INTANGIBLE EFFECTS OF GREEN LABELLING
EVIDENCE FROM SINGAPORE

by

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ABSTRACT

Since the 1990s, environmental certifications have been introduced in an attempt to curb the environmental impact that building construction has on the environment. This study analyses the intangible effects of such certification, separating them from the economic effects of energy savings that the certified properties provide. This gives an estimate of the value of a certification that is independent of the economic benefits provided from the features required to attain the certification.

A difference-in-difference (DID) design is used with a hedonic pricing model to estimate the intangible effects of the Green Mark (GM) certification in Singapore. A total of 134,183 new sale transactions of private residential properties (excluding Executive Condominiums) were used in the analysis. The results suggest that the intangible effects of the GM award provide a price premium of about 1 to 2 percent.

Keywords: Green certification; housing market; difference-in-difference; hedonic analysis

FOREWORD

(Place holder) acknowledgements

ABBREVIATIONS

BCA: Building and Construction Authority of Singapore

CONQUAS: Construction Quality Assessment System

DID: Difference-in-differences methodology

GM: Green Mark environmental certification in Singapore

HDB: Housing Development Board. Statutory board in Singapore in charge of public housing.

MRT: Mass Rapid Transit. Public rail system in Singapore.

psm: Per square metre

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1 INTRODUCTION

In recent years, numerous green building certification schemes have been developed, "aimed at mitigating the impact of buildings on the natural environment through sustainable design" (Vierra, 2016). The impact of buildings on the environment is huge; for instance, "US buildings alone are responsible for more CO_2 emissions than any other entire country in the world except China" (Kats, 2003). Many of these certifications focus on rating the sustainability and energy efficiency of buildings.

This drive towards sustainable design started in the 1990s with the Building Research Establishment (BRE) Environmental Assessment Method (BREEAM), and was followed in 2000 by the US Leadership in Energy and Environmental Design (LEED) rating system (Vierra, 2016). This drive for environmental sustainability in products and buildings has accelerated in recent years due to growing concerns about environmental issues.

Certifications encourage the construction of green buildings by reducing information asymmetries associated with green buildings, which cause potential buyers to not fully price in the benefits of green technology (Matisoff, Noonan, & Flowers, 2016). While green features provide tangible and intangible benefits such as lower electricity bills and better environment, these features are unobservable at the demand side before purchase. Some of these features such as material sourcing might not even be observable after purchase. This problem is similar to the "market for lemons" problem (Akerlof, 1970), where potential buyers cannot differentiate between the presence and absence of green features. As a result, there is a pooling equilibrium where potential buyers/tenants are not willing to fully price in the green features which landlords or developers claim to exist. Assuming green features require additional costs to build in, the lack of price premiums means that building in green features leads to lower profits. Developers and constructors will choose not to build in green features to their buildings because the additional costs are not covered by a corresponding price premium.

A credible certification can verify these unobservable green characteristics, increasing confidence in the validity of the environmental information provided, and hence act as a signal to potential buyers about the green features and quality of the building. This would justify a price premium for green features, which would in turn pay for the additional costs required to build in green features, increasing the construction of these environmentally sustainable buildings.

Some literature have shown that the costs of building green features are actually not that high, implying that developers should not require large incentives to build in green features. These studies have demonstrated that the average cost premium for green buildings are only about 1% to 2% (see Bartlett & Howard, 2000; also Kats, 2003). The Building and Construction Authority of Singapore (BCA) conducted a study in 2008 and found a cost premium of between 0.3% to 8% for their Green Mark certification, depending on the level of certification desired.

Regardless, even if the cost premiums are low, these cost premiums still need to be offset by a corresponding price premium. Buyers and tenants are unwilling to pay for green features not because they do not value green features, but because they cannot observe them before the purchase or rental agreement. A certification acts as a signal or assurance of quality, to allow potential tenants and buyers to fully price in the benefits from the green features.

1.1 Green Mark (GM) Certification in Singapore

The Green Mark scheme was launched in January 2005 by the BCA to encourage the construction of more environmentally friendly and energy efficient buildings. The GM scheme rates and certifies buildings according to five main criteria: energy efficiency, water efficiency, environmental protection, indoor environmental quality, and other green and innovative features (Building and Construction Authority, 2017).

Buildings which apply for the GM certification would be assessed on the criteria listed above, and would be scored on a points basis. These scores would then be converted to an award type (Certified, Gold, Gold Plus, Platinum).

In order to further encourage developers to incorporate Green Building Technologies (GBTs) into their developments, the BCA set aside $20 million on the Green Mark Incentive Scheme (GMIS) in 2006. This was a scheme aimed at accelerating the adoption of green technologies, by providing cash incentives to developers, building owners, architects and mechanical and electrical (M&E) engineers who "[made] efforts to achieve at least a BCA Green Mark Gold rating or higher". The cash incentives would be split into two stages: half of which would be disbursed upon successful certification during the design or construction stage, and the remaining would be disbursed after validation, one year after the Temporary Occupation Permit (TOP) date. (Building and Construction Authority, 2015)

1.2 Aim of Study

The aim of this paper is to explore the intangible effects of an environmental certification or award, using data from housing transactions in Singapore.

This study uses a difference-in-differences (DID) approach to separate the intangible effects of the GM award from the tangible effects of it (energy savings), through its effect on housing transaction prices.

The intangible effects of environmental certifications are important because these certifications are meant to incentivise certain behaviour, in this case, constructing energy efficient buildings. In order for certifications to incentivise private companies to adopt certain practices, they need to provide a price premium to offset the cost premium associated with “good behaviour”. This price premium generated must be on top of the premium that buyers attach to the developers’ claims about the energy performance of the property.

2 LITERATURE REVIEW

Even before the proliferation of green certification schemes, some early papers in the 1980s have already demonstrated the relationship between energy efficiency ad residential property prices (Dinan & Miranowski, 1989; see Johnson & Kaserman, 1983; Laquatra, 1986). These papers demonstrate that improvements in energy efficiency, which lead to cost savings, are capitalised in the housing market. Cost savings from energy efficient investments are translated into increased housing prices.

More recently, the growing concern about climate change (and the proliferation of green certifications) has sparked more research on the effect of green certifications on housing prices. These studies show that green labelling or certification has a positive effect on residential property prices.

Using a hedonic pricing model, Jayantha and Man (2013) studied two green certifications in Hong Kong, namely the Hong Kong Building Environmental Assessment Method (HK-BEAM) and the Hong Kong Green Building Council (HK-GBC) award. Using data from 1 July 2003 to 1 September 2008 (to avoid the SARS outbreak in 2003 and the global financial crisis in 2008), the study found that people were willing to pay between 3.4 and 6.4 percent more for green certified buildings.

Several studies also used used hedonic price models to analyse the LEED programme in the US. For instance, Bond and Devine (2016) used a hedonic model with property-level characteristics such as presence of gym or swimming pool, as well as unit-level characteristics like the size of a dwelling unit, to model housing prices. The study also used coarsened exact matching (CEM) to balance the control (non-certified) and treatment (certified) groups. The motivation behind this is similar to propensity score matching; that is to find suitable controls for each treatment observation. The results from this study indicate that non-certified properties which are marketed as having green features do command a price premium over other non-certified properties, and certification adds a 4 percent premium on top of this, demonstrating the effect of the certification signal.

Another study by Kahn and Kok (2014) analysed various certifications like Energy Star, LEED and GreenPoint in the California housing market. The study used transactions of all single-family home sales in California from 2007 to 2012 and found a small premium of about 5% for certified homes. The study also found variations in the premium based on environmental ideology and local climatic conditions (e.g. hotter areas demand more cooling and hence higher importance of energy efficiency).

Although many studies focus on the US market, there are a few studies that have attempted to examine if the same price premium holds in other markets around the world. Fuerst and Shimizu (2016) analysed the Japanese housing market and found a 5% higher asking price for Tokyo Green Label certified condominiums compared to uncertified condominiums. The study also specifically tested if sellers overestimate the value of the green label by testing if transaction prices of green labelled buildings differed from their average asking prices, and found no evidence of such phenomena. This provides some evidence that the price premium is not unique to the US market, and can be generalised to other countries.

Deng, Li, and Quigley (2012) studied the GM program in Singapore using a two-stage hedonic regression model, and found a four percent premium for GM-rated dwellings. In this approach, the first stage regression was to model price as a function of hedonic characteristics, year and month fixed effects, and project-level fixed effects. The project-level fixed effects were then regressed on the project-level characteristics in the second stage regression to obtain the marginal willingness to pay (WTP) for the project-level characteristics, including the GM award.

Heinzle, Yip and Xing (2013) also studied the GM program using a stated preference study and found a price premium between 3.78 and 7.98 percent, depending on the level of certification (e.g. Gold, Platinum). This study also looked at the importance of various housing attributes in determining the purchase decisions of a potential buyer. The study found that price, size, location (Core Central Region/Rest of Central Region/Outside Central Region), the direction or facing of the living room and distance to MRT are the most important attributes (in that order). Apart from price which is the dependent variable in the hedonic model and facing of the living room which is unavailable, the rest of these variables are included in some form or other (e.g. location is absorbed by the 4 digit postal code fixed effects in the hedonic model).

A few studies pointed out the heterogeneous incentives to invest in energy efficiency between owner-occupiers and landlords. Michelsen, Mense, and Kholodilin (2015) studied the Berlin apartment housing market and found that the implicit price of energy efficiency in a tenant-occupied dwelling is less than that of an owner-occupied one, by a factor of 2.5. They also explain that this is due to tenants not having enough technical understanding to evaluate the true quality of a dwelling, and that they also apply larger discount rates to future energy savings or energy price increases.

Even though there are plenty of studies that show that green labelled properties command a price premium over non-labelled ones, most of these studies, as Brounen and Kok (2011) pointed out in their study, are unable to distinguish between the intangible effects of labelling itself and the economic effects of energy savings. This is because most of these studies do not employ a DID or fixed effects methodology to separate the two effects. These studies are also vulnerable to omitted variable bias, since it is quite likely that green labelled properties are of higher quality. One of the reasons this is so is because many “green” features also have positive non-environmental effects; for instance “double-glazing reduces noise pollution and increases security” (Fuerst, McAllister, Nanda, & Wyatt, 2016). As a result, the certification dummy in these models is also capturing unobserved quality differences between labelled and non-labelled properties, overestimating the effect of labelling or certification.

A few studies try to get around the problem of being unable to distinguish between the intangible effects of labelling and tangible effects of energy saving, but are still unable to separate the effect from unobserved quality differences between labelled and non-labelled properties. The study by Kahn and Kok (2014) use a proxy for ideology to partially separate the effects of the energy savings from the intangible labelling effects. Another study uses information on building-level energy usage to separate the effects of energy savings from the intangible effects of labelling (Fuerst, Oikarinen, & Harjunen, 2016).

It is also important to note that while green certifications do contribute a price premium to properties, the price premium has been found to decrease as the supply of certified properties increase, indicating the presence of general equilibrium effects (Chegut, Eichholtz, & Kok, 2014).

This study will use a DID approach to separate the intangible labelling effects from the energy saving effects, and also to avoid the omitted variable bias problem. This should be a cleaner approach than using proxies, but also relies on a (reasonable) assumption that energy saving features of a property would be marketed to property buyers regardless of whether a property is (or going to be) GM-rated.

3 DATA AND METHODOLOGY

3.1 Data Sources

About eighty percent of the Singapore population lives in public housing (Department of Statistics Singapore, 2017). Property characteristics are heterogeneous across different submarkets (Sing, Tsai, & Chen, 2006), so this paper studies only new sales in the condominium and apartment market, of which 134,183 transactions were collected. Public housing by the Housing Development Board (HDB) as well as executive condominiums (ECs) are subsidised and have eligibility criteria (see Housing and Development Board, 2015b, also 2015a), hence they might function differently from the private housing market. In the private property market, I use only residential properties, because commercial and office buildings do undergo asset enhancement initiatives (AEIs) every once in a while. If the timing of the GM award coincides with these AEIs, the DID cannot isolate the effect of the GM award from the other relevant improvements in the property as a result of the AEI.

Housing transactions ranging from Jan 2003 to Mar 2016 was obtained from the Real Estate Information System (REALIS) of Singapore. A total of 331,405 private residential housing transactions were collected. These transactions were then geocoded using the Onemap Search API. After geocoding, the distance of each property to the nearest MRT station was calculated. The coordinates of MRT stations was obtained again by using the Onemap Search API.

Information about the GM awards was obtained by scraping the Building Construction Authority of Singapore (BCA) Green Mark Buildings Directory,[1] searching for Residential and Mixed Developments. Since the GM Buildings Directory only contained the year of award, I obtained the exact dates of the award by searching for "BCA Awards" the Straits Times archive from LexisNexis. Green Mark winners are announced on the BCA awards night, so I searched for the dates of the BCA awards night for each year (2005 till 2015).

Information about condominium facilities was obtained from (??). Construction Quality Assessment System (CONQUAS) scores for projects were obtained from the BCA's Information on Construction Quality (IQUAS) database.[2]

[1]The BCA Green Mark Buildings Directory contains a list of buildings which are awarded with the Green Mark award. Information about the award such as the award year is provided. Website can be found here: https://www.bca.gov.sg/green_mark/KnowledgeResources/BuildingDirectory.aspx

[2]The IQUAS database contains information about projects, such as the CONQUAS score and Quality Mark certification. Website can be found here: https://www.bca.gov.sg/Professionals/IQUAS/IQUAS/default.aspx?menuID=4

3.2 Descriptive Statistics

As of Feb 2017, there are around 1600 GM rated properties, of which 172 are relevant for this study (private residential properties excluding ECs). There are 1033 non-GM rated projects. For the main sample used in the analysis (new sales from the above criteria), there are 172 GM rated projects and 1033 non-GM rated projects.

Table 3.1 shows some basic descriptive statistics for the new, non-EC sales, including a comparison between GM and non-GM rated properties.

Table 3.1: Comparison of GM and non-GM rated Properties

	Overall (N = 134,183)	Non-GM (N = 83,367)	GM (N = 50,816)
Property Type			
Apartment	44,594 (33%)	36,170 (43%)	8,424 (17%)
Condominium	89,589 (67%)	47,197 (57%)	42,392 (83%)
Unit Price (S$/sqm)			
Min	3253.686	3253.686	4231.134
Mean (SD)	14,068.65 (6,043.71)	13,854.19 (6,088.18)	14,420.48 (5,953.39)
Max	78067.94	78067.94	66968.64
Unit Size (sqm)			
Min	24	24	34
Mean (SD)	100.98 (51.51)	96.38 (49.75)	108.52 (53.43)
Max	1289	879	1289
Distance to MRT (km)			
Min	0.04728256	0.04728256	0.05318607
Mean (SD)	0.94 (0.73)	1.03 (0.71)	0.80 (0.72)
Max	5.745097	5.745097	3.355272
Lease Type			
Leasehold	76,686 (57%)	37,913 (45%)	38,773 (76%)
Freehold	57,497 (43%)	45,454 (55%)	12,043 (24%)
Floor			
Mean (SD)	9.64 (8.04)	8.62 (7.11)	11.31 (9.13)
Max	70	52	70

	Overall (N = 134,183)	Non-GM (N = 83,367)	GM (N = 50,816)
Green Mark Award			
Certified	4,997 (4%)	0 (0%)	4,997 (10%)
Gold	21,345 (16%)	0 (0%)	21,345 (42%)
Gold Plus	20,128 (15%)	0 (0%)	20,128 (40%)
Platinum	4,346 (3%)	0 (0%)	4,346 (9%)
No Award	83,367 (62%)	83,367 (100%)	0 (0%)
CONQUAS Score			
61-70	638 (0%)	548 (1%)	90 (0%)
71-80	4,259 (3%)	3,584 (4%)	675 (1%)
81-90	25,202 (19%)	15,663 (19%)	9,539 (19%)
> 90	37,741 (28%)	15,044 (18%)	22,697 (45%)
Missing	66,343 (49%)	48,528 (58%)	17,815 (35%)
Facilities (%)			
BBQ Pit	0.66 (0.47)	0.64 (0.48)	0.69 (0.46)
Swimming Pool	0.67 (0.47)	0.71 (0.45)	0.62 (0.49)
Tennis Court	0.51 (0.50)	0.42 (0.49)	0.66 (0.47)
Basketball Court	0.06 (0.24)	0.07 (0.25)	0.05 (0.23)
Gym	0.75 (0.43)	0.76 (0.43)	0.73 (0.45)
Function Room	0.31 (0.46)	0.26 (0.44)	0.38 (0.48)
Jacuzzi	0.44 (0.50)	0.46 (0.50)	0.40 (0.49)
Sauna	0.12 (0.32)	0.09 (0.29)	0.15 (0.36)
Transaction Year			
2003	4,179 (3%)	3,953 (5%)	226 (0%)
2004	4,867 (4%)	3,945 (5%)	922 (2%)
2005	6,964 (5%)	4,878 (6%)	2,086 (4%)
2006	8,815 (7%)	6,663 (8%)	2,152 (4%)
2007	11,920 (9%)	7,304 (9%)	4,616 (9%)
2008	3,767 (3%)	2,771 (3%)	996 (2%)
2009	12,729 (9%)	6,677 (8%)	6,052 (12%)
2010	14,379 (11%)	8,704 (10%)	5,675 (11%)
2011	14,927 (11%)	9,207 (11%)	5,720 (11%)

	Overall (N = 134,183)	Non-GM (N = 83,367)	GM (N = 50,816)
2012	19,603 (15%)	10,979 (13%)	8,624 (17%)
2013	14,591 (11%)	7,719 (9%)	6,872 (14%)
2014	6,833 (5%)	3,395 (4%)	3,438 (7%)
2015	7,083 (5%)	4,547 (5%)	2,536 (5%)
2016	3,526 (3%)	2,625 (3%)	901 (2%)

In general, GM-rated properties tend to be of higher quality, selling for higher price psm. The average GM-rated property is also larger, closer to an MRT station, on a higher floor, is more likely to be CONQUAS rated and have higher CONQUAS score. Within the GM-rated properties, about 10% of them are Certified, 42% are awarded Gold, 40% are awarded Gold Plus, and 9% are awarded Platinum.

3.3 Methodology

Certified buildings can have a price premium due to two reasons: either the signalling effect provided by the certification, or that good features tend to cluster together such that green buildings are also higher quality buildings in other aspects. Fuerst (2016) also pointed out that energy efficient features present in green buildings may also affect building performance in non-environmental aspects, and hence also generate a price premium that is unrelated to environmental friendliness.

This study uses a difference-in-differences (DID) approach to isolate the signalling effect from any other factors associated with the GM certification that might contribute to a price premium.

Housing prices are modelled using the hedonic price model introduced by Rosen (1974). In this model, housing price is a function of structural, environmental and locational attributes. These attributes carry implicit prices, which are revealed from observed prices of different properties with different combinations of attributes. These implicit prices are estimated with regression analysis.

This paper uses a feature of the GM program in Singapore to isolate the signalling effects of an environmental certification. Because certification takes time, developments sometimes get the award only after their launch. This makes it possible to use a DID framework to isolate the effect of the award as a signal from other unobserved characteristics. The idea is that the award is an “unexpected shock” to buyers, and hence the price premium attributed to the property after the award will be independent of other unobserved characteristics, which may cluster together with green features. In essence, because nothing about the property has changed after it is awarded with the GM award, any price premium that is generated after the award should be independent of unobserved characteristics.

This study uses only new sales of private residential properties, excluding ECs. This is because ECs are subsidised by HDB and have eligibility criteria, which implies that it is limited to a certain group of buyers.

3.3.1 "Naive" Model

The first models run are basic models that test the difference in price between GM and non-GM rated dwellings. These are hedonic pricing models with the natural log of price per square metre (psm)[3] as the dependent variable, and hedonic characteristics as the independent variables.

I first start off by regressing the natural log of price psm on a dummy indicating whether or not a property is GM certified:

$$P_i = \beta_0 + \beta_1 GM_i + \epsilon_i \tag{3.1}$$

where i indexes housing transactions, GM_i indicates if the property associated with transaction i is GM-certified.

The model specified by (3.1) has several weaknesses. It does not consider any hedonic characteristics at all. Since the GM award is likely to be correlated with other hedonic characteristics which affect housing prices, the model suffers from omitted variable bias. As such, the model can be improved by adding other hedonic characteristics and locational controls:

$$P_i = \beta_0 + \beta_1 GM_i + \beta X_i + \lambda loc_i + \epsilon_i \tag{3.2}$$

where X_i is a vector of hedonic attributes, including the property type (apartment or condominium), the natural log of the area in sqm of the unit, a freehold dummy, two order polynomial of the floor that the unit is on, dummies indicating if the unit is on the bottom or top floor (these units have less liveable space), distance to MRT (in kilometres), the number of years to completion when the sale happened, and availability of facilities such as gymnasium or swimming pool. loc_i is a vector of 4-digit postal code dummies.

The predictive performance of this model can be further improved by controlling for the property market cycle. This is done by adding in year-month dummies:

[3]Prices were deflated by the CPI before being log-transformed

$$P_{it} = \beta_0 + \beta_1 GM_i + \beta X_i + \lambda loc_i + \gamma_t + \epsilon_{it} \tag{3.3}$$

3.3.2 DID Model

Even with these controls, it is likely that there are other omitted variables that are correlated with the GM award and the price of a property. Unobserved quality of the property is one such omitted variable.

In order to separate the effect of the award from the effect of unobserved quality differences between GM and non-GM rated properties, a DID approach can be used. In this context, the cross-section variation (treatment or control group) is simply whether or not a property is GM-rated. The time variation is before and after a property gets its GM rating.

There is a challenge in defining the time variation for a traditional DID model, because the timing of award varies between properties. However, this issue is solved by using time (year-month) dummies in the regression equation, like in a fixed effects (FE) model, except without entity fixed effects. The resulting model is as follows:

$$P_{it} = \beta_0 + \beta_1 GM_i + \beta_2 GM_i \times AfterGM_{it} + \beta X_i + \lambda loc_i + \gamma_t + \epsilon_{it} \tag{3.4}$$

where $CONQUAS_i$ represents the CONQUAS score of the property

The model can still be improved further, by adding available measures of quality of a property. For instance, the CONQUAS score can be added to control for the construction quality of a property, which is likely to be correlated with the GM award and also the price of a property.

$$P_{it} = \beta_0 + \beta_1 GM_i + \beta_2 GM_i \times AfterGM_{it} + \beta X_i + \beta_3 CONQUAS_i + \lambda loc_i + \gamma_t + \epsilon_{it} \tag{3.5}$$

where $CONQUAS_i$ represents the CONQUAS score of the property

Since CONQUAS is a voluntary rating scheme, the model specified in equation (3.5) results in a lot of observations being dropped. This is problematic because it might result in selection bias in the model, since unevaluated properties are dropped from the model. Instead, dummies representing ranges of the CONQUAS score can be used; a dummy indicating missing CONQUAS score can also be included so as to not exclude non-CONQUAS rated properties.

$$P_{it} = \beta_0 + \beta_1 GM_i + \beta_2 GM_i \times AfterGM_{it} + \beta X_i + \delta CONQUAS_i + \lambda loc_i + \gamma_t + \epsilon_{it} \tag{3.6}$$

where $CONQUAS_i$ is a vector of CONQUAS score range dummies (e.g. 61-70, 71-80, 81-90, >90, missing)

3.3.3 Placebo DID Checks

In order to ensure that the DID models are robust (i.e. non-GM properties are comparable to GM properties after accounting for the other regressors), a placebo DID model was run.

A conventional placebo DID approach that simply shifts the time variation dummy to some time before the actual treatment would not work in this case. Since property developers can inform potential buyers that their property would be GM-rated, buyers are likely to price in part of the premium associated with green features before the official GM announcement date. As a result, the placebo DID coefficient may be significant even if the assumption of common trend between the treatment and control groups is satisfied.

Instead, the same DID model was run on resale transaction data, testing if there were any changes in the property around the time of the award (leading to a change in price premium). The "after GM" dummy was defined as whether or not the new sale of the unit was after the GM announcement. This way, the resale transaction of a GM-rated unit is always already GM-rated by the time of resale; the DID coefficient in this specification should have a coefficient of zero. Any GM-rated project which had resale transactions before being GM-rated were removed. The placebo DID coefficient is checking that there is no difference between GM-rated properties, regardless of whether the GM announcement happened before the first sale or before the resale. If a GM-rated resale property sells before it obtains the GM certification, there will be a price difference between it and other GM-rated properties which have already obtained the GM certification. Here is an example:

Order of GM	Placebo DID Dummy Value
Non-GM	0
New Sale-GM-Resale	0
GM-New Sale-Resale	1
New Sale-Resale-GM	0 (these are excluded from the model to avoid causing problems)

4 EMPIRICAL RESULTS

4.1 Results from "Naive" Models

Table 4.1 reports the regression results from the "basic" hedonic models. The most basic model specified by equation (3.1) suggests that the GM award provides a 4.54% price premium over non-GM properties. However, this model suffers from omitted variable bias and also has a very low R^2 of 0.003. The model specified by equation (3.2) which adds hedonic characteristics, locational controls (4-digit postal code dummies) and condominium/apartment facilities shows a GM award effect of 8.3%. Because this model adds a significant number of variables, the R^2 also increases significantly to 0.825. After controlling for property market trends using year-month dummies, this effect changes to 2.51%.

The coefficients of the hedonic characteristics are all expected. For instance, condominiums are more expensive compared to comparable apartments, higher floors command higher prices but suffer from diminishing returns. Units on the first and top floors of any block are cheaper than comparable units on other floors because these typically have unliveable space (first floors have patios and top floors have roof terraces). Properties further away from the closest MRT station also sell for lesser.

Table 4.1: Effects of GM Award on Price

	Dependent variable:		
	Natural log of Price psm		
	(1)	(2)	(3)
GM Award	0.045***	0.083***	0.025***
	(0.002)	(0.003)	(0.002)
Property Type: Condominium		0.084***	0.054***
		(0.004)	(0.003)
ln(Area (sqm))		−0.178***	−0.129***
		(0.002)	(0.002)
Freehold		0.150***	0.148***
		(0.005)	(0.004)
Floor		0.008***	0.008***
		(0.0003)	(0.0002)
Floor^2		−0.00002**	−0.0001***
		(0.00001)	(0.00001)
First Floor		−0.037***	−0.044***
		(0.002)	(0.002)
Top Floor		−0.059***	−0.083***
		(0.003)	(0.002)
Distance to MRT (km)		−0.082***	−0.024***
		(0.003)	(0.002)
Years to Completion		−0.027***	−0.027***
		(0.001)	(0.001)
4-digit Postal Code Fixed Effects	No	Yes	Yes
Year-Month Dummies	No	No	Yes
Condo Facilities Dummies	No	Yes	Yes
Observations	134,183	103,123	103,123
R^2	0.003	0.825	0.927
Adjusted R^2	0.003	0.824	0.926
Residual Std. Error	0.375 (df = 134181)	0.163 (df = 102612)	0.106 (df = 102451)

Note: *p<0.1; **p<0.05; ***p<0.01

4.2 Results from DID Models

The above models were further improved by using a DID methodology as outlined in the previous section. The results from the DID specifications are reported in Table 4.2. Controlling for hedonic characteristics, availability of facilities, locational effects and year-month effects, the announcement of GM award increases a property's price by 1.65%. GM rated properties are also higher quality than non-GM rated ones, having a 1.45% premium before they receive the award.

Adding CONQUAS score as a regressor changes the premium associated with the GM award announcement to 2.93%, indicating that quality is an important factor in determining housing prices. This implies that the previous models suffered from omitted variable bias, due to the announcement of award being correlated with the unobserved quality of the building (which can be captured by the CONQUAS score).

Unfortunately, since CONQUAS scoring is optional, many buildings do not apply for it; about 37% of the observations were dropped. This might cause selection problems. This can be solved by categorising the CONQUAS score into bands, and including a category for missing scores. Doing so could also reduce noise as it is unlikely that people are able to take into account the exact scores into pricing decisions. This model shows that the GM announcement is associated with a 1.22% increase in price of a GM rated property. It also shows that higher CONQUAS scores are associated with higher prices, especially when compared to the lowest scores of 61-70. Properties with missing CONQUAS scores also command a premium over properties with CONQUAS scores of 61-70. This indicates that property buyers really do not like low quality properties.

Table 4.2: Difference-in-difference Models

	Dependent variable:		
	Natural log of Price psm		
	(1)	(2)	(3)
GM Award	0.015^{***}	0.023^{***}	0.017^{***}
	(0.002)	(0.003)	(0.002)
GM x After GM	0.016^{***}	0.029^{***}	0.012^{***}
	(0.002)	(0.002)	(0.002)
Property Type: Condominium	0.054^{***}	0.052^{***}	0.049^{***}
	(0.003)	(0.005)	(0.003)
ln(Area (sqm))	-0.129^{***}	-0.110^{***}	-0.129^{***}
	(0.002)	(0.002)	(0.002)
Freehold	0.147^{***}	0.095^{***}	0.145^{***}
	(0.004)	(0.005)	(0.004)
Floor	0.008^{***}	0.008^{***}	0.008^{***}
	(0.0002)	(0.0002)	(0.0002)
Floor^2	-0.0001^{***}	-0.0001^{***}	-0.0001^{***}
	(0.00001)	(0.00001)	(0.00001)
First Floor	-0.044^{***}	-0.052^{***}	-0.044^{***}
	(0.002)	(0.002)	(0.002)
Top Floor	-0.083^{***}	-0.075^{***}	-0.083^{***}
	(0.002)	(0.002)	(0.002)
Distance to MRT (km)	-0.024^{***}	-0.004	-0.025^{***}
	(0.002)	(0.003)	(0.002)
Years to Completion	-0.028^{***}	-0.030^{***}	-0.027^{***}
	(0.001)	(0.001)	(0.001)
CONQUAS Score		0.004^{***}	
		(0.0002)	
CONQUAS Score: 71-80			0.218^{***}
			(0.010)
CONQUAS Score: 81-90			0.179^{***}
			(0.009)
CONQUAS Score: > 90			0.209^{***}
			(0.009)
CONQUAS Score: Missing			0.193^{***}
			(0.009)
4-digit Postal Code Fixed Effects	Yes	Yes	Yes
Year-Month Dummies	Yes	Yes	Yes
Condo Facilities Dummies	Yes	Yes	Yes
Observations	103,123	65,403	103,123
R^2	0.927	0.940	0.927
Adjusted R^2	0.926	0.939	0.927
Residual Std. Error	0.106 (df = 102450)	0.100 (df = 64951)	0.106 (df = 102446)
Note:			*p<0.1; **p<0.05; ***p<0.01

4.3 Results from Placebo DID

Finally, a placebo DID model is also run, to ensure that GM rated and non-GM rated properties are comparable. The specification is described in the previous section. Running the model on 97,005 resale transactions shows a positive but insignificant DID coefficient. This result indicates that there is no selection bias that is not controlled for by the regressors in the DID model with CONQUAS scores.

Table 4.3: Placebo Difference-in-difference Tests

	Dependent variable:		
	Natural log of Price psm		
	(1)	(2)	(3)
GM Award	0.075***	0.069***	0.071***
	(0.005)	(0.006)	(0.005)
GM x GM After New Sale	0.006	−0.005	0.005
	(0.005)	(0.005)	(0.005)
Property Type: Condominium	0.058***	0.028***	0.052***
	(0.003)	(0.004)	(0.003)
ln(Area (sqm))	−0.140***	−0.134***	−0.141***
	(0.002)	(0.003)	(0.002)
Freehold	0.182***	0.188***	0.179***
	(0.003)	(0.004)	(0.003)
Floor	0.007***	0.006***	0.007***
	(0.0002)	(0.0002)	(0.0002)
Floor^2	−0.00005***	−0.00003***	−0.00005***
	(0.00001)	(0.00001)	(0.00001)
First Floor	−0.031***	−0.039***	−0.032***
	(0.002)	(0.002)	(0.002)
Top Floor	−0.078***	−0.067***	−0.078***
	(0.002)	(0.002)	(0.002)
Distance to MRT (km)	−0.001	0.008***	−0.003
	(0.002)	(0.002)	(0.002)
Years to Completion	−0.009***	−0.014***	−0.009***
	(0.0002)	(0.0003)	(0.0002)
CONQUAS Score		−0.00002	
		(0.0002)	
CONQUAS Score: 61-70			0.045*
			(0.025)
CONQUAS Score: 71-80			0.099***
			(0.025)
CONQUAS Score: 81-90			0.117***
			(0.025)
CONQUAS Score: > 90			0.122***
			(0.025)
CONQUAS Score: Missing			0.100***
			(0.025)
4-digit Postal Code Fixed Effects	Yes	Yes	Yes
Year-Month Dummies	Yes	Yes	Yes
Condo Facilities Dummies	Yes	Yes	Yes
Observations	97,005	63,180	97,005
R^2	0.905	0.931	0.905
Adjusted R^2	0.904	0.930	0.904
Residual Std. Error	0.127 (df = 96194)	0.107 (df = 62667)	0.127 (df = 96189)
Note:			*p<0.1; **p<0.05; ***p<0.01

5 CONCLUSION

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