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Title: Housing Market Segmentation and the Price Effect of Certified Green Residential Properties

Abstract

One important yet overlooked theme in the literature regarding green building certifications (GBC) is the latent differences in pricing behaviors among property buyers in different housing market segments. Specifically, are buyers in the mass housing market willing to pay larger premiums (in terms of the % above average prices) for properties in certified buildings than buyers in the luxury market? This question is particularly crucial for high-rise environments in which properties belonging to different housing sub-markets are within the same building. This, in turn, could have profound implications for the availability of housing flats of varying sizes in certified green residential buildings. This study, therefore, explores this issue by comparing price premiums, if any, for living space in buildings certified with several green building certifications in the two housing sub-markets in Hong Kong. Utilizing a sample of over 220,000 transactions, the main finding is that buyers in the mass housing market were generally willing to pay larger price premiums for properties in certified buildings than buyers in the luxury housing market, unless the certification represented noticeable and actual (not simulated) improvements in the overall environmental performance or energy performance. Implications for different stakeholders are then discussed based on the findings.

Keywords: Green Building Certifications; Residential Flats; Mass Housing Market; Luxury Housing Market

Introduction

Ever since 155 countries around the world signed the United Nations Framework Convention on Climate Change (UNFCCC) during the Rio Earth Summit of 1992, climate change has become a significant challenge that needs to be addressed on a global scale. The goal of UNFCCC, and subsequently the Kyoto Protocol (1997) and the Paris Agreement (2016), is to reduce greenhouse gas (GHG) emissions and limiting temperature growth.

The emphasis on the reduction of GHG emissions has profound impact on the construction industry, due to the immense environmental effect both in the construction of buildings and in their daily operations. According to the International Energy Agency (IEA) (2019), buildings were responsible for 36% of global final energy consumption and nearly 40% of energy and process-related CO2 emissions in 2018. Within the context of Hong Kong, a report compiled by the Environmental Bureau (2017) reveals that over 60% of all GHG emissions in Hong Kong is the result of electricity generation, and that more than 90% of electricity is consumed for the operation of buildings. In this light, "green" buildings, conceptualized to save energy and water, improve indoor air quality, and reduce GHG emissions, have been promoted by the construction industry.

Nevertheless, for prospective property buyers, other than the visible features such as the presence of plants and trees, and the use of natural lighting and ventilation, it is otherwise very difficult to evaluate how energy efficient these "green" buildings really are. Without such crucial information, potential property buyers (and tenants) are not able to value this green factor, and developers are not able to determine the financial feasibility of green building development. As a result, various voluntary green building certifications, which provide more scientific indicators to assess a building's level of "greenness", have been introduced worldwide.

Since then, numerous academic studies have explored whether certified green buildings carry a price/rental premium over non-certified buildings with similar characteristics, both in the office market and in the housing market. Among the previous housing studies, relatively few studies have focused on housing flats in multi-unit, high-rise residential buildings. As to be shown in the literature review section, these studies, however, tend to model the housing market as a whole, by estimating the average price/rental premium incurred by green building certification. Yet, as flats of different sizes are available even within the same residential building, it is reasonable to suggest that the property owners of different housing sub-markets would price the "green" factor of certified buildings differently though their properties are located within the same building or at least the same residential development. This, in turn, could have profound implications for developers' strategies with respect to 1) whether or not to obtain green building certification for their residential developments (and the level of achievement to go for if they do) and 2) the class of housing flats (in terms of floor area) to be available to potential homebuyers should they obtain these certifications.

In view of this knowledge gap, this paper, using Hong Kong's housing market as a case study, aims to explore how homebuyers in different housing sub-markets (as proxied by the size of housing flats) value the "greenness" of living space within certified high-rise residential buildings. Following this introduction section, this paper first provides a discussion of housing literature regarding to the relationship between green building certification and property prices/rents. Then, the research methodology and data is described. It is followed by the presentation of the descriptive statistics and the empirical findings, based on which the implications of findings for different stakeholders are discussed. The final section concludes the study.

Literature Review

Previous research on the price and/or rental effects of green building certifications (GBC) in residential markets, be they single-family housing or apartments/condominiums, has focused on several areas:

1) whether or not GBCs lead to price/rental premiums or not;

2) the relationship between the rating under a GBC and housing price/rent;

3) comparison between the price effects of international GBCs and local/regional GBCs; and

4) a comparison of price/rental effects of GBCs on different housing market segments.

This section presents a review of these relevant studies.

Price/rental effects of Green Building Certifications

In some of the earlier investigations regarding GBCs in residential property markets, the primary focus had been on whether properties certified with one of the voluntary GBCs were sold/leased at higher prices/rents than other similar non-certified properties.

Numerous studies have been conducted for the housing markets in western nations as well as in Asian countries. The majority of them have reported that certified housing properties are normally sold at higher prices than non-certified housing properties. For instance, Kok and Kahn (2012) found that single-family homes which are certified with LEED, Energy Star, and/or the local Green Point Ratings programme, on average, were sold at prices approximately 9% higher than other similar homes. The authors' subsequent study (Kahn and Kok, 2014) revealed positive, but smaller price effects for certified green homes. In the rental sector, Bond and Devine (2016) reported that the rental level of LEED-certified residential properties was about 8.9% higher than non-certified housing properties with similar characteristics. In addition, an investigation by Bruegge et al. (2016) studied the Energy Star Certification and concluded that properties with the Energy Star Certificate are about 1.2-4.9% more costly than non-certified properties. Similar results have also been obtained in other studies in the U.S. (Yang et al., 2013; Freybote et al., 2015), the U.K. (Chegut et al., 2010), Singapore (Addae-Dapaah and Chieh, 2011; Deng et al., 2012; 2014; Fesselmeyer, 2018), Japan (Shimizu, 2010), Hong Kong (Wadu Mesthrige and Man, 2013; Hui et al. 2017), and Mainland China (Zhang et al., 2016).

Nevertheless, there have also been some exceptions. Couch et al. (2015) found that housing prices of LEED-certified houses in New York, Chicago, Seattle, and Portland were not significantly higher than similar non-certified houses. In a study of Japan's housing market, Yoshida and Sugiura (2015) discovered that eco-labelled condominiums were actually cheaper than non-certified ones. Their argument for this unique finding is that the depreciation rates of eco-labelled condominiums, owed to long-life designs and higher durability, are also lower. A similar negative relationship between rents and energy performance was also reported in another study of the Swiss housing market (Feige et al., 2013). According to the authors, this finding could be explained by the bundling of energy costs and rents in the leasing arrangements.

The relationship between a GBC's rating and housing prices and rents

While most of the previous studies listed above concern voluntary GBCs, the situations with regard to green building certifications are different in Europe, as energy efficiency assessment for semi-detached houses is mandatory. Houses in nations within the European Union are required, under the EU Energy Performance of Buildings Directive (EPBD) (Directive 2002/91/EC [Original] and Directive 2010/31/EU [Recast]), to undergo energy efficiency assessment under the Energy Performance Certificate (EPC). As a result, the majority of studies conducted for European housing markets have concentrated on the relationship between a property's EPC rating, instead of certification in studies outside the E.U., and its price or rent. Three main findings have usually been reported in these studies. The first finding is that a higher-rated property under EPC is sold at a higher price than a similar property with a lower rating (see for instance, Brounen and Kok, 2011; Fuerst et al., 2015; Fuerst et al., 2016a; 2016b; Hyland et al., 2013; Leboullenger et al., 2018; Ayala et al., 2016; Aydin et al., 2020). From a broader perspective, a report commissioned by the European Commission (2013) reveals that a unit change in the EPC rating leads to varying levels of price/rental premiums for houses in Greater Vienna, in France, and in Ireland. In addition to EPC, the positive relationship between a GBC's rating and housing prices/rents has also been identified for Australia's Energy Efficiency Ratings (EER) (Fuerst and Warren-Myers, 2018), Singapore's Green Mark Scheme (GM) (Heinzle et al., 2013; Deng and Wu, 2014), and China's Chinese Green Building Label (CGBL) (Zhang, et al. 2016).

Interestingly, several studies, instead, have found some rather peculiar results in this regard. Wahlström (2016) did not identify any price premiums for single-family housing certified with the EPC in Sweden. Instead, substantial price premiums were found for housing attributes which helped improve the houses' energy efficiency. Fesselmeyer's (2018) recent investigation of Singapore's GM revealed that the price premiums for properties with higher ratings under GM were actually lower. A possible reason behind this unique finding, according to the author, is that when a residential development's level of "greenness" is not obvious (i.e. the lack of noticeable green features) to buyers, the role of green building certification in their assessment (and subsequently valuation) of these buildings' energy efficiency becomes more important.

Comparison between international and local/regional GBCs

Several studies, instead, have paid their attentions to the price/rental premiums, if any, among different international and local/regional GBCs. Interestingly, the relatively limited number of studies in this area have yielded similar results, in that local certifications tend to have been valued more favourably by property owners than national/international certifications. For instance, Walls et al. (2017) compared the Energy Star certification and local certifications in the housing markets of North Carolina, Austin, and Portland, and reported that that local certifications had relatively higher price effects than national ones such as Energy Star. Another study by Zheng et al. (2018) found that the prices of homes certified with the regional EarthCraft certificate are slightly higher than similar homes certified with Energy Star.

Comparisons between housing segments

In comparison, a much smaller number of studies have investigated whether there are disparities in price premiums from green certifications on different segments of the housing market, all of which concern housing markets in E.U. nations. Pontus et al. (2014), in their study of the Swedish housing market, discovered a positive relationship between housing prices and the level of energy consumption listed in their respective energy performance certificate. Yet, when the sample was segmented, it was found that the price premium was larger for cheaper housing. Similar conclusions have also been reached in an investigation of the Irish housing market by Hyland et al. (2013) and Marmolejo-Duarte and Chen (2019).

On the other hand, inconsistent results have been obtained when it comes to the comparison of price premiums for single-family housing and apartments (or townhouses). While Fuerst et al. (2015) identified a larger price impact of EPC on townhouses than single-family dwellings in England, Salvi et al. (2008) reported the opposite in their study of the Swiss housing market.

As revealed in this section, the majority of previous studies on the residential sector have concentrated on either single-family houses or apartments/townhouses. By contrast, much fewer studies have focused on the price or rental impact of multiple green building certifications, with different scopes of assessment, within the context of multi-unit, high-rise residential buildings. Worse, as flats of different sizes are available even within the same residential building, it is reasonable to suggest that the property owners of different housing segments would price even the same "green" factor differently even though the respective properties share the same building and neighborhood attributes. This, in turn, could have profound implications for developers' strategies as to 1) whether to obtain green building certification or not (and the level of achievement if they do) and 2) the size of certified green housing flats to be available to potential homebuyers. This study intends to fill this knowledge gap by exploring the price effects of several green building certifications with varying assessment scopes (i.e. overall environmental performance vs. specific aspect of environmental/energy performance) on the mass housing market (categorized as Classes A, B, and C by the Rating and Valuation Department) and the luxury housing market (categorized as Classes D & E by the Rating and Valuation Department) of Hong Kong.

After presenting the relevant literature (a more detailed summary of the studies stated above is provided in Table 1), the next sector describes the methodology used in this study as well as the data necessary for the analysis.

Author(s)	Country	Green Building Certification(s) Studied	Data Source(s)	Sample Size	Findings
Chegut et al. (2010)	U.K.	EcoHomes	Real Capital Analytics (RCA) database and CoStar FOCUS database	4,417 (sales) 26,118 (rental)	Price Premium: 8% Rental Premium: 16-20%
Shimizu (2010)	Japan	"Green" Labels	MRC database and transaction price database owned by Recruit Co., Ltd	82,270	Price Premium: 5%
Addae-Dapaah and Chieh (2011)	Singapore	Green Mark Scheme	Real estate information system (REALIS)	13,899	Price Premium: 9.61-27.74% (sales data); 5.47-6.82% (survey data)
Brounen and Kok (2011)	The Netherlands	EPC	The Dutch Association of Realtors (NVM)	177,318	Price Premium: 3.7% A-grade property 10.2% more expensive than a D-grade property
Deng et al. (2012)	Singapore	Green Mark Scheme	Real Estate Information System (REALIS)	74,278	Price Premium: 4%
Kok and Kahn (2012)	U.S.	LEED/ES/Green Point Ratings Programme	DataQuick	1,609,879	Price Premium: 9%
European Commission (2013)	Austria, Belgium, France, and Ireland	EPC	Daft.ie, Konstantin Kholodilin (DIW), Notaires de France, the Department of Communities and Local Government,	2,323 (Austria) 26,000 (Belgium) 3,400 (France) 48,000 (Ireland)	Price Premium: 8% (Greater Vienna), 4% (France), 2.8% (Ireland) Rental Premium: 4% (Greater Vienna), 1.4% (Ireland)

			Landmark and Land Registry		
Hyland et al. (2013)	Ireland	EPC	Daft.ie	15,060 (sales) 20,825 (rental)	A-rated properties 9% (2%) costlier in price (rent) than D-rated properties
Heinzle et al. (2013)	Singapore	Green Mark Scheme	Survey Interview	62	Price: Platinum (7.98%), Certified (3.78%)
Wadu Mesthrige and Man (2013)	Hong Kong	HK-BEAM/ HK-GBC Award	Economic Property Research Centre (EPRC)	4,206	Price Premium: 3.4-6.4%
Feige et al. (2013)	Switzerland	Individual sustainability attributes	Five different portfolio owners in Switzerland	2,453	Positive (negative) relationship between environmental (energy) performance and rental levels
Deng and Wu (2014)	Singapore	Green Mark Scheme	Real Estate Information System (REALIS)	35,730	Price Premium: Platinum (11%), Gold (5%), Certified (1.6%).
Kahn and Kok (2014)	U.S.	LEED/ES/Green Point Ratings Programme	DataQuick	1,609,879	Price Premium: 2.1-3.9%
Couch et al. (2015)	U.S.	LEED	CoStar	136	No significant (positive) relationship between LEED certification and housing prices
Fuerst et al. (2015)	U.K.	EPC	Calnea Analytic	325,950	Price Premium: 5% (A/B), 1.8% (C), -0.7% (E), -0.9% (F), -6% (G)
Yoshida and Sugiura (2015)	Japan	“Green” Labels	Transaction Price Information Service (TPIS)	41,560	Properties with green labels sold at discount.
Freybote et al. (2015)	U.S.	LEED	Regional Land Information System (RLIS)	1,320	Price Premium: 8.1% (compared to non-certified); 4.3% (compared to certified LEED Neighborhood);

		(Building & Neighborhood Certifications)			Condos within LEED neighborhood do not have higher prices
Bond and Devine (2016)	U.S.	LEED	NCREIF	1,589	Rental Premium: 8.9%
Bruegge et al. (2016)	U.S.	ES	Alachua County Property Appraiser's Office	5,528	Price Premium: 1.2-4.9%
Fuerst et al. (2016a)	Wales	EPC	The Land Registry house price index for Wales	62,464	Price Premium: 12.8% (A/B), 3.5% (C), -3.6% (E), -6.5% (F).
Fuerst et al. (2016b)	Finland	EPC	Kiinteistömaailma	6,203	Price Premium: 3.3% (Top three categories); 1.5% with other neighborhood attributes included as controls.
Chegut et al. (2016)	The Netherlands	EPC	Autoriteit Woningcorporaties	17,835	Price Premium: 2.1-2.6% (A/B); 5.8-6.5% (A); 1.1-2% (B)
Zheng et al. (2016)	China	CGBL	MOHURD and Soufun	748 housing projects	Price Premium: 6.9% (Average); 8.7% (2-star); 5.8% (1-star)
Wahlström (2016)	Sweden	EPC	Swedish National Board of Housing, Building and Planning & Swedish Central Bureau of Statistics	77,000	No price premium for EPC, but substantial price premiums for housing attributes which help improve the houses' energy efficiency
Hui et al. (2017)	Hong Kong	BEAM Plus	EPRC	626	Price Premium: 4.4% (Certified); -5.9% (Unclassified); 6.2% (Certified if omitting Unclassified)

Kholodilin et al. (2017)	Berlin, Germany	Energy Performance Score (EPS)	immobilienscout24.de/immonet.de/ immowelt.de.	29,680	WTP for energy efficiency in owner-occupied dwellings is almost 2.5 times larger than in rented out dwellings.
Walls et al. (2017)	U.S.	ES/Local Certificates	Real Estate Multiple Listing Services (MLS)	176,469	Price Premium: 2% in Portland/NC (ES); Not significant in Austin; 7-8% in Austin (AEGB); 3% in Portland (Earth Advantage)
Fuerst and Warren-Myers (2018)	Australia	Energy Efficiency Ratings	Allhomes	31,061 (sales) 59,336 (rental)	Price Premium: 9.4% (EER 7 with EER 3 as reference); 2-2.4% (EER 5-6); Between -3.1% and -1.8% (EER 0-2) Rental Premium: 2.6%-3.6% (EER 5 or above; non-linear); Between -2.8% and -2.4% (EER 0/1)
Portnov et al. (2018)	Israel	Green Building in general	Nationwide Survey	438	WTP: 7-10%
Fesselmeyer (2018)	Singapore	Green Mark Scheme	Real Estate Information System (REALIS) database of the Singapore Land Authority	119,826	Price Premium: 4.1% (Certified); 2.6% (Gold); Lower or insignificant for higher ranks
Zheng et al. (2018)	U.S. (Single-family Homes)	EarthCraftor/ES	Family Multiple Listing Services (FMLS)	1,679	Price Premium: 12.2% [non-standardized]/7.1% [standardized] (EarthCraftor); 8.5%/6.7% (EnergyStar); 11.7% (Average)
Leboullenger et al. (2018)	France	EPC	Notarial database	1,587 (Collective dwellings)	Price Premium: 1-3% (Individual Houses); 1.2% (Collective Dwellings)

				1,185 (Individual Houses)	
Aydin et al. (2020)	The Netherlands	EPC	The National Association of Realtors (NVM)	127,021	Price Premium: 2.2% for every 10% improvement in energy efficiency

Table 1: A summary of findings from previous studies
Note: ES (Energy Star); EPC (Energy Performance Certificate)

Methodology and Data

As for the research methodology, a modified hedonic pricing model will be used for analysis. A hedonic pricing model is a linear regression model grounded on the hedonic pricing theory (Rosen, 1974), according to which there exists an implicit price for each utility-bearing attribute within a good, even though these attributes are inseparable and cannot be traded individually. Within the context of real estate, the price of a property, thus, equals the sum of the implicit prices of these inseparable attributes. With the use of linear regression modeling, hedonic equations are able to deconstruct property price/rent into measurable implicit prices for individual attributes. The hedonic technique, described in detail in Braden and Kolstad (1991), has been extensively used in previous studies on the impact of green building certifications on property prices and/or rents (see the literature review section).

However, the original hedonic pricing model, essentially an Ordinary Least Squares (OLS) regression model, is susceptible to issues such as heteroscedasticity and autocorrelations as well as has stringent assumptions with regard to the (normal) distributions of disturbances. In studies utilizing property transaction data, heteroscedasticity occurs when the disturbances have different variances, resulting in varying explanatory power (and the scale of the dependent variable) across observations (for the issue of heteroscedasticity in housing studies, see Sun et al. 2005). This applies to this study, as a preliminary Breusch-Pagan/Cook-Weisberg test rejects the hypothesis that the variance is constant (chi-square = 19,311.67; p-value: 0.0000). Whereas, autocorrelation, usually appearing in time-series models, arises as the value of a variable in the present is correlated with that in the past. Even though this study deploys housing transaction data within a 7-year period (April 2011-September 2017), autocorrelation is not as prominent of an issue as is heteroscedasticity, which renders the estimator inefficient though unbiased, consistent, and asymptotically normally distributed.

Therefore, in order to tackle the issue of heteroscedasticity, two separate measures are deployed. First, rather than computing the disturbances under the assumptions of the OLS, the hedonic pricing model in this study is modified, in that the potential bias in the disturbances due to heteroscedasticity are corrected. And second, given that residential buildings which have been certified with at least one of the GBCs to be studied in this paper are not evenly distributed geographically (See Table 2), a weighted regression specification is introduced along with the aforementioned correction for the heteroscedasticity bias, in that a frequency weight, based upon a property's location proxied by the Education Bureau's School Net under the Primary One Admission (POA) System (for more details about the POA, see the following section), is added to further tackle the heteroscedasticity issue.

School Net	BEAM Plus	HK-BEAM 4/04 & 5/04	Energywi$e	Wastewi$e	Carbon Reduction Certificate
Hong Kong Island					
11	1134	272	554	788	32
12	230	403	411	147	164
14	0	0	55	108	671
16	489	0	46	147	0
18	0	0	2423	365	809
Kowloon					
31	1272	1125	531	18	209
32	421	1088	426	341	239
34	568	0	62	594	166
35	91	102	473	0	1785
40	333	363	595	709	822
41	0	131	0	13	0
43	0	0	0	0	435
45	0	0	272	11	272
46	0	0	0	72	0
48	0	0	0	334	0
The New Territories					
62	0	373	788	761	970
64	0	0	0	0	281
65	0	0	0	0	287
66	0	0	900	0	900
70	0	0	792	1745	0
71	0	485	642	681	788
72	141	0	17	2088	78
73	1796	0	0	267	33
74	402	3756	1354	9	538
80	0	0	0	454	739
81	0	0	1041	0	1041
84	0	868	55	980	170
88	0	1084	0	16	309

89	0	1034	230	230	715
91	921	0	692	425	505
95	4713	0	1383	643	4685
97	0	0	0	0	0
98	0	0	0	0	0
99	0	0	0	0	0

Table 2: GBC-Certified housing properties by location (proxied by the school nets under the Education Bureau's Primary One Admission [POA] system)
Note: Information regarding the areas covered in each School Net under POA can be accessed at https://www.edb.gov.hk/en/edu-system/primary-secondary/spa-systems/primary-1-admission/school-lists/index.html

Description of selected variables

The dependent variable in the models is the transaction price for a housing unit. It should be noted that, the models follow a semi-log specification, in that the transaction price in natural log form (LnP) is deployed. The reason behind such a specification is twofold. First, the interpretation of the results is more straightforward, as the premium generated from the selected attributes becomes a percentage. And second, the use of LnP takes the possible non-linear relationships between the dependent variables and the explanatory variables into consideration and minimizes the potential problem as a result of heteroskedasticity (Sirmans et al., 2005).

The explanatory variables, on the other hand, fall into three categories: core variables, control variables, and interaction effect variables.

The Core Variables (GBC)

The core variables are the green building attributes proxied by different green building certifications (GBC). The price impacts of each certifiable rating for the selected GBCs (i.e. 1) Platinum, Gold, Silver, and Bronze [applicable to HK-BEAM 4/04 & 5/04 and BEAM Plus]; 2) Basic Level, Good Level, and Excellence Level [applicable to the HKGOC's Wastewi$e and Energywi$e Certificates]) are evaluated separately. Accordingly, four groups of dummy variables, plus a single dummy variable for the HKGOC's Carbon Reduction Certificate (CARBON) which does not have a rating system, are incorporated in the model, as follows:

1) HK-BEAM 4/04 & 5/04: BEAMPLAT (Platinum), BEAMG (Gold), BEAMS (Silver), BEAMB (Bronze)

2) BEAM Plus: BEAMPPLAT (Platinum), BEAMPG (Gold), BEAMPS (Silver), BEAMPB (Bronze)

3) Wastewi$e Certificate (WW): WWBASIC, WWGOOD, WWEXCEL (Excellence)

4) Energywi$e Certificate (EW): EWBASIC, EWGOOD, EWEXCEL (Excellence)

5) Carbon Reduction Certificate: CARBON

Grounded on the findings in previous studies, the following hypotheses are to be tested in this study:

H1: Certification under a GBC generates a positive impact on property price

H2: GBCs that assess residential buildings' overall environmental performance (i.e. HK-BEAM 4/04 & 5/04 and BEAM Plus) yield larger price premiums than GBCs that assess a specific aspect of buildings' environmental performance (i.e. the HKGOCs such as Wastewi$e, Energywi$e, and Carbon Reduction Certificates)

H3: A higher rating under a GBC results in a larger price premium for a housing flat

In addition to these GBC variables, one particular feature which distinguishes BEAM Plus from HK-BEAM 4/04 & 5/04 and the three HKGOCs is a non-certifiable "Unclassified" rating for assessed buildings. This rating refers to buildings which have met all the pre-requisites (i.e. legal requirements) but have not achieved a level of performance that warrants at least a bronze rating. Therefore, in order to take this factor (and its potential price impact) into account, another BEAM Plus-related dummy variable, BEAMPUNC, is incorporated into the pricing model as well.

The Control Variables

The control variables include property attributes (PROPERTY), locational attributes (LOCATION), neighborhood attributes (NEIGHBORHOOD), and transaction time fixed effects (TIME). As for the property attributes (PROPERTY), the first variable is the size of the transacted housing flat (in square feet) in natural log form (LnAREA). Another property attribute concerns the age of the residential building (AGE) when the housing unit was transacted. The third property attribute is the housing unit's floor level (FLR), proxied by several categorical dummy variables (i.e. 10^{th}-19^{th} floor, 20^{th}-29^{th} floor, 30^{th}-39^{th} floor, 40^{th}-49^{th} floor, 50^{th}-59^{th} floor, 60^{th}-69^{th} floor, 70^{th} floor or above) are used. Lastly, a housing class dummy variable (LUXURY), which separates the sampled flats in the luxury housing market ("1") from flats in the mass housing market ("0"), will be included in the equations to control for the price differences, if any, as a result of luxury fit-outs.

In addition to these housing flat-exclusive variables, four other building-related variables will be added into the models. The first variable (POPULAR) separates flats situated within one of the "selected popular residential developments" ("1"), according to the Rating & Valuation Department, from those in other residential developments ("0"). The second variable (ESTATE) distinguishes flats within housing developments which provide 1,000 flats or more ("1") from others that provide less than 1,000 units ("0"). Then, as a sizeable number of housing units in the sample are pre-sale flats, a dummy variable, PRESALE, is incorporated into the models to control its latent effects on transaction price. Fourth, the model also explores whether the availability of clubhouse facilities (CLUBHOUSE) for the owner of a particular property generates a price effect for it. Lastly, since April 2013, the introduction of *Residential Properties (First-hand Sales) Ordinance* (Cap. 621) has required developers (or vendors) to "quote property size and property price per square foot/per square meter in the sales brochures, price lists and advertisements of first-hand residential properties," using saleable area only, as opposed to gross floor area. Therefore, to control for the price impact due to such a regulation change, the dummy variable SALEABLE is introduced separating flats subject to this new rule ("1") from those that are not ("0").

In addition, for the locational attributes (LOCATION), four variables are introduced. The first two variables are included to control for the locational differences in the prices of housing space in Hong Kong. They refer to the distance (DIS) between the building in which a housing unit is located and Hong Kong's CBD (represented by the HSBC Headquarters in Central), computed using their respective GPS coordinates, with a non-linear relationship between DIS and LnP assumed. In addition, another set of locational dummy variables provide further controls with reference to the location (other from its distance to the CBD) of the sampled properties. In this case, we use the School Net (SCHOOL) the residential flat in question belongs in under the Education Bureau's Primary One Admission (POA) system as a proxy. In Hong Kong, there are a total of 36 POA School Nets, of which 5 are on Hong Kong Island, 10 in Kowloon, and the remaining 21 in the New Territories[1]. Considering the critical impact of an applicant's residential location on his/her eventual school allocation during the "Central Allocation" stage of the POA, parents in Hong Kong are well-known for moving to areas within School Nets in which famous primary schools are located. Therefore, the location of a housing unit, with reference to the School Net in which it belongs, could have major housing price implications (see for instance, Wen et al., 2018). Therefore, dummy variables relating to school districts are included in their respective models to control for their fixed effects on transaction prices, if any. Besides DIS and SCHOOL, a NEWTOWNS dummy variable is introduced to the model to separate properties located within the new town areas of the New Territories from properties situated outside these new towns. Lastly, the median household income (in natural log form, LnHHINCOME) of the district council a property is located by the time when it was transacted is incorporated in the model as a control variable as well, taking into account the noticeable disparities in this regard among the 18 district councils in Hong Kong.

Then, for the neighbourhood attributes (NEITHBOURHOOD), a housing unit's proximity, determined by 5-minute walking distance or less, to 1) one of the MTR stations (MTR) and 2) one of the top 10 super-regional shopping malls (MALL) in Hong Kong, as determined by the International Council of Shopping Centres (Table 3) will be included in the models (see for instance, Ooi et al., 2007).

Last but not least, fixed effects relating to the transaction date of a housing unit (by month of the year) (TIME) are incorporated in the models to further control for the variances caused by housing market conditions at a particular time period.

The Interaction Effect Variables (GBCINTERACT)

In addition to the aforementioned fixed effects (core and control) variables, several interaction effect variables involving the core green building certification variables are also to be included with reference to the main research question, that is, whether there are significant differences in the price premiums of GBCs in different housing sub-

[1] https://www.edb.gov.hk/en/edu-system/primary-secondary/spa-systems/primary-1-admission/school-lists/index.html

markets. Hence, several interaction terms between luxury market properties and certified housing properties (for instance, BEAMPG_LUXURY) for each of the five GBCs are specifically included in the models to test the fourth hypothesis of this study:
H4: Buyers in the mass housing market are willing to pay a larger premium (in %) than buyers in the luxury housing market

Besides the GBC-luxury market interaction effect variables, other interactions terms between green building certification and i) age of building where the property is located when it was transacted (for instance, BEAMPG_AGE) and ii) the distance between the property and the CBD (for instance, BEAMPG_DIS) (see Hui and Liang, 2016) are also included in the pricing model.
Lastly, since BEAM Plus has two types of assessment, namely the "Provisional Assessment" (i.e. the *estimated* environmental performance of a building through computer simulations) and the "Final Assessment" (i.e. the *actual* measurement of a building's environmental performance), some of the buildings that have obtained a rating under this scheme have not been completed (or have yet to commence their construction phase). Also, due to developers' financial considerations, many flats were sold to the public during the presale phase. In view of these factors, two additional groups of interaction terms will be incorporated into the models to gauge the price effects of BEAM Plus under these two conditions:

- Interaction terms between BEAM Plus certification and presale flats (i.e. BEAMPX_PRESALE, where "X" denotes the rating an assessed building obtains);
- Interaction terms between BEAM Plus certification and final assessment (i.e. BEAMPX_FINAL)

In summary, the prices of housing space in Hong Kong can be seen as a function of these six groups of attributes:

$$LnP = c + \sum_{i=1}^{n} GBC_i + \sum_{i=1}^{n} GBCINTERACT_i + \sum_{i=1}^{n} PROPERTY_i + \sum_{i=1}^{n} LOCATION_i + \sum_{i=1}^{n} NEIGHBOURHOOD_i + \sum_{i=1}^{n} TIME_i + \varepsilon$$

Descriptions of all the variables stated above are provided in Table 3.

Name of Super Regional Mall	**Location**	**Area (in m²)**
New Town Plaza (Phase 1)	Shatin (New Territories)	185,806
Harbour City	Tsim Sha Tsui (Kowloon)	177,724
Wonderful Worlds of Whampoa	Hung Hom (Kowloon)	130,001
Cityplaza	Taikoo Shing (Hong Kong Island)	103,122
Megabox	Kowloon Bay (Kowloon)	103,122
Elements	Tsim Sha Tsui (Kowloon)	92,903
Tuen Mun Town Plaza	Tuen Mun (The New Territories)	92,903
Metro City Plaza (Phase 2)	Tseung Kwan O (The New Territories)	88,894
EMax	Kowloon Bay (Kowloon)	83,613
IFC Mall	Central (Hong Kong Island)	74,323

Table 3: Hong Kong's Top 10 Super Regional Malls
(Source: International Council of Shopping Centers)

Data

Housing transactions in Hong Kong from April 2011 (i.e. the date the Building Department's GFA concession policy [i.e. PNAP APP-151] came into effect) to September 2017 are required for the analysis (for information regarding PNAP APP-151, see Appendix 1). After excluding outliers as a result of transactions with abnormally low transaction prices (i.e. those with a per square feet price of HKD3,000 or less), because of either 1) transactions between family members or 2) transferal of ownership among co-owners, a total of 225,758 residential flats are included in the sample, of which 42,939 flats are located on Hong Kong Island, 52,650 flats in Kowloon, and the remaining 130,169 flats in the New Territories. However, Hong Kong does not have a comprehensive database for property transactions, similar to the CoStar database in the U.S., in which transactional information, along with information about the property (including its quality) and its GBC assessment result, is included. As a result, several sets of data are required:

- Residential flat transaction records
- Status of BEAM-registered residential buildings in Hong Kong
- Status of residential buildings in Hong Kong certified with HKGOC
- Other building-related information of the sampled buildings such as location, the year it which its Occupation Permit (OP) was issued, school net, and proximity to public transportation such as MTR stations and/or shopping malls

These data sets are gathered from a variety of sources. First, housing transaction data is based upon Land Registry records available at 28Hse.com. As for the information relating to green certifications, records of BEAM-registered buildings are compiled from the BEAM Society and the Hong Kong Green Building Council (HKGBC), whereas those of HKGOC-certified buildings are collected from the Hong Kong Awards for Environmental Excellence (HKAEE) webpage. Other building-related information is collected from well-known companies specialized in the sale/leasing of residential properties, such as Centaline and Midland Realty.

Research Findings

Descriptive Statistics

The descriptive statistics for the sampled properties in the mass and luxury housing markets of Hong Kong are listed on Tables 4-7.

Among the sampled housing flats (Table 4), the mean transaction price for those belonging in the mass housing market is HKD 5,500,000, which is less than one-fifth of that for luxury housing flats even though the average size of mass market housing properties in the sample is approximately 37% of the mean floor area of luxury housing flats. Viewing these two factors as a whole, the mean per sq. ft. transaction price of sampled flats in the mass housing market is slightly more than half of that of sampled luxury housing properties. The findings also show that, the sampled flats in the mass housing market are, on average, 6 years older than the sampled flats in the luxury housing market. Interestingly, the sampled residential properties in the luxury market (7.33km), on average, are closer to the CBD than the mass market housing properties included in the sample. The distribution of housing properties in terms of floor levels are very similar, in that the vast majority of them are located below the 30th floor (Table 5).

In terms of other housing attributes (Table 6), it is found that more than 35% of sampled flats in the mass housing market are within "popular" housing developments as defined by the Rating & Valuation Department, compared to 27% among luxury flats. While around 7% of the sampled flats in the two markets were sold prior to the completion of the construction phase, a much larger (over 40%) proportion of flats have access to clubhouse facilities especially luxury housing properties. Over 50% of mass market housing flats are within large housing estates (i.e. developments with over 1,000 housing units), compared to 32% amongst the sampled luxury properties. On the other hand, while approximately half of the sampled flats in the mass housing market are within walking distance to an MTR station, less than one-third of sampled luxury housing flats share the same attribute. By contrast, the percentage of sampled flats in the luxury housing market (over 10%) that are located in close proximity to a supermall are higher than that within the mass housing market.

As for the green building certification status of the sampled flats (Table 7), while the proportions of mass housing flats certified with BEAM Plus, Wastewi$e Certificate, and Carbon Reduction Certificate are slightly higher than luxury housing flats, substantially higher percentages of flats certified with either BEAM 4/04 & 5/04 or Energywi$e Certificate (over 10%) are found in the luxury market

	Mass Market	**Luxury Market**
Price	5.5 mil	28.3 mil
Area	672.08	1776.19
Per Square Feet Price	8084.76	15273.44
Age	17.64	11.44
Distance to CBD	11.91	7.33

Table 4: Descriptive Statistics of Sampled Properties (Numerical Variables)

	Mass Market	Luxury Market
0-9	29.9	30.6
10-19	31.2	32.5
20-29	21.6	21.4
30-39	10.0	9.1
40-49	4.2	3.9
50-59	2.0	1.7
60-69	0.8	0.7
70 or higher	0.2	0.2

Table 5: Floor Level of Sampled Properties (in %)

	Mass Market	Luxury Market
"Popular" housing development	36.1	26.5
Presale flats	6.7	6.9
Availability of clubhouse	42.3	51.9
Within housing estate	57.9	31.8
Access to MTR station	49.8	31.8
Proximity to supermall	8.0	11.7

Table 6: Descriptive Statistics of Sampled Properties (Dummy Variables) (in %)

		Mass Market	Luxury Market
BEAM Plus	Certified	5.6	5.3
	Platinum	<0.1	0.9
	Gold	3.6	3.2
	Silver	1.1	0.9
	Bronze	0.8	0.3
	Unclassified	0.7	1.0
HK-BEAM 4/04 & 5/04	Certified	4.3	16.6
	Platinum	0.7	<0.1
	Gold	0.0	1.2
	Silver	2.8	11.3
	Bronze	0.8	4.0
Wastewi$e Certificate	Certified	5.3	4.9
	Basic	0.0	0.0
	Good	1.4	1.0
	Excellence	3.9	3.9
Energywi$e Certificate	Certified	5.8	11.7
	Basic	1.9	3.6
	Good	1.2	1.0
	Excellence	2.7	7.0
Carbon Reduction Certificate		7.9	6.6

Table 7: Green Building Certification Status of Sampled Properties (in %)

Heteroskedastic Weighted Hedonic Pricing Model Findings

Prior to the presentation of the results, it is worth noting that, as the green building certifications included in this study are by no means mutually exclusive, there may be concerns that some of the sampled properties are located in buildings which had obtained more than one GBCs. This could lead to multicollinearity issues that result in biased estimators. Therefore, a multicollinearity test is conducted, using only the core (GBC) variables as introduced in the methodology section. The results, as reported in Table 8, show that the Variance Inflation Factors (VIF) of these variables range from 1 to 1.33. This indicates that there is either no or low degrees of correlations between these GBC variables. Thus, all the green building certification variables are incorporated in the final model.

Variable	Variance Inflation Factor (VIF)
BEAMPB	1.00
BEAMPS	1.00
BEAMPG	1.01
BEAMPPLAT	1.00
BEAMPUNC	1.00
BEAMB	1.30
BEAMS	1.01
BEAMG	1.00
BEAMPLAT	1.01
WWGOOD	1.00
WWEXCEL	1.02
EWBASIC	1.02
EWGOOD	1.33
EWEXCEL	1.09
CARBON	1.14

Table 8: Multicollinearity test results using only the GBC variables

The findings of the final model (Table 9; for the other control variables, see Appendix 2) reveal that, of the GBCs under study, the older HK-BEAM 4/04 & 5/04 (BEAM) yielded the largest price effect on the sampled housing units. The price premium for properties certified with this GBC ranged from 32-40%. The newer BEAM Plus (BEAMP), surprisingly, carried lower price premiums for properties certified under this scheme than HK-BEAM 4/04 & 5/04. The price effect of certification under BEAM Plus ranged between 5.5-26.9%, with those in buildings with a Platinum rating being the largest. Then, the negative coefficients for the BEAM Plus-Presale interaction variables (BEAMPX_PRESALE) suggest that developers had the tendency to set lower prices for the sale of housing properties that had been assessed under BEAM Plus. This is particularly the case for properties in buildings with a bronze rating. Further, the BEAM Plus Final Assessment interaction variables (BEAMP_FINAL) report significant negative coefficients for properties in bronze- and gold-rated buildings. This indicates that undergoing the final assessment (and obtaining a final rating) under the BEAM Plus certification, if anything, dissipated a portion of the price premiums obtainable after the granting of the provisional certification.

As of the three HKGOCs included in this study, the certification that yielded the largest price premium is Energywi$e Certificate (EW). This is followed by Wastewi$e certificate at 6.3% (Excellence Level Certificate; WWEXCEL). By contrast, properties in residential buildings that obtained a Carbon Reduction Certificate (CARBON) under the HKGOC were sold at a discount of 4.3% in comparison to other non-certified properties in the sample, even though actual price premiums were obtainable for older properties that were further away from the CBD based on the positive price effects found for the respective interaction terms. Based upon the findings, it can be said that **H1** is generally supported as shown by the positive and significant coefficients of the non-interaction terms among the BEAMP, BEAM, WW, and EW variables (with the only exception of Carbon Reduction Certificate [CARBON] under certain conditions), and **H2** is partially supported as the Wastewi$e (WW) and Carbon Reduction (CARBON) Certificates yielded lower price premiums than the two BEAM certifications, whereas the Energywi$e (EW) certificate incurred price premiums on par with the two BEAM Certifications.

Nevertheless, it is also found that, unlike what has been reported in other GBC studies on the residential sector (see Brounen and Kok, 2011; Hyland et al., 2013; Heinzle et al., 2013; Fuerst et al., 2015; 2016; Chegut et al., 2016; Zheng et al., 2016; Fuerst and Warren-Myers, 2018), properties in buildings with a higher rating under a particular GBC do not necessarily mean that these properties were sold at higher price premiums (or less price discounts). This, in accordance with Fesselmeyer (2018), is the result of property buyers willing to pay more for visible green features surrounding/on residential buildings, despite their supposedly lower environmental performance/rating(s). With reference to the hypotheses, **H3** is not supported by the findings.

As to the effects of the three groups of interaction terms, first, in response to the research question of whether price premium disparities for certified properties exist between flats in different housing segments, the findings, first, reveal that the price premiums for certified properties under the majority of GBCs under study were larger in the mass housing market than in the luxury housing market, as reflected by the significant negative coefficients of the luxury market-related interaction variables. This is generally in line with the findings in Hyland et al. (2013) and Pontus et al. (2014). The only exceptions are properties in buildings with either a Platinum rating under HK-BEAM 4/04 & 5/04 (BEAMPLAT) or a Good Level Certificate under the Energywi$e Certificate (EWGOOD). For BEAM 4/04 & 5/04, since the rating(s) for certified buildings were all finalized, rather than provisional among the vast majority of residential developments assessed under BEAM Plus, the better environmental performance was more evident owed to the actual measurement of it during the final assessment stage. This actual, rather than simulated as in the Provisional Assessment under BEAM Plus, improvement in environmental performance, thus, was valued accordingly by buyers in the luxury housing market. As for the Energywi$e Certificate under HKGOC, the higher price premium in the luxury housing market can be attributed to the nature of the certificate itself, as it measures, rather than simulates, the improvement in a building's energy performance, albeit in terms of achievable goals instead of the (estimated) percentage of energy savings under the two BEAM certifications. Similar to HK-BEAM 4/04 & 5/04, the achievement of the goals necessary for this certification was valued more by buyers in the luxury housing market. To sum up, **H4** is partially supported by the negative and significant coefficients of the interaction variables relating to luxury market among certifications such as BEAM Plus, Wastewi$e Certificate, and Carbon Reduction Certificate.

In addition, it is also found that a property's age and its distance to CBD have differing impacts on the price premiums, if any, of the various GBCs under study. For instance, the price premiums became higher for Wastewi$e Certificate (WW) and the Energywi$e Certificate (EW) when a property became older. By contrast, the price premiums for properties certified with either BEAM Plus (BEAMP), HK-BEAM 4/04 & 5/04 (BEAM), Carbon Reduction Certificate (CARBON), or an Excellence Level Energywi$e Certificate gradually dissipated as the property gets older. The disparities in the different levels of the Energywi$e Certificate can be explained by the additional cost incurred for property owners for older residential buildings to meet the extra goals (in comparison to a Good Level certificate [EWGOOD]) necessary for the Excellence Level Energywi$e Certificate (EWEXCEL), which may be accounted for through lower transaction prices for properties within these buildings. On the other hand, the price effects for properties located away from the CBD were higher when they were certified with BEAM Plus (Bronze [BEAMPB] or Platinum [BEAMPPLAT] rating) or Carbon Reduction Certificate, whereas the price premiums for BEAM Plus (Gold rating [BEAMPG]), HK-BEAM 4/04 & 5/04 (BEAM), Wastewi$e Certificate (WW), and Energywi$e Certificate (Basic [EWBASIC] and Excellence [EWEXCEL] Levels) reduced as the distance between a property and the CBD became larger.

Variable	**Description**	**Coefficient**
Constant	Constant Term	8.229**
Core Variables (GBC)		
BEAM Plus (BEAMP)		
BEAMPB	Bronze rating under BEAM Plus	0.055*
BEAMPS	Silver rating under BEAM Plus	0.148**
BEAMPG	Gold rating under BEAM Plus	0.136**
BEAMPPLAT	Platinum rating under BEAM Plus	0.270**
BEAMPUNC	Unclassified rating under BEAM Plus	0.191**
BEAM 4/04 & 5/04 (BEAM)		
BEAMB	Bronze rating under BEAM 4/04 & 5/04	0.328**
BEAMS	Silver rating under BEAM 4/04 & 5/04	0.400**
BEAMG	Gold rating under BEAM 4/04 & 5/04	0.389**
BEAMPLAT	Platinum rating under BEAM 4/04 & 5/04	0.335**
Wastewi$e Certificate (WW)		
WWGOOD	Wastewi$e certificate with a "Good" rating	-0.019
WWEXCEL	Wastewi$e certificate with an "Excellence" rating	0.063**
Energywi$e Certificate (EW)		
EWBASIC	Energywi$e certificate with a "Basic" rating	0.189**
EWGOOD	Energywi$e certificate with a "Good" rating	0.027**
EWEXCEL	Energywi$e certificate with a "Excellence" rating	0.191**
Carbon Reduction Certificate (CARBON)		

CARBON	Carbon Reduction Certificate	-0.043**
Interaction Effect Variables (GBCINTERACT)		
BEAM Plus		
BEAMPB_LUXURY	A luxury flat with a bronze rating under BEAM Plus	-0.166**
BEAMPS_LUXURY	A luxury flat with a silver rating under BEAM Plus	-0.066*
BEAMPG_LUXURY	A luxury flat with a gold rating under BEAM Plus	-0.029
BEAMPP_LUXURY	A luxury flat with a platinum rating under BEAM Plus	-0.244**
BEAMUNC_LUXURY	A luxury flat with an unclassified rating under BEAM Plus	-0.098**
BEAMPB_AGE	Interaction term of a flat with a bronze rating under BEAM Plus and its age	0.125
BEAMPS_AGE	Interaction term of a flat with a silver rating under BEAM Plus and its age	-0.026*
BEAMPG_AGE	Interaction term of a flat with a gold rating under BEAM Plus and its age	-0.037**
BEAMPP_AGE	Interaction term of a flat with a platinum rating under BEAM Plus and its age	-0.044
BEAMPUNC_AGE	Interaction term of a flat with an unclassified rating under BEAM Plus and its age	-0.115**
BEAMPB_DIS	Interaction term of a flat with a bronze rating under BEAM Plus and its distance from the CBD	0.008**
BEAMPS_DIS	Interaction term of a flat with a silver rating under BEAM Plus and its distance from the CBD	-0.001
BEAMPG_DIS	Interaction term of a flat with a gold rating under BEAM Plus and its distance from the CBD	-0.011**
BEAMPP_DIS	Interaction term of a flat with a platinum rating under BEAM Plus and its distance from the CBD	-0.031**
BEAMPUNC_DIS	Interaction term of a flat with an unclassified rating under BEAM Plus and its distance from the CBD	-0.001
BEAMPB_PRESALE	A presale flat with a bronze rating under BEAM Plus	-0.223**
BEAMPS_PRESALE	A presale flat with a silver rating under BEAM Plus	-0.155**
BEAMPG_PRESALE	A presale flat with a gold rating under BEAM Plus	-0.065**
BEAMPP_PRESALE	A presale flat with a platinum rating under BEAM Plus	-0.149**
BEAMUNC_PRESALE	A presale flat with an unclassified rating under BEAM Plus	-0.181**

BEAMPB_FINAL	A flat with a bronze rating in the final assessment of BEAM Plus	-0.175**
BEAMPS_FINAL	A flat with a silver rating in the final assessment of BEAM Plus	0.041
BEAMPG_FINAL	A flat with a gold rating in the final assessment of BEAM Plus	-0.073**
BEAMPPLAT_FINAL	A flat with a platinum rating in the final assessment of BEAM Plus	N.A.
BEAMUNC_FINAL	A flat with an unclassified rating in the final assessment of BEAM Plus	N.A.
HK-BEAM 4/04& 5/04		
BEAMB_LUXURY	A luxury flat with a bronze rating under BEAM 4/04 & 5/04	-0.038**
BEAMS_LUXURY	A luxury flat with a silver rating under BEAM 4/04 & 5/04	-0.174**
BEAMG_LUXURY	A luxury flat with a gold rating under BEAM 4/04 & 5/04	N.A.
BEAMPLAT_LUXURY	A luxury flat with a platinum rating under BEAM 4/04 & 5/04	0.249**
BEAMB_AGE	Interaction term of a flat with a bronze rating under BEAM 4/04 & 5/04 and its age	-0.026**
BEAMS_AGE	Interaction term of a flat with a silver rating under BEAM 4/04 & 5/04 and its age	-0.025**
BEAMG_AGE	Interaction term of a flat with a gold rating under BEAM 4/04 & 5/04 and its age	0.008
BEAMP_AGE	Interaction term of a flat with a platinum rating under BEAM 4/04 & 5/04 and its age	-0.030**
BEAMB_DIS	Interaction term of a flat with a bronze rating under BEAM 4/04 & 5/04 and its distance from the CBD	-0.013**
BEAMS_DIS	Interaction term of a flat with a silver rating under BEAM 4/04 & 5/04 and its distance from the CBD	-0.019**
BEAMG_DIS	Interaction term of a flat with a gold rating under BEAM 4/04 & 5/04 and its distance from the CBD	N.A.
BEAMP_DIS	Interaction term of a flat with a platinum rating under BEAM 4/04 & 5/04 and its distance from the CBD	-0.055**
Wastewi$e Certificate		
WWGOOD_LUXURY	A luxury flat with a "Good" rating under the Wastewi$e certificate	-0.125**
WWEXCEL_LUXURY	A luxury flat with an "Excellence" rating under the Wastewi$e certificate	0.019

WWGOOD_AGE	Interaction term of a flat with a "Good" rating under the Wastewi$e certificate and its age	0.002**
WWEXCEL_AGE	Interaction term of a flat with an "Excellence" rating under the Wastewi$e certificate and its age	0.005**
WWGOOD_DIS	Interaction term of a flat with a "Good" rating under the Wastewi$e certificate and its distance from the CBD	-0.005**
WWEXCEL_DIS	Interaction term of a flat with an "Excellence" rating under the Wastewi$e certificate and its distance from the CBD	-0.008**
Energywi$e Certificate		
EWBASIC_LUXURY	A luxury flat with a "Basic" rating under the Energywi$e certificate	0.005
EWGOOD_LUXURY	A luxury flat with a "Good" rating under the Energywi$e certificate	0.237**
EWEXCEL_LUXURY	A luxury flat with a "Excellence" rating under the Energywi$e certificate	0.019
EWBASIC_AGE	Interaction term of a flat with an "Basic" rating under the Energywi$e certificate and its age	0.001
EWGOOD_AGE	Interaction term of a flat with an "Good" rating under the Energywi$e certificate and its age	0.005**
EWEXCEL_AGE	Interaction term of a flat with an "Excellence" rating under the Energywi$e certificate and its distance from the CBD	-0.009**
EWBASIC_DIS	Interaction term of a flat with an "Basic" rating under the Energywi$e certificate and its distance from the CBD	-0.010**
EWGOOD_DIS	Interaction term of a flat with an "Good" rating under the Energywi$e certificate and its distance from the CBD	0.002**
EWEXCEL_DIS	Interaction term of a flat with an "Excellence" rating under the Energywi$e certificate and its distance from the CBD	-0.004**
Carbon Reduction Certificate		
CARBON_LUXURY	A luxury flat with a Carbon Reduction certificate	-0.084**
CARBON_AGE	Interaction term of a flat with a Carbon Reduction certificate and its age	0.002**
CARBON_DIS	Interaction term of a flat with a Carbon Reduction certificate and its distance from the CBD	0.002**
Control Variables		
PROPERTY	Property attributes	Yes
LOCATION	Locational attributes	Yes
NEIGHBOURHOOD	Neighbourhood attributes	Yes

TIME	Transaction time fixed effects	Yes
N		225,706
F		9429.00
R-square		0.907
Root MSE		0.1671

Table 9: Heteroskedastic Weighted Hedonic Pricing Model Results
Note: * denotes significance at 5%; ** at 1%

Implications of Findings

Grounded on the findings as reported in the last section, there are a handful of implications which can be useful to stakeholders such as investors, property developers, property management companies, and Owners' Corporations alike.

First, the significant price premiums among BEAM Plus-certified residential properties also have implications for property developers. The premium, if anything, indicates the high demand for certified green housing properties in Hong Kong. Yet, buyers in the luxury market were willing to pay a substantially smaller price premium for BEAM Plus-certified flats than those in the mass market, unless the certification refers to sizeable and *actual* improvements in a building's overall environmental performance or energy performance. This provides a dilemma for developers when it comes to whether a proposed housing development should be certified under BEAM Plus, even when the GFA concessions under the Building Department's PNAP APP151 policy is taken into account. Besides, from a profit-maximizing perspective, this could have implications in terms of the allocation of mass market flats and luxury market flats within a housing development should a developer decide to obtain BEAM Plus certification, and hence, the eventual supply of certified "green" housing properties in the respective housing markets.

Second, to those who view green housing properties as an investment option, it is revealed in the findings that housing flats in BEAM Plus-certified buildings in general were sold at price premiums over other non-assessed housing properties. This indicates that "green" housing properties certified with BEAM Plus are sound investment choices considering the sizeable price premiums obtainable, especially for people who purchased them during the presale phase and sold them before the final assessment was completed. The substantial price difference between completed flats and presale flats (in comparison with other non-certified presale flats and completed flats), with the same provisional rating under BEAM Plus, is highly similar to the “IPO pop” among some of the Initial Public Offering (IPO) stocks which skyrocket in prices when they are finally traded in stock markets.

Lastly, the third implication concerns companies which are assigned to manage these certified green properties (or Owners’ Corporations). It is shown via the findings that obtaining the highest possible rating under the GBCs selected for this study does not always result in higher price premiums for flats within buildings that these parties manage. This rather surprising finding can be explained by two reasons. The first reason is that, regardless of how much improvement a certain rating under a certain GBC may represent, it does not have a direct impact on energy cost inside these housing units, for which homeowners are solely responsible. The second reason concerns the cost implications for certified housing properties, as the capitalization of maintenance cost has been raised by Yoshida and Sugiura (2015) as a reason behind the lower transaction prices among condominiums in Tokyo. Another reason, specifically for properties certified with HKGOCs (applicable to existing buildings only), is the extra cost incurred in the additional measures introduced in order to achieve the goals necessary for certification.

Conclusion

Although many researchers across the globe have conducted studies on the pricing of “green” properties, in both office and residential sectors, through the relationship between property prices and selected “green” building certifications, the property markets in question have normally been investigated as a whole. This, in effect, overlooks the potential differences in pricing behavior between property buyers in different housing sub-markets, namely the mass housing market and the luxury housing market. Considering that housing flats of different sizes (thus, different housing sub-markets) are normally situated within the same building (or at least the same residential development) in a high-rise living environment, this has profound implications for developers’ strategies in terms of the type of potential customers they cater to, and subsequently, the level of environmental performance under GBC(s) to maximize revenue.

This study of Hong Kong's residential property market, utilizing a Heteroskedastic Weighted Hedonic Pricing Model, finds that, unless the certification was an indication of a substantial, actual, improvement in either a building's overall environmental performance (i.e. Platinum rating under HK-BEAM 4/04 & 5/04) or energy performance (i.e. Good Level under HKGOC's Energywi$e Certificate), the price premiums for the other GOCs under study, including BEAM Plus, were considerably lower among buyers in the luxury market than those in the mass housing market. This finding is generally in line with Pontus et al. (2014) and Hyland et al. (2013). Also, the now-defunct HK-BEAM 4/04 & 5/04 carried larger price premiums than BEAM Plus and individual Hong Kong Green Organization Certificates (HKGOCs).

Another interesting finding is that BEAM Plus-assessed housing properties carried much higher price premiums when they were completed, rather than presale, flats in buildings with a provisional rating instead of a final rating. The significant and sizeable disparities in price between provisionally-assessed presale flats and completed flats highly resemble the behavior of some IPO stocks that skyrocket in prices by the time they are officially traded in the stock markets. In other words, the presence of provisional and final assessments under a green building certification helps create the real estate equivalent to IPO stocks for investors.

However, it should be noted that green building certifications do not necessarily enhance property value and that obtaining the highest possible rating under a GBC does not always result in the largest price premiums. This can be attributed to the cost considerations towards the maintenance of the visible and invisible green features within new buildings, and the cost considerations towards the additional measures needed in order to achieve the goals required for certification for existing buildings. This is expected to yield some implications for parties involved in the management of these properties such as property management companies and Owners' Corporations in their decision-making relating to GBCs (and the rating to be achieved).

Besides, the noticeable disparities in terms of the amount homebuyers in different housing sub-markets could have some implications for property developers with regard to the allocation of mass housing flats and luxury housing flats within a housing development, and as a consequence, the eventual supply of certified green properties in the respective housing markets.

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