling process is applied to our sample to randomly choose 2800 sample from each year's pre sale sample as well as resale sample. The descriptive statistics are given in Tables A1 to A4. Tables A1 to A4 in Appendix show that the unit transaction prices between green and non green units as well as between original sample and randomly selected sample are very similar.

The geo-statistical hedonic price model developed by Dubin (1992, 2003) is adopted to model housing prices. The advantage of the model is that it requires a few hedonic variables and leaves all the spatial information to be captured by a correlation function, which can successfully capture spatial autocorrelations among housing prices to produce robust coefficient estimation.

Following Dubin (1992, 2003), three types of empirical correlation functions--namely, negative correlation function, spherical correlation function and Gaussian correlation function--are adopted. In this analysis, we adopted negative correlation function as it fits into Singapore housing transaction data better. The diagnoses on the empirical models are based on four out-of-sample prediction errors, including the sum of squared errors (SSE), the mean absolute error (Mean ABS), the median absolute error (Median ABS) and the Theil's U (THE' U).

Semi-logarithmic Hedonic function is represented by eq (1) and (2):

$$Y = Log(P) = X\beta + u \quad (1)$$

$$E[uu'] = \sigma^2 K = \Omega \quad (2)$$

Where P is a vector of dwelling transaction prices, X is a vector of structure characteristics, β is the vector of parameters to be estimated, u is a vector of residuals. When the residuals are spatially auto-correlated, K is a correlation matrix with ones along the main diagonal and non-zero off diagonal terms. We assume u is second-order stationary.

In the geo-statistical literature, conventionally, a semivariogram is used to estimate the spatial process. In this paper, we follow the advice of Dubin (1998) to choose the correlogram rather than semivariogram because in correlogram, the correlations are parameters of multivariate normal distribution, which enables us to estimate the regression coefficients and the parameters of the correlogram simultaneously. While the semivariogram has some desirable properties, but if second-order stationarity is assumed, the two approaches are identical (Dubin, 1998). The relationship between semivariogram and correlogram K is stated in eq (3)

$$\gamma(d) = \sigma^2 - K(d) \tag{3}$$

The negative exponential correlation function is

$$K(d) = \begin{cases} b_1 \exp(-\frac{d}{b_2}) & for \quad d > 0 \\ b_1 & for \quad d = 0 \end{cases} \tag{4}$$

Where K(d) is the correlation between two observations separated by distance d, b_1 and b_2 are the parameters to be estimated. One might think that b_1 should be restricted to be one as the correlation of an observation with itself should be one. However, the correlation function may be discontinuous at the origin, that is, at very small separation distance the correlation may be very different from one. In the ore literature, this is known as the nugget effect.

Estimation:

$$L = -\frac{N}{2} \times \ln\left[(Y - X\tilde{\beta})' \tilde{K}^{-1} (Y - X\tilde{\beta})\right] - \frac{1}{2} \ln\left|\tilde{K}\right| \tag{5}$$

$$\tilde{\beta} = (X' \tilde{K}^{-1} X)^{-1} X' \tilde{K}^{-1} Y \tag{6}$$

Prediction:

The prediction at site s_0 is as below.

$$\hat{Y}(s_0) = x_0 \tilde{\beta} + \hat{u}(s_0) \tag{7}$$

$$\hat{u}(s_0) = w' e \tag{8}$$

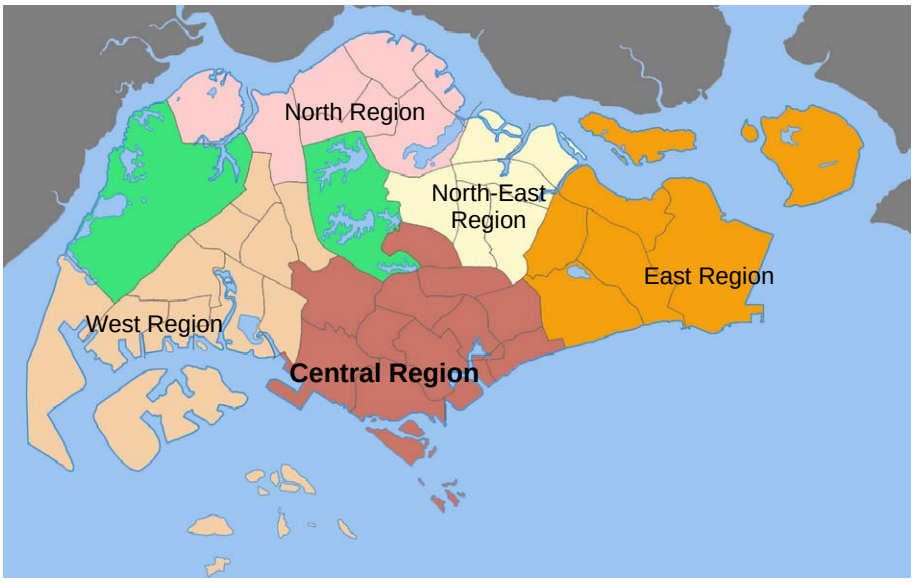
$$w = K^{-1}k(s_0) \qquad (9)$$

Where $\hat{u}(s_0)$ is the predicted error at site s_0, $\hat{Y}(s_0)$ is the predicted value at site s_0, $\tilde{\beta} = (X'\tilde{K}^{-1}X)^{-1}X'\tilde{K}^{-1}Y$ is the maximum likelihood estimate of the regression coefficients, and $\tilde{K}^{-1}$ is the correlation matrix obtained by substituting the ML estimate of b_1 and b_2 into the correlation function and applying this function to the data locations.

5. Data and Analysis

The transaction data is obtained from the Real Estate Information System (REALIS) owned by the Urban Redevelopment Authority (URA) in Singapore, we selected only new (i.e. pre-sold by developers to the first buyer and sub-sale) condominium and apartment sale transactions that occurred between January 2005 (in tandem with the launch of Green Mark Scheme) and June 2010 in Singapore (Figure 1)

Figure 1: Planning Regions in Singapore



Source: Mapsof.net (2010)

A total of 68,000 presale (including new sales and subsales) transactions between January 2005 and June 2010 are extracted for the analysis. Transactions for some 84 Green Mark condominium and apartment projects are recorded, amounting to some 18,638 transactions. All 100 non-green condominium and apartment projects are also identified in order to choose the matched non-green mark projects. These account for a total of 13,944 presale transactions for non-green mark projects. 1,114 green mark housing units were resold during the time period, which are matched by 2,209 non-green mark housing

units. Besides price, the transaction records also include floor area, floor level, contract year, tenure and postal district.

Table 1 below gives the definition of all variables. The descriptive analysis is given in Tables 2a and 2b. Table 3 briefly states that the selected samples are comparable.

Table 1 Definition of Variables

Variable	**Variable Label**	**Variable Definition**
Dependent	Y(LPRICE)	Natural logarithm of the transaction price of the unit per square foot, in Singapore dollars.
Independent	Floor Level	Floor level.
	Area	Total floor area measured in sq.m.
	Age	Age of building, in month.
	Age square	The square of age (in month).
	Dten	1 if the building is freehold, 0 leasehold.
	DC1	1 if the building is an apartment; 0 otherwise.
	DC2	1 if the building is a small Condo; 0 otherwise.
	DC3	1 if the building is a large Condo; 0 otherwise.
	DG1	1 if the building is Non-Green Mark (NGM); 0 otherwise.
	DG2	1 if the building is Green Mark (GM) Certified Award; 0 otherwise.
	DG3	1 if the building is GM Gold Award; 0 otherwise.
	DG4	1 if the building is GM Gold plus Award; 0 otherwise.
	DG5	1 if the building is GM Platinum Award; 0 otherwise.
	Y_t	Year dummy variable, with t ranging from 1 (2005) to 6 (2010). $Y_t = 1$ if the building is transacted in year t; 0 otherwise.
	T_t	Quarter dummy variable for each year, with t ranging from 1 (first quarter of one year) to 4 (fourth quarter of one year). $T_t = 1$ if the building is transacted in quarter t; 0 otherwise.

Table 2a presents the descriptive analysis of presale transactions (including presales and subsales). Between January 2005 and June 2010, there were 18,636 green mark properties presold, which are matched with 13,944 non-green mark properties that were transacted during the same time period and are comparable with the green mark properties in quality. In Tables A1 of the appendix, the unit housing transaction prices are comparable between green and carefully selected non-green properties over the years. Across the categories of green marks, the properties with platinum green mark have fetched the highest transaction price since 2007, while properties with GOLD green mark

fetched a higher price than Gold plus. Out of all presold green mark properties, 24% obtained certified green mark, 50% obtained gold and 23% obtained gold plus. Only 3% properties achieved platinum. Besides there is no clear price changing pattern observed over the years for each green mark category. These seemingly conflicting results suggest that other non-green related hedonic factors play an important role in pricing.

Only 1,114 properties out of these green mark properties were resold during the same time period (Table 2b), which are matched with 2,209 non-green mark properties that are comparable in quality. Out of which, 35% are certified, 57% are gold and 8% are Gold plus. None of the platinum green mark properties were resold. Table A2 of the appendix shows that among the resale properties, green mark properties fetched higher prices than non-green mark properties.

Table 2a Descriptive statistics for presale data (N=32,580)

	aver	std.	min	max	Value	Frequency	Percentage
Transacted Price ($)	1,397,700	843,906.4	500,000	5,000,000			
Unit Price ($psm)	11,033	4,891.4	3,298	37,893			
Floor Level	12.03	9.772	1	67			
Area (sqm)	125.36	38.829	60	300			
Dten	0.47	0.499	0	1	0	17,229	53%
					1	15,351	47%
DC1	0.2	0.397	0	1	0	26,174	80%
					1	6,406	20%
DC2	0.05	0.222	0	1	0	30,888	95%
					1	1,692	5%
DC3	0.75	0.432	0	1	0	8,098	25%
					1	24,482	75%
DG1	0.43	0.495	0	1	0	18,636	57%
					1	13,944	43%
DG2	0.14	0.343	0	1	0	28,151	86%
					1	4,429	14%
DG3	0.29	0.452	0	1	0	23,250	71%
					1	9,330	29%
DG4	0.13	0.336	0	1	0	28,361	87%
					1	4,219	13%
DG5	0.02	0.141	0	1	0	31,922	98%
					1	658	2%
Y1	0.07	0.259	0	1	0	30,224	93%
					1	2,356	7%
Y2	0.12	0.324	0	1	0	28,704	88%
					1	3,876	12%
Y3	0.26	0.438	0	1	0	24,154	74%
					1	8,426	26%
Y4	0.11	0.315	0	1	0	28,934	89%
					1	3,646	11%
Y5	0.35	0.477	0	1	0	21,169	65%
					1	11,411	35%
Y6	0.09	0.283	0	1	0	29,715	91%
					1	2,865	9%

Notes: for the definitions of variables, see Table A1 in Appendix.

Table 2 b Descriptive statistics for resale data (N=3,323)

	aver	std.	min	max	Value	Frequency (for dummy)	Percentage
Transacted Price ($)	1,173,560.7	636,009	510,000	5,000,000			
Unit Price ($psm)	10203.35	4754.02	3946	35122			
Floor Level	10.42	9.068	1	67			
Area (sqm)	117.07	31.86	61	276			
Age (months)	36.3649	18.7729	0.8667	73.3667			
Dten	0.38	0.486	0	1	0	2,058	62%
					1	1,265	38%
DC1	0.15	0.36	0	1	0	2,813	85%
					1	510	15%
DC2	0.03	0.177	0	1	0	3,215	97%
					1	108	3%
DC3	0.81	0.389	0	1	0	618	19%
					1	2,705	81%
DG1	0.6	0.49	0	1	0	1,114	34%
					1	2,209	66%
DG2	0.07	0.263	0	1	0	2,923	88%
					1	400	12%
DG3	0.14	0.342	0	1	0	2,684	81%
					1	639	19%
DG4	0.01	0.077	0	1	0	3,248	98%
					1	75	2%
Y1	0.01	0.099	0	1	0	3,290	99%
					1	33	1%
Y2	0.07	0.254	0	1	0	3,093	93%
					1	230	7%
Y3	0.18	0.385	0	1	0	2,720	82%
					1	603	18%
Y4	0.06	0.24	0	1	0	3,120	94%
					1	203	6%

Y5	0.36	0.48	0	1	0	2,130	64%
					1	1,193	36%
Y6	0.32	0.466	0	1	0	2,262	68%
					1	1,061	32%

Notes: for the definitions of variables, see Table A1 in Appendix.

As it was justified previously, geo-statistical model programmed by MATLAB can only estimate a sample of 3000 or less. Hence, we adopted a randomly sampling strategy to reduce our sample size in order to estimate geo-statistic model. Tables A1 and A3 as well as Tables A2 and A4 of the appendix illustrate that the randomly selected samples are representative. A brief descriptive analysis of the randomly selected sample is given in Table 3 below. Green mark properties fetched higher price as well as having larger standard deviation.

As previously discussed, due to data limitation and methodology, most previous studies adopting hedonic approach failed to separate green mark effect from other hedonic effects. Hence, the green premiums estimated in these studies are questioned. In the rest of this paper, we apply a more advanced geo-statistic model to a set of carefully selected property transaction data, attempting to provide further evidence on how green mark scheme enhances property value.

Table 3 Descriptive statistics for randomly selected sample

	Presale		Resale	
	Green	Non Green	Green	Non Green
Sample Size	8,389	8,032	1,114	1,686
Average	11,121.52	11,034.55	11,282.71	9,711.34
Min	3,298	3,903	4,026	3,946
Max	36,458	31,438	35,122	23,681
Std.	5,107.482	4,654.816	6,229.009	3,739.325

Notes:

1. For the definition of unit price, see Table 1.
2. The presale and resale data are randomly selected from total dataset. See Tables A3 and A4 in Appendix.

In Table 4, we report the results of 8 specifications. Models 1&8 are estimated against all years' sample for presale and resale transactions separately. Our modeling experience shows that presale and resale transactions should be modeled separately as the pricing schemes are different. In presales, developers (sellers) play a critical rile in determining prices, while in resale, buyers play a more important role in determining prices. Hence, Table 1 reports a geo-statistic hedonic model based on presale transactions, and model 8 reports a model based on resale.

Models 2 to 7 are estimated against yearly presale transactions between 2005 and 2010. This strategy allows us to minimize the temporal effect as well as to investigate if green premiums vary over time when people are more aware of green mark benefit.

Table 4 Empirical models

	Presale							Resale
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**	**Model 8**
	By year Presale_all	**By quarter**						**By year Resale_ all**
		2005	**2006**	**2007**	**2008**	**2009**	**2010**	
Constant	5.4990** (0.0147)	5.4893** (0.0385)	5.4802** (0.0414)	5.5587** (0.0497)	5.7375** (0.0453)	5.5837** (0.0305)	5.7220** (0.0392)	5.4967** (0.0625)
Floor Level	0.0022** (0.0002)	0.0012** (0.0002)	0.0020** (0.0001)	0.0028** (0.0001)	0.0017** (0.0001)	0.0026** (0.0001)	0.0026** (0.0001)	0.0018** (0.0002)
Area	0.0029** (0.0000)	0.0030** (0.0000)	0.0031** (0.0000)	0.0030** (0.0000)	0.0029** (0.0000)	0.0028** (0.0000)	0.0026** (0.0000)	0.0027** (0.0000)
Dten	0.0569**	0.1137**	0.0846**	0.0553**		0.0681**	0.0521**	0.2049**
	(0.0100)	(0.0383)	(0.0293)	(0.0219)		(0.0148)	(0.0216)	(0.0304)
DC2	-0.0171#				0.0725*			0.1326**
	(0.0167)				(0.0365)			(0.0418)
DC3	-0.0136#	-0.0564**		-0.0209#	-0.0339#	0.0285**	0.0204*	
	(0.0094)	（0.0233）		(0.0181)	(0.0275)	(0.0096)	(0.0110)	
DG2		-0.0808*	-0。0716#			0.0156#	0.0206#	0.0809*
		(0.0417)	(0.0453)			(0.0131)	(0.0155)	(0.0416)
DG3	0.0434**	-0.0456#	0.0438#	0.0450**	0.0475*	0.0256**	0.0169#	0.0399#
	(0.0081)	（0.0288）	(0.0278)	(0.0160)	(0.0260)	(0.0116)	(0.0139)	(0.0304)
DG4	0.0221*		0.0953** (0.0384)	0.0592**	0.0663*			0.0984#
	(0.0136)			(0.0253)	(0.0384)			(0.0797)
DG5	0.1079**			0.1839*		0.0658**		
	(0.0188)			(0.1009)		(0.0218)		
Age								
Age								-0.0001**

squared								(0.0000)
T2		0.0341**	0.0081*	0.0414**	-0.0203**	0.0216**	0.0159**	
		(0.0054)	(0.0051)	(0.0036)	(0.0041)	(0.0029)	(0.0017)	
T3		0.0539**	0.0145**	0.0884**	-0.0281**	0.0800**		
		(0.0053)	(0.0053)	(0.0041)	(0.0039)	(0.0037)		
T4		0.0772**	0.0305**	0.1119**	-0.0505**	0.0895**		
		(0.0048)	(0.0053)	(0.0053)	(0.0042)	(0.0041)		
Y2	0.0754**							
	(0.0075)							
Y3	0.1747**							0.0780**
	（0.0072）							(0.0048)
Y4	0.1983**							0.0855**
	（0.0081）							(0.0068)
Y5	0.1748**							0.0448**
	（0.0074）							(0.0079)
Y6	0.2353**							0.0803**
	（0.0083）							(0.0099)
b1	0.45	0.7	0.9	0.9	0.95	0.9	0.95	0.9
b2	0.75	1	2	3	1.75	2.25	2.25	4.5
VOF	-4768.8	-5859.6	-3602.2	-3917.5	-2982.5	-2782	-2361.2	-3805.9
In sample size	2200	1756	2200	2200	2200	2200	2200	2200
Out of sample size	600	600	600	600	600	600	665	600

MSE	0.0033	0.0076	0.0023	0.0025	0.0014	0.0014	0.0012	0.0019
TheilsU	0.0003	0.0006	0.0002	0.0002	0.0001	0.0001	0.0001	0.0002
Meanabs	0.0429	0.0527	0.032	0.0368	0.0262	0.0265	0.024	0.0326
Medianabs	0.0315	0.0323	0.0215	0.0265	0.0175	0.0196	0.0164	0.0255

Notes:

1. Dependent Variable: Log Transaction Price

2. Standard errors are reported in brackets and significance at 0.05, 0.01 and 0.10 levels are indicated by *, ** and # respectively. ^ is denoted as non-significant.

Across all models, the model fits are measured by out-of sample prediction (see equations 7, 8&9). Four model fit measures (MSE, TheilsU, Meanabs and Medianabs) show that the eight estimated geo-statistic models fit into our data very well. For example, across all 8 models, the MSE is less that 8 per thousand. The absolute difference between the medium and the predicted medium (in log term) is less than 4 %.

Larger, newer, higher floor level and freehold properties fetched premiums. The coefficients of the four key hedonic factors (area, floor level, Dten and age) are significant, robust with correct sign. For presale, the price difference between apartments and condominiums are less significant, while for resale, condominiums fetched more significant and higher premiums than that of apartments.

Do green buildings fetch a premium at presale as developers need to cover the costs incurred by implementing the green features? Green buildings may fetch a green premium at resale because they are likely to be better maintained in order to retain or upgrade their green mark as well as incur lower maintenance cost due to energy saving features.

In the previous section, we proposed these hypotheses. Descriptive analysis seems to weakly support the arguments. To further verify the hypotheses, we derive the green premiums from the coefficients in Table 4 (Table 5).

At presale stage, green mark properties excluding certified properties fetched green premiums of 10.5%, 5% and 28.2% for GOLD, GOLD+ and PLATINUM separately. The respective coefficients in the geo-statistic model are significant at 5% or 1% (Model-1 in Table 4) as well. For resale, green mark properties excluding (GOLD+ and PLATINUM due to limited transactions) fetched the green premiums of 4.9% and 3.9%, which are significantly lower than the green premiums found in presales. Furthermore, their respective coefficients are only significant at 10% (Model 8 in Table 4). These results strongly support the first hypothesis, weakly support the second hypothesis.

Table 5 Green premiums compared with non-green mark properties derived from Table 4

Green marks	Presale	Resale	Presale 2005	Presale 2006	Presale 2007	Presale 2008	Presale 2009	Presale 2010
Certified		20.50%	-0.18%	-15%		3.70%	3.70%	4.90%
Gold	10.50%	9.60%	-10%	10.50%	10.60%	6%	6%	3.90%
Gold +	5%	25%		24.50%	14.60%			
Platinum	28.20%				52.70%	16.30%	16.30%	

If we further investigate the green premiums across years, we have found strong evidences that higher green mark properties fetched higher premiums (the columns of “Presale 2007”, Presale 2008” and “Presale 2009” in Table 5). However, we did not find evidence to show that the premiums are higher over the years as people may be more aware of the green mark benefits. This implies that in Singapore, the public awareness

about the benefits of green mark scheme is still at lower level. More positive advocating is needed to achieve sustainable green building development.

In summary, the results show that,

1. certified green mark did not fetch significant green premium over the years (at 5% significant level).
2. Gold green mark did not fetch green premium until 2006
3. Gold+ green mark did not fetch green premium until 2006
4. Platinum green mark fetched premium in and after 2007 (note that, there was no platinum green mark building in 2005).
5. From certified to platinum, green premiums becomes bigger. Or green premium is positively related to green mark grading. However, this conclusion needs to be further verified as, in certain years, some green marks did not fetch significant green premium as we expected.
6. In general, our data shows green premiums are more significant and higher for presale transactions than for resale transactions.

From above results, we can conclude that, at the pre-sale stage, green mark does generate a premium, with higher green mark grading generates higher premium. This implies that developers attempt to ask a higher price to cover the green cost, but the buyers may not pay for it. Hence, it is not necessary that a new green mark building must fetch a higher premium. It depends on the level of green mark grading as well as the features embedded in the green mark. However, as more people (buyers/sellers) are aware of green mark scheme in the time to come, our results weakly imply that green premium will become significantly bigger.

6. Conclusion

Based on the analysis presented above, it appears that developers in Singapore do seem to be placing a premium on green in general although the evidence is weak. The analysis also shows that it is not necessary that the higher the award of the green label, the greater the premium will be. In fact, conversely, Green Mark Gold properties have an effect of 10.5%% while Green Mark GOLD plus properties fetch a lower premium of 5%. Among the resale properties, the green premium is almost insignificant. The inconsistent findings found between presale and resale data indicate that the green premium is likely to be cost driven rather than market driven, which implies that Singapore developers value social responsibility stimulated by the government policies.

This initial research is unable to explain why this is so except that the green mark scheme is fairly new and the market is still unsure as to the benefits and utility of such properties. The Green Mark scheme, having been introduced for five years now, may be seen as relatively new and therefore have yet to garner extensive interest and response from the general public as well as developers. However, notably, it appears that developers do somewhat capitalize on this Green Mark status of their properties, even though it does not

seem to increase according to the Green Mark award achieved. Anecdotally, given that the advertising of properties emphasizes its Green Mark awards, developers seem to ride on this green status and in turn price the green costs into their asking prices. On the other hand, perhaps the reason for smaller premiums is that of developers having the abilities to absorb certain green costs due to the incentive schemes introduced by BCA. So unless such detailed information can be obtained, empirical analysis based on current market transactions may not yield meaningful results.

With increasing international pressure to reduce carbon emission, green buildings are here to stay and given the Singapore government's commitment to ensure the majority of the building stock being green by 2030, there will be more green than non-green buildings in the near future. It is therefore imperative that more research needs to be undertaken to provide a better understanding of the differences between green and non-green. First, the cost and benefits need to be quantifiable such that not only developers are able to analyze the feasibility, users and owners are able to decide the premium that they would pay. Second, more detailed information and public awareness of green buildings especially how the features could enhance the living environment would help the market to be more efficient in its pricing mechanism. And third, an important step towards raising awareness in the market is to ensure that all the stakeholders themselves must proactively recognize and account for the difference between green and non-green buildings. The valuation profession, for example, should introduce a new set of guidance notes on the valuation of green properties. In this respect, the responsibility for a sustainable future in real estate development belongs not only to the government but everyone.

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Appendices

Table A1 Unit presale housing price by years and green marks

	Total	Nongreen	Green				
			Green total	Certified	Gold	Gold Plus	Platinum
	[9029.83]	[9401.39]	[8623.95]	[6236.25]	[9293.36]	[7415.06]	0
2005	2356	1230	1126	163	827	136	0
	[10301.04]	[10212.45]	[10398.86]	[11528.86]	[10321.08]	[10340.05]	[7883.60]
2006	3876	2034	1842	493	970	192	187
	[12438.90]	[11688.74]	[13127.58]	[6746.97]	[14160.69]	[13841.56]	[20158.79]
2007	8426	4033	4393	626	2960	750	57
	[10449.47]	[11172.85]	[10010.98]	[9161.23]	[14475.74]	[7951.42]	[17749]
2008	3646	1376	2270	580	582	1090	18
	[10154.92]	[10009.13]	[10234.98]	[7802.92]	[11955.69]	[9102.01]	[17555.29]
2009	11411	4045	7366	2271	3274	1590	231
	[13783.24]	[14000.66]	[13620.60]	[13425.46]	[15003.18]	[10776.45]	[15909.12]
2010	2865	1226	1639	296	717	461	165
	[11033.66]	[10936.75]	[11106.17]	[8564.4]	[12640.71]	[9832.21]	[14624.68]
Total	32580	13944	18636	4429	9330	4219	658

Notes:

1. There are no data referring to platinum in 2005.

2. The numbers in bracket are average unit prices ($per square meter)for corresponding categories. For example, 9108.03 means for total data in 2005, the average unit price is 9108.03.

Table A2 Unit resale housing price by year and green mark

	Total	Nongreen	Green			
			Green total	Certified	Gold	Gold Plus
	[5043.03]	[4968.5]	[5066.88]	0	[5066.88]	0
2005	33	8	25	0	25	0
	[7307.21]	[6919.66]	[7560.935]	[11746.02]	[5209.764]	0
2006	230	91	139	50	89	0
	[8472.44]	[8388.51]	[8361.84]	[9741.442]	[7208.76]	0
2007	603	311	292	156	137	0
	[8207.463]	[8340.049]	[7883.864]	[9147.789]	[7283.5]	0
2008	203	144	59	19	40	0
	[10375.11]	[9311.33]	[13717.88]	[10570.49]	[15181.95]	[15903.2]
2009	1193	905	288	93	185	10
	[12164.15]	[11241.09]	[14390.17]	[11295.01]	[14613.71]	[17730.85]
2010	1061	750	311	82	164	65
	[10203.35]	[9659.03]	[11282.71]	[10475.05]	[11060.06]	[17487.16]
Total	3323	2209	1114	400	639	75

Notes:

1. There are no data referring to platinum for each year.

2. The numbers in bracket are average unit prices ($per square meter)for corresponding categories. For example, 5044.971 means for total data in 2005, the average unit price is 5044.971.

Table A3 Unit presale housing price by years and green marks (based on randomly selected sample)

	total	Nongreen	Green				
			Green total	Certified	Gold	Gold Plus	Platinum
	[9029.83]	[9401.39]	[8623.95]	[6236.25]	[9293.36]	[7415.06]	0
2005	2356	1230	1126	163	827	136	0
	[10276.97]	[10163.24]	[10390.7]	[11384.52]	[10377.6]	[10402.13]	[7753.173]
2006	2800	1400	1400	377	740	144	139
	[12282.81]	[11625.98]	[12939.64]	[6741.191]	[13949.24]	[13848.84]	[20831.13]
2007	2800	1400	1400	215	943	219	23
	[10643.25]	[11172.85]	[10131.49]	[9301.841]	[14554.46]	[7933.82]	[17633.5]
2008	2800	1376	1424	378	377	657	12
	[10070.09]	[10015.89]	[10124.28]	[7735.50]	[11894.4]	[9081.04]	[17680.95]
2009	2800	1400	1400	439	616	308	37

	[13783.24]	[14000.66]	[13620.60]	[13425.46]	[15003.18]	[10776.45]	[15909.12]
2010	2865	1226	1639	296	717	461	165
	[11078.98]	[11034.55]	[11121.52]	[9445.26]	[12343.71]	[9619.05]	[13424.49]
Total	16421	8032	8389	1868	4220	1925	376

Notes:

1. There are no data referring to platinum in 2005.

2. The numbers in bracket are average unit prices ($per square meter)for corresponding categories. For example, 9108.03 means for total data in 2005, the average unit price is 9108.03.

3. All the data from 2005 were selected to be tested. All the green data from 2010 were selected. The data from other years were randomly selected from their total data.

Table A4 Unit resale housing price by years and green marks (based on randomly selected sample)

			Green			
	total	Nongreen	Green total	Certified	Gold	Gold Plus
	[5035.09]	[4921.57]	[5066.88]	0	[5066.88]	0
2005	32	7	25	0	25	0
	[7284.12]	[6726.46]	[7560.94]	[11746.02]	[5209.76]	0
2006	208	69	139	50	89	0
	[8584.32]	[8611.78]	[8561.84]	[9741.44]	[7208.76]	0
2007	531	239	292	156	136	0
	[8164.30]	[8314.72]	[7883.86]	[9147.79]	[7283.5]	0
2008	169	110	59	19	40	0
	[10633.49]	[9340.48]	[13717.88]	[10580.49]	[15181.95]	[15903.2]
2009	975	687	288	93	185	10
	[12384.58]	[11297.92]	[14390.17]	[11295.01]	[14613.71]	[17730.85]
2010	885	574	311	82	164	65
	[10336.52]	[9711.34]	[11282.71]	[10475.05]	[11060.06]	[17487.16]
Total	2800	1686	1114	400	639	75

Notes:

1. There are no data referring to platinum for each year.

2. The numbers in bracket are average unit prices ($per square meter)for corresponding categories. For example, 5044.971 means for total data in 2005, the average unit price is 5044.971.

3. All green data were selected so the green part is the same as in Table 1b.