INTANGIBLE EFFECTS OF GREEN LABELLING: EVIDENCE FROM SINGAPORE

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ABSTRACT

Since the 1990s, environmental certifications have been introduced in an attempt to curb the environmental impact of building construction. This study analyses the intangible effects of such certifications, 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 133,920 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

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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). This is in part because 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 a 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 developers or landlords claim to exist. Assuming green features require additional costs to build in, the lack of price premium 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 incentive to construct of these environmentally sustainable buildings.

On top of solving the information asymmetry problem, certification also provides certified properties with a price premium through other intangible award effects. Such effects include, but are not limited to, signalling quality unrelated to environmental performance, or raising awareness about environmental effects to increase demand for green features.

Some literature have shown that the costs of building green features like natural lighting and ventilation 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 (Building and Construction Authority, 2008).

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 (providing confirmation about green features, signalling quality etc.) from the tangible effects of certified buildings (energy savings), through its effect on housing transaction prices.

The intangible award or certification effects 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, otherwise there is no point in obtaining the certification even if green features are built into a 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 and 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.

Several studies 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 the 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 that 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 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.

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.

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 use a simple hedonic pricing approach without attempting to control for the energy savings, for instance by using a DID or fixed effects approach. 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 hedonic 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) used 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). Moving forward, it might not be surprising to see future studies reporting smaller premiums associated with green certified properties.

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

About eighty percent of the population of Singapore lives in public housing (Department of Statistics Singapore, 2017). However, public housing by the Housing Development Board (HDB) as well as executive condominiums (ECs) are regulated, subsidised and have eligibility criteria (see Housing and Development Board, 2015b, also 2015a), hence they might function differently. 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. In the private property market, I use only residential properties, because it is quite common that commercial and office buildings undergo asset enhancement initiatives (AEIs). 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.

3.1 Data Sources

Housing transactions ranging from Jan 2003 to Mar 2016 were 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 were 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 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). This is still not perfect for the purposes of this study but it is the best available data. The GM certification is awarded to a development upon completion of the assessment; the BCA Awards Night is just a ceremony to recognise companies and developments that received BCA awards in a given year.

[1] The BCA Green Mark Buildings Directory contains a list of buildings which are awarded with the Green Mark award. While there are datasets on GM buildings from data.gov.sg and dex.sg, these datasets do not contain information on the date of the GM award as of the time of data collection. Website can be found here: https://www.bca.gov.sg/green_mark/KnowledgeResources/BuildingDirectory.aspx

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

3.2 Descriptive Statistics

As of Feb 2017, there are around 1600 GM rated properties, most of which are commercial and office properties. 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 between GM and non-GM rated Properties

	Overall (N = 133,920)	Non-GM (N = 83,367)	GM (N = 50,553)
Property Type			
Apartment	44,495 (33%)	36,170 (43%)	8,325 (16%)
Condominium	89,425 (67%)	47,197 (57%)	42,228 (84%)
Unit Price (S$/sqm)			
Min	3253.686	3253.686	4231.134
Mean (SD)	14,068.75 (6,049.17)	13,854.19 (6,088.18)	14,422.58 (5,967.52)
Max	78067.94	78067.94	66968.64
Unit Size (sqm)			
Min	24	24	34
Mean (SD)	100.98 (51.52)	96.38 (49.75)	108.58 (53.46)
Max	1289	879	1289
Distance to MRT (km)			
Min	0.04728256	0.04728256	0.05318607
Mean (SD)	0.94 (0.72)	1.03 (0.71)	0.79 (0.72)
Max	5.745097	5.745097	3.355272
Lease Type			

[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

	Overall (N = 133,920)	Non-GM (N = 83,367)	GM (N = 50,553)
Leasehold	76,686 (57%)	37,913 (45%)	38,773 (77%)
Freehold	57,234 (43%)	45,454 (55%)	11,780 (23%)
Floor			
Mean (SD)	9.65 (8.04)	8.62 (7.11)	11.33 (9.14)
Max	70	52	70
Green Mark Award			
Certified	4,734 (4%)	0 (0%)	4,734 (9%)
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	37,478 (28%)	15,044 (18%)	22,434 (44%)
Missing	66,343 (50%)	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)	0.61 (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)	0.06 (0.23)
Gym	0.75 (0.43)	0.76 (0.43)	0.72 (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%)

	Overall (N = 133,920)	Non-GM (N = 83,367)	GM (N = 50,553)
2007	11,920 (9%)	7,304 (9%)	4,616 (9%)
2008	3,767 (3%)	2,771 (3%)	996 (2%)
2009	12,729 (10%)	6,677 (8%)	6,052 (12%)
2010	14,215 (11%)	8,704 (10%)	5,511 (11%)
2011	14,913 (11%)	9,207 (11%)	5,706 (11%)
2012	19,522 (15%)	10,979 (13%)	8,543 (17%)
2013	14,589 (11%)	7,719 (9%)	6,870 (14%)
2014	6,831 (5%)	3,395 (4%)	3,436 (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 a higher price psm. The average GM-rated property is also larger, closer to an MRT station, on a higher floor, 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 a few reasons: the intangible effects provided by the certification, the economic effects of energy and water savings, or simply because good features tend to cluster together, such that green buildings are also higher quality buildings in other aspects.

This study uses a difference-in-differences (DID) approach to isolate the intangible effects of certification from any other factors associated with the GM certification that might contribute to a price premium. The DID approach abstracts away the baseline differences between GM-rated and non-GM rated properties and also differences in prices across time, leaving the intangible certification effect.

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 intangible effects of an environmental certification, that is, that certification takes time and hence developments sometimes get the award only after sales have started. This makes it possible to use a DID framework to isolate the intangible effects of certification from other unobserved characteristics, or the economic value of energy savings.

The idea is that the announcement of 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 or energy savings.

3.3.1 Basic Hedonic Regression 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:

$$P_i = \beta_0 + \beta_1 GM_i + \epsilon_i \tag{1}$$

where P is the natural log of the CPI-deflated price psm, i indexes housing transactions, GM_i indicates if the property associated with transaction i is GM-certified.

The coefficient of interest, β_1, measures the premium of GM-rated housing units over non-GM rated ones.

The model specified by equation (1) has several weaknesses; most importantly, 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:

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

$$P_i = \beta_0 + \beta_1 GM_i + \beta X_i + \lambda loc_i + \epsilon_i \tag{2}$$

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:

$$P_{it} = \beta_0 + \beta_1 GM_i + \beta X_i + \lambda loc_i + \gamma_t + \epsilon_{it} \tag{3}$$

where t indexes time (year-month), γ_t represents year-month fixed effects.

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, and can happen if good features tend to cluster together. If this is so, the price premium of a GM-rated property is not solely due to the GM award, and is partly due to GM-rated properties being more likely to be of higher quality.

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. A dummy indicating whether or not a property is GM-rated will capture the economic benefits of energy savings and also the unobserved quality differences between GM-rated and non-GM rated properties. The time variation is before and after a property gets its GM rating.

There is a challenge in defining the time variation in this model, because the timing of award varies between properties. There is also no intuitive way to classify the timing of award for non-GM rated properties. However, this issue is solved by using time (year-month) dummies in the regression equation. This is not unlike a fixed effects (FE) model, except without entity fixed effects. The resulting model is as follows:

$$P_{it} = \beta_0 + \beta_1 GM_i + \beta_2 GM_i \times AfterGM_{it} + \beta X_i + \lambda loc_i + \gamma_t + \epsilon_{it} \tag{4}$$

where $AfterGM_{it}$ is a dummy indicating if t is after the GM award date for a GM-rated property, and 0 otherwise (also 0 for non-GM rated properties).

The coefficient of interest, β_2, measures the intangible award effects of the GM award on a housing unit's price, controlling for hedonic characteristics, locational differences and property market cycles.

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.

$$P_{it} = \beta_0 + \beta_1 GM_i + \beta_2 GM_i \times AfterGM_{it} + \beta X_i + \beta_3 CONQUAS_i + \lambda loc_i + \gamma_t + \epsilon_{it} \tag{5}$$

where $CONQUAS_i$ represents the CONQUAS score of the property.

Since CONQUAS is a voluntary rating scheme, the model specified in equation (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. While a "CONQUAS missing" dummy can be added in the above specification to avoid dropping observations, it does not solve the problem that raw CONQUAS scores may be noisy.

$$P_{it} = \beta_0 + \beta_1 GM_i + \beta_2 GM_i \times AfterGM_{it} + \beta X_i + \delta CONQUAS_i + \lambda loc_i + \gamma_t + \epsilon_{it} \tag{6}$$

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

These DID models can easily be extended into a fixed effects framework with project-level fixed effects; however, this study does not do so, in order to retain information about the total premium attached to GM-rated properties.

3.3.3 Robustness Check

The claim of this study is that the DID methodology can isolate the intangible award effects from all other effects; this claim is evaluated by testing if there were any changes in the property around the time of the award (leading to a change in price premium).

One reason there might be a change in the quality of a property around the time of the award could be that a development which previously did not meet the GM certification criteria undergoes some form of asset enhancement or renovation works, and then meets the criteria for GM certification.

To test this, I run the same DID models, except with resale data, and re-defined the "after GM" dummy. The "after GM" dummy was re-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 idea is that by the time of the resale transaction, all GM-rated units are already GM-rated; any price difference observed between GM-rated properties rated before or after their new sale must be from effects other than the intangible award effects. If the DID coefficients in this model are statistically significant, it might indicate that the timing of the award coincides with some unobserved changes in the property. This would imply that the DID coefficients in the main results are capturing some unobserved changes in the property around the time of the award.

Any GM-rated project which had resale transactions before being GM-rated were removed. This is because 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 Basic Hedonic Regression Models

Table 4.1 reports the regression results from the basic hedonic models. The most basic model specified by equation (1) suggests that the GM award provides a 4.52% price premium over non-GM properties. However, this model suffers from omitted variable bias and also has a very low predictive power, with a R^2 of 0.003. The model specified by equation (2), which adds hedonic characteristics, locational controls (4-digit postal code dummies) and condominium/apartment facilities, shows a GM award effect of 8.36%. 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, the premium associated with GM-rated properties changes to 2.62%.

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 an MRT station also sell for lesser, as residents in these properties have to incur higher transportation costs.

These results are in line with the study by Deng, Li and Quigley (2012), which also studied the GM award in the Singapore private residential property market with a similar specification. This study excludes some covariates such as buyer characteristics, and adds others, such as distance to the nearest MRT station and the availability of facilities like swimming pool and gymnasium.

Overall, the results from these basic hedonic models indicate that GM-rated properties command a premium over non-GM rated properties. These results show that, after controlling for property characteristics such as size and location, the combined benefits of energy savings as well as the intangible certification effects contribute about a 3 to 8 percent price premium.

Table 4.1: Effects of GM Award on Price

	Dependent variable:		
	Natural log of Price psm		
	(1)	(2)	(3)
GM Award	0.045^{***}	0.084^{***}	0.026^{***}
	(0.002)	(0.003)	(0.002)
Property Type: Condominium		0.084^{***}	0.053^{***}
		(0.004)	(0.003)
ln(Area (sqm))		-0.178^{***}	-0.128^{***}
		(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^{***}	-0.045^{***}
		(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	133,920	102,860	102,860
R^2	0.003	0.825	0.927
Adjusted R^2	0.003	0.824	0.926
Residual Std. Error	0.375 (df = 133918)	0.163 (df = 102349)	0.106 (df = 102188)
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 chapter. 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 1.71%. GM rated properties are also higher quality than non-GM rated ones, having a 1.53% premium before they receive the award.

Adding CONQUAS score as a regressor changes the premium associated with the GM award announcement to 2.94%, 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 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, which 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 since they cannot observe quality fully. This model shows that the GM announcement is associated with a 1.28% 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.

Comparing the results from the DID to the basic hedonic models, the intangible award effects contribute about a 1 to 2% premium, which is smaller but still economically significant. This is especially so considering that the GM award was found to be of the lowest importance in condominium buyers' decision making process, among many factors such as size, location and condominium facilities (Heinzle et al., 2013).

Table 4.2: Difference-in-difference Models

	Dependent variable:		
	Natural log of Price psm		
	(1)	(2)	(3)
GM Award	0.015***	0.023***	0.018***
	(0.002)	(0.003)	(0.002)
GM x After GM	0.017***	0.029***	0.013***
	(0.002)	(0.002)	(0.002)
Property Type: Condominium	0.053***	0.052***	0.048***
	(0.003)	(0.005)	(0.003)
ln(Area (sqm))	−0.129***	−0.110***	−0.128***
	(0.002)	(0.002)	(0.002)
Freehold	0.146***	0.095***	0.144***
	(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	−0.045***	−0.053***	−0.045***
	(0.002)	(0.002)	(0.002)
Top Floor	−0.083***	−0.074***	−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			0.219***
			(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	102,860	65,140	102,860
R^2	0.927	0.940	0.927
Adjusted R^2	0.926	0.939	0.927
Residual Std. Error	0.106 (df = 102187)	0.100 (df = 64688)	0.106 (df = 102183)
Note:			*p<0.1; **p<0.05; ***p<0.01

4.3 Results from Robustness Check

A robustness check was also carried out, to ensure that the effect captured by the DID dummy is indeed due to intangible award effects, and not unobserved quality changes that coincide with the announcement of the GM award, such as asset enhancement or renovation works. The specification of the models are the same as the main DID models, with some exceptions. The data used is resale data instead of new sale data, and the award period variable is defined as whether a resale unit's new sale happened after the development received the GM award.

Running the model on 96,999 resale transactions shows a positive but insignificant DID coefficient. This result indicates that there is no issue with GM announcements coinciding with unobserved changes in quality of the property; there are no other effects associated with the announcement of the GM certification other than the intangible award effects.

Table 4.3: Robustness Check

	Dependent variable:		
	Natural log of Price psm		
	(1)	(2)	(3)
GM Award	0.075***	0.068***	0.071***
	(0.005)	(0.006)	(0.005)
GM x GM After New Sale	0.006	−0.006	0.005
	(0.005)	(0.005)	(0.005)
Hedonic Characteristics	Yes	Yes	Yes
4-digit Postal Code Fixed Effects	Yes	Yes	Yes
Year-Month Dummies	Yes	Yes	Yes
Condo Facilities Dummies	Yes	Yes	Yes
CONQUAS Score	Not Included	Continuous	Categorical
Observations	96,999	63,174	96,999
R^2	0.905	0.931	0.905
Adjusted R^2	0.904	0.930	0.904
Residual Std. Error	0.127 (df = 96188)	0.107 (df = 62661)	0.127 (df = 96183)

Note: *p<0.1; **p<0.05; ***p<0.01
Models are of the same specification as the main DID models, except that instead of new sales, resale transactions are used. The interaction term is re-defined as whether or not the new sale of the corresponding housing unit occurred after the GM award.

The GM award premium is also larger in the resale market compared to the premium for new sales, which is in line with the findings by Deng and Wu (2014), who find a 10% premium at the resale stage but only 4% during the presale stage. They conclude that developers pay almost all the costs associated with sustainable development, but are unable to extract all of the benefits associated with these investments. This, they explained, might "impede the further development of green residential properties".

The authors offered two explanations for this phenomena. The first is that there is information asymmetry in housing presale arrangements, and households do not fully trust the GM evaluation, which is based on design and document reviews and not the actual building performance. The premium would increase after an owner has lived in it, since the green claims can be verified then.

The second explanation is a general equilibrium argument; the supply of GM-rated properties in the resale market was much smaller than that in the new sales market during the period of data used in that study (2000 to 2010) when the GM scheme was still new, which causes the premium to in the resale market to be larger.

In the context of this study which uses data up to March 2016, the first explanation is more likely. In light of this, the authors' suggested to introduce new business arrangements or financial products which allow developers to capture more of the benefits associated with green properties. This might be warranted, but still, a 1.28% price premium is not that small; it is unlikely to cause developers to ignore sustainable design.

4.4 Common Trend Assumption

For the DID to produce convincing results, the main assumption required is that GM-rated and non-GM rated properties follow some common trend in price before the GM award. If this is not the case, the DID model might simply be capturing some sort of selection effects associated with the assignment GM award, and not the actual award effects.

The way to test for this is to run a regression on the data before the respective GM-rated properties receive their award, and assign a GM rating period that is before the actual date of award, to test if this fake DID coefficient is statistically significant. If the fake DID coefficient is found to be statistically significant, then the main DID results may simply be capturing some selection effects.

However, because developers are presented a letter of award when the certification process is completed, which will be before the BCA awards night, the intangible award effects would have kicked in before the BCA awards night (i.e. the treatment period).

This means that a placebo DID methodology which shifts the treatment timing before the actual treatment would not work, unless the fake GM rating period is far enough back in time (i.e. at least

1 year before the actual GM rating date[4]). If the fake award date is within 1 year of the real one, the placebo DID coefficient might be statistically significant simply because the award effects have already kicked in by the time of the fake award date.

Table 4.4 shows the results of such a placebo DID check, by shifting the date of award back by 12 and 18 months.

Table 4.4: Placebo Difference-in-difference Tests

	Dependent variable:	
	Natural log of Price psm	
	Award date shifted left by 12 months	Award date shifted left by 18 months
	(1)	(2)
GM Award	−0.003	0.014***
	(0.004)	(0.005)
GM x After GM	0.036***	0.013***
	(0.004)	(0.005)
Hedonic Characteristics	Yes	Yes
4-digit Postal Code Fixed Effects	Yes	Yes
Year-Month Dummies	Yes	Yes
Condo Facilities Dummies	Yes	Yes
Observations	79,517	79,517
R^2	0.931	0.931
Adjusted R^2	0.930	0.930
Residual Std. Error (df = 78862)	0.101	0.101
Note:		*p<0.1; **p<0.05; ***p<0.01
		Models are of the same specification as the main DID model with categorical CONQUAS scores (i.e. column (3) in Table 4.2). The only difference is the definition of the award date.

On face value, these placebo DID model results indicate that GM-rated and non-GM rated properties do not follow a common price trend, implying that non-GM rated properties are not suitable controls for GM-rated properties. This is seen from the positive and statistically significant DID coefficient (GM x After GM).

However, it should be noted that units which only receive their GM award very long after their sale (> 1 year) might be fundamentally different from other GM-rated units, and this might cause the placebo DID coefficients to be significant even when there is no difference in trend between GM-rated and non-GM rated properties.

To investigate if this is the case, I run another regression, this time modelling the logarithm of price per square metre as a function of the number of years between the time of sale and the time of the GM award, including all the controls used in the prior regression models:

[4]The BCA Awards Night is an annual event where developers receive BCA awards, such as the GM award. Since it is held every year, the maximum time lag between a developer receiving a letter of GM award for their property and the date of the BCA Awards Night is 1 year.

$$P_{it} = \beta_0 + \beta_1 YearsBetweenSaleAndGM_{it} + \beta X_i + \beta_2 CONQUAS_i + \lambda loc_i + \gamma_t + \epsilon_{it} \quad (7)$$

Table 4.5: Check if time between sale and GM award affects price

	Dependent variable:
	Natural log of Price psm
Years between Sale and GM Award	-0.189^{***}
	(0.030)
Hedonic Characteristics	Yes
4-digit Postal Code Fixed Effects	Yes
Year-Month Dummies	Yes
Condo Facilities Dummies	Yes
CONQUAS Score	Categorical
Observations	13,707
R^2	0.953
Adjusted R^2	0.952
Residual Std. Error	0.076 (df = 13512)
Note:	*p<0.1; **p<0.05; ***p<0.01

Indeed, the results from Table 4.5 indicate that the longer the time between a unit's sale and its award date, the lower its unit price. This implies that the placebo DID dummies could have been statistically significant simply because they were picking up the difference between "normal" GM-rated units and GM-rated units that sold way before they were awarded with the GM certification.

Unfortunately, there is no way to tell how much of the placebo treatment effect is driven by the differences between GM-rated and non-GM rated properties, or the effect mentioned in the previous paragraph. There is no way to empirically confirm if GM-rated and non-GM rated properties are really comparable, though intuitively, there is not a compelling reason to suggest otherwise.

5 CONCLUSION

The main objective of this study was to investigate the intangible effects of green labelling on residential housing prices. A large percentage of previous studies on green labelling or certifications did not try to separate the economic effects of energy savings from the intangible effects of labelling, bundling these effects together. A few studies attempted to separate these effects using proxies for environmental ideology or data on energy usage to separate these effects; this study uses a DID approach instead.

The empirical results suggest that GM-rated dwellings are higher quality in general, and that the intangible effects of labelling contribute a 1.28% price premium in the private residential market in Singapore.

These results corroborate previous studies' findings that green certification is a good selling point for developers, since they provide a price premium on top of the economic effects of energy savings. This should encourage more property developers to integrate sustainable designs into their projects, thereby helping to reduce the environmental impact from building construction.

One important implication is that green certification can be a viable strategy for governments seeking to promote sustainable development. The findings in this study show that the the housing market values the certification on top of information on energy savings, which is the main assumption behind the use of certification to promote sustainable development.

One of the limitations of this study is that it does not distinguish between the various intangible effects that a certification might have. Firstly, the GM certification could raise awareness about sustainable construction amongst home buyers and hence increase the demand for green properties, resulting in the observed price premium. Secondly, the award provides confidence and verification about developers' claims about the energy efficiency of the development and increase home buyers' willingness to pay for the energy efficient or green features. Thirdly, it could simply signal quality that could be unrelated to green features; home buyers might feel that if a property can receive a certification, then it cannot be too bad. The intangible effects are likely to be a combination of these effects (and some others not stated), but if home buyers do not actually care about the green features as they do about using the certification as an assurance of general quality, the use of certifications to increase sustainable development will be limited since it does not increase the demand for energy efficient features. There is some evidence that the intrinsic meaning of certifications does not matter as much as having a certification (see De Magistris, Del Giudice, & Verneau (2015)), so it could well be possible that the price premium that is found on GM-rated properties is mainly due to the certification providing an assurance of general quality instead of assurance of sustainable development.

Another limitation of this study is that the use of the date of the BCA awards night as the date of GM award makes it challenging to check the common trend assumption required for the DID methodology. This study fails to empirically confirm that GM-rated and non-GM rated properties are indeed comparable (i.e. their prices trend together), though I cannot think of a reason why they would not be.

While the scope of this study is limited (green certification in Singapore housing market), further research could be done to explore if these intangible labelling effects are valid outside of the Singapore housing market, or even if they hold for other types of certifications. Such studies can evaluate the viability of using certifications to encourage or incentivise “good behaviour”.

REFERENCES

Akerlof, G. A. (1970). The Market for “Lemons”: Quality Uncertainty and the Market Mechanism. *The Quarterly Journal of Economics*, *84*(3), 488. https://doi.org/10.2307/1879431

Bartlett, E., & Howard, N. (2000). Informing the decision makers on the cost and value of green building. *Building Research & Information*, *28*(5-6), 315–324. https://doi.org/10.1080/096132100418474

Bond, S. A., & Devine, A. (2016). Certification Matters: Is Green Talk Cheap Talk? *Journal of Real Estate Finance and Economics*, *52*(2), 117–140. https://doi.org/10.1007/s11146-015-9499-y

Brounen, D., & Kok, N. (2011). On the economics of energy labels in the housing market. *Journal of Environmental Economics and Management*, *62*(2), 166–179. https://doi.org/10.1016/j.jeem.2010.11.006

Building and Construction Authority. (2008). Business Case for Green Buildings in Singapore. Retrieved from https://www.bca.gov.sg/GreenMark/others/bizcasefeb08.pdf

Building and Construction Authority. (2015). Enhanced $20 Million Green Mark Incentive Scheme for New Buildings (BCA-GMIS). Retrieved from https://www.bca.gov.sg/GreenMark/gmis.html

Building and Construction Authority. (2017). BCA Green Mark Assessment Criteria. Retrieved from https://www.bca.gov.sg/GreenMark/green_mark_criteria.html

Chegut, A., Eichholtz, P., & Kok, N. (2014). Supply, Demand and the Value of Green Buildings. *Urban Studies*, *51*(1), 22–43. https://doi.org/10.1177/0042098013484526

De Magistris, T., Del Giudice, T., & Verneau, F. (2015). The Effect of Information on Willingness to Pay for Canned Tuna Fish with Different Corporate Social Responsibility (CSR) Certification: A Pilot Study. *Journal of Consumer Affairs*, *49*(2), 457–471. https://doi.org/10.1111/joca.12046

Deng, Y., & Wu, J. (2014). Economic returns to residential green building investment: The developers’ perspective. *Regional Science and Urban Economics*, *47*(1), 35–44. https://doi.org/10.1016/j.regsciurbeco.2013.09.015

Deng, Y., Li, Z., & Quigley, J. M. (2012). Economic returns to energy-efficient investments in the housing market: Evidence from Singapore. *Regional Science and Urban Economics*, *42*(3), 506–515.

https://doi.org/10.1016/j.regsciurbeco.2011.04.004

Department of Statistics Singapore. (2017). Infographic - Singapore Population. Retrieved from http://www.singstat.gov.sg/statistics/visualising-data/infographics/population

Dinan, T. M., & Miranowski, J. A. (1989). Estimating the implicit price of energy efficiency improvements in the residential housing market: A hedonic approach. *Journal of Urban Economics*, *25*(1), 52–67. https://doi.org/10.1016/0094-1190(89)90043-0

Fuerst, F., & Shimizu, C. (2016). Green luxury goods? The economics of eco-labels in the Japanese housing market. *Journal of the Japanese and International Economies*, *39*, 108–122. https://doi.org/10.1016/j.jjie.2016.01.003

Fuerst, F., McAllister, P., Nanda, A., & Wyatt, P. (2016). Energy performance ratings and house prices in Wales: An empirical study. *Energy Policy*, *92*, 20–33. https://doi.org/10.1016/j.enpol.2016.01.024

Fuerst, F., Oikarinen, E., & Harjunen, O. (2016). Green signalling effects in the market for energy-efficient residential buildings. *Applied Energy*, *180*, 560–571. https://doi.org/10.1016/j.apenergy.2016.07.076

Heinzle, S. L., Yip, A. B. Y., & Xing, M. L. Y. (2013). The Influence of Green Building Certification Schemes on Real Estate Investor Behaviour: Evidence from Singapore. *Urban Studies*, *50*(10), 1970–1987. https://doi.org/10.1177/0042098013477693

Housing and Development Board. (2015a). Buying a New Executive Condominium. Retrieved from http://www.hdb.gov.sg/cs/infoweb/residential/buying-a-flat/new/eligibility/executive-condominiums

Housing and Development Board. (2015b). Buying a New Flat. Retrieved from http://www.hdb.gov.sg/cs/infoweb/residential/buying-a-flat/new

Jayantha, W. M., & Man, W. S. (2013). Effect of green labelling on residential property price: a case study in Hong Kong. *Journal of Facilities Management*, *11*(1), 31–51. https://doi.org/10.1108/14725961311301457

Johnson, R. C., & Kaserman, D. L. (1983). Housing Market Capitalization of Energy-Saving Durable Good Investments. *Economic Inquiry*, *21*(3), 374–386. https://doi.org/10.1111/j.1465-7295.1983.

tb00639.x

Kahn, M. E., & Kok, N. (2014). The capitalization of green labels in the California housing market. *Regional Science and Urban Economics*, *47*(1), 25–34. https://doi.org/10.1016/j.regsciurbeco.2013.07.001

Kats, G. H. (2003). Green Building Costs and Financial Benefits. *Massachusetts Technology Collaborative*, 2–5. https://doi.org/10.1089/jop.2006.22.291

Laquatra, J. (1986). Housing market capitalization of thermal integrity. *Energy Economics*, *8*(3), 134–138. https://doi.org/10.1016/0140-9883(86)90011-3

Matisoff, D. C., Noonan, D. S., & Flowers, M. E. (2016). Green Buildings: Economics and Policies. *Review of Environmental Economics and Policy*, *10*(2), rew009. https://doi.org/10.1093/reep/rew009

Michelsen, C., Mense, A., & Kholodilin, K. A. (2015). The market value of energy efficiency in buildings and the mode of tenure. *Urban Studies*, (August 2015). https://doi.org/10.1007/s10273-011-1262-2

Rosen, S. (1974). Hedonic Prices and Implicit Markets : Product Differentiation in Pure Competition. *Journal of Political Economy*, *82*(1), 34–55.

Sing, T. F., Tsai, I. C., & Chen, M. C. (2006). Price dynamics in public and private housing markets in Singapore. *Journal of Housing Economics*, *15*(4), 305–320. https://doi.org/10.1016/j.jhe.2006.09.006

Vierra, S. (2016). Green Building Standards and Certification Systems. Retrieved from https://www.wbdg.org/resources/green-building-standards-and-certification-systems