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Effects of Green Attributes on Residential Price in Taiwan

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Taiwan is committed to reducing greenhouse gas emissions and established a green building certification system called the ecology, energy saving, waste reduction, and health (EEWH) system in 1999. However, only 0.44% of the private projects have obtained green building labels in 2017, and almost all of them have expired and not renewed. This study analyzes green attributes of market preferences by using a multi-regression. The results show that green indicators have a significant impact on green premium. That is, greenery, building envelope design, energy conserving air conditioning, construction waste reduction and indoor environment quality have discounted effects on the green premium. But some high-weighed indicators in EEWH are not favored by developers, and therefore have negative impacts on prices, such as building envelope design and energy conserving air conditioning. On the contrary, some low-weighed indicators have positive impacts on prices, such as energy conserving indoor lighting and water conservation, and therefore are already incorporated by developers based on buyers' demand. It is suggested to modify the weighting of such indicators so that they are in line with buyers' preferences, which will incentivize developers to incorporate green attributes in future projects that are more valued by buyers.

Keywords

Green building, Sustainable property, Green attribute, Green premium, EEWH

1. Introduction

Under the Paris Climate Agreement in 2015, 196 parties committed to slowing down global warming. Taiwan also committed to reducing greenhouse gas emissions by 2050 to half of the level of 2005. Since 1999, the green building certification system in Taiwan called the ecology, energy saving, waste reduction, and health (EEWH) system has been designed from the perspective of architectural and urban planning. Of the 542,854 building permits issued up to 2017, only 2,357 projects obtained a green building label, and out of those, only 648 applications came from projects by private developers.[1]. Moreover, only 0.12% private residential projects obtained a green building label, and almost all of them have expired. There is no intention to renew their label. Obviously, the take up rates of green building labelled construction projects by private developers are very low.

There are many research studies that have demonstrated that green buildings can enhance energy efficiency and reduce operating expenditures (Turner and Frankel, 2008; Jo et al., 2009; Lau et al., 2009). Typical viewpoints are that green buildings are supposed to improve residential quality and contribute to the health or utility of residents, however, some studies have proven that green building users are dissatisfied with the quality of the green attributes in their indoor environment quality (Abbaszadeh et al., 2006; Gou and Lau, 2013).

Robinson et al. (2016) categorize the features of green buildings into the three Ps: profit, people and planet by using the triple bottom line theory. Lee and Guerin (2009) and Chen (2017) point out that people-oriented green attributes such as daylight penetration, transportation convenience and open space utilization are preferred by most residents. However, developers and government officials tend to emphasize profit and planet oriented green attributes because they prioritize the reduction of operating costs and energy saving respectively. The EEWH system in Taiwan is fundamentally based on the environmental considerations of the planet and categorized into the four categories of ecology, energy saving, waste reduction, and health. To obtain green building certification, the candidate is evaluated on EEWH through nine indicators: biodiversity, greenery, soil water retention, daily energy conservation, Co2 emission, waste reduction, indoor environment quality, water conservation and improvement of sewage and garbage systems. How marketable is each feature? How well do these features fit the needs of homebuyers?

This paper first reviews the relationships between green building features and their individual effect on the market value. Hence, a semi-log model is developed to analyze which green attribute incentivizes private residential developers. Finally, the mismatch between the government allocated EEWH

[1] Refer to http://gb.tabc.org.tw/ and https://www.cpami.gov.tw/

high weightage green labelling indicators and consumer preferences such that developers in Taiwan are not keen to incorporate these high weight features into their developments are highlighted in the conclusion.

2. Literature Review

2.1 Effect of green attributes

Elkington (1998) advocates for the triple bottom line theory to delineate the notion of sustainable development into profit, planet and people oriented green attributes, which is generally applied to studies related to green buildings. Robinson et al. (2016) explore the green attributes of ecological office buildings on the basis of these three attributes. Their research suggests that profit oriented green attributes are concerned with economic value such as energy-efficient equipment. Planet oriented green attributes like water circulatory systems offer environmentally sustainable benefits. Finally, the surrounding amenities are an example of people oriented green attributes which are defined as the utility of green attributes that users can obtain from a quality indoor environment. In a nutshell, Robinson et al. (2016) interview developers, property managers, appraisers and tenants based on these three green oriented attributes. They find that the first preference order for most of the interviewees is people oriented green attributes, followed by profit and then planet oriented green attributes.
In reality, the quality of the indoor environment plays the key role in how users perceive green buildings. The indoor environment quality is often influenced by the emission of volatile organic compounds (VOCs) and other pollutants from building products (Yu and Kim, 2010). Additionally, a number of studies have clarified that the quality of the indoor environment of green buildings is higher than that of non-green buildings in terms of health, productivity and comfort of users. Nevertheless, Leaman and Bordass (2007) find that residents of green buildings are usually comparatively tolerant of the shortcomings of green buildings. This implies that enhancement of the internal environmental quality of green buildings might be due to psychological effects. Gou and Lau (2013) survey 1,251 users living in 14 green buildings in China on their satisfaction and living comfort. They find that the majority of the occupants are satisfied with living in a green building and the thermal environment while the remainder are dissatisfied with the lower temperatures during the summer and winter.

The main characteristic of the profit oriented green attributes involves the reduction of operating and maintaining costs. Fowler et al. (2010) note that green buildings are more effective than non-green buildings in terms of water and energy usage and cost efficiency. Moreover, Lau et al. (2009) also refer to a 55% decline of energy spending which influences ecological office buildings. Likewise, authorities in San Diego, USA successfully reduced power consumption and greenhouse gas discharging of construction projects by continuing green building policies (Anders, 2010). Nevertheless, the development costs of green buildings would certainly be higher than non-green buildings for an energy saving effect (Ross et al., 2007). Besides, Langdon (2007) finds 4% and 10% of additional construction costs for green buildings to meet respectively five-star or six-star standards of the Green Building Council of Australia. In addition, the study mentions that the extra costs during the construction stage would be offset in the maintenance stage and are conducive to reducing the capital pay-off time as well.

A majority of research studies have indicated that operation costs could be reduced with the use of green buildings, while Miller et al. (2010) make the opposite argument. Scholars have demonstrated that the total operating costs of ecological buildings are higher than non-green buildings on average despite the high quality and low vacancy rate of green office buildings. Hence, these researchers infer that managing the difficulties of green buildings might incur spending unrelated to energy use. Yoshida and Sugiura (2015) find a 5.5% price discount of construction with a green building label in an empirical study in Tokyo. This phenomenon could be attributed to lack of recognition and confidence of users of ecological buildings. Additionally, added costs like management and renovation expenditures of planting or open space produced by green buildings might be potential reasons for the value discount.

The primary connotations for the planet oriented green attributes emphasize the efficient use of energy, water or resources, and reduction of greenhouse gas emissions (Zabaneh, 2011; Anders, 2010). Furthermore, sustainable land use patterns can also sustain biodiversity and protect ecosystems in urban areas (Henry and Frascaria- Lacoste, 2012). In addition, Coelho and Brito (2012) state that the materials of systematic structures such as precast steel or concrete for green buildings can be recycled. This will reduce building waste and facilitates the recovery rate of an entire construction project to reach 90% which will improve its environmental performance.

The heat island effect is increasing in severity in urban areas. The green cover on a building however offers a cooling effect on the surrounding environment, and also improves indoor thermal comfort and indoor energy efficiency. Takakura et al. (2000) indicate an enhanced cooling effect when the leaf area per unit roof area is increased. Hao et al. (2020) investigate the effects of vertical greenery systems and green roofs on indoor air temperatures of an air-conditioned space. They find that operative temperature in the room with a vertical greenery system and green roofs is lower than that of a room without these systems. However, these systems have a smaller impact on the operative temperature of an air-conditioned room than that of a naturally ventilated room. Moreover, Carver et al. (2020) review nine articles and identify seven positive associations between greenery (use and presence of gardens) at residential aged care facilities and the mental well-being of residents. However, Noordzij et al. (2020) do not find evidence of an association between changes in green spaces and mental health in the Eindhoven area (Netherlands) between 2004 and 2014.

Jo et al. (2009) examine green buildings with LEED certification in Seoul and find that an increase in energy or water efficiency and reduced carbon discharge are the most obvious differences between green buildings and non-green buildings. In addition, Newsham et al. (2009) analyze 100 ecological buildings certified by LEED in the U.S.A. and show that the energy consumption of green buildings for each floor space has a 18%-39% decline relative to non-green buildings, but also report that 30% of green buildings actually waste more energy than non-green buildings.

In brief, comprehensively analyzing these three aspects of green attributes, Lee and Guerin (2009) survey users of green buildings with a questionnaire, and the results show that people oriented green attributes are the most important, such as natural light exposure, traffic development and the establishment of open spaces, followed by profit and planet oriented attributes. However, Chau et al. (2010) assess the value of willingness to pay of experienced users of green buildings, and find that both residents of ecological buildings and non-green buildings pay the most attention to efficiency of energy saving, then in order of importance, users are attracted to indoor air quality, noise reduction, scenery and water circulation. Among these outcomes, the great divergence is that the willingness of the green building dwellers to pay for the value of scenery is much lower than non-green building residents.

Chen (2017) indicated users of ecological buildings prefer people oriented green attributes such as the quality of inside air, degree of noise reduction, accessibility of transportation and so on and so forth, which imparts direct benefits to the residents. However, developers tend to prefer profit oriented green attributes as they place priority on reducing building and operating costs. With regard to policy execution, the government often takes planet oriented green attributes more seriously which shows the significant differences between public welfare policy and self-interest of users or developers. In these circumstances, the price of green buildings would not be comparable to conventional buildings when developers, users and governments do not have consensus on the prioritized elements of green buildings.

In summary, even though a number of research work shows that green buildings might increase energy efficiency and reduce operating costs (Turner and Frankel, 2008; Jo et al., 2009; Lau et al., 2009), some studies have the opposite viewpoint and state that green buildings consume more energy and their actual operating expenditures are higher than those of non-green buildings (Newsham et al., 2009). Additionally, it is generally recognized that green buildings are supposed to improve the quality of life and increase the health or utility of their users. Nevertheless, some of the studies in the literature show that users of green buildings are dissatisfied with the indoor environment quality (Abbaszadeh et al., 2006; Gou and Lau, 2013), thus indicating the ambiguity in the quality of ecological buildings and their green attributes.

2.2 Green attributes in Taiwan

Taiwan launched the EEWH evaluation system for green building labels in 1999. As Table 1 shows, the certification process examines ecology, energy saving, waste reduction and health. These four factors are assessed by nine indicators: biodiversity, greenery, soil water retention, daily energy conservation, Co_2 emission, waste reduction, indoor environment quality, water conservation, and improvements in sewage and garbage systems. The candidate has to pass four indicators with two mandatory indicators (daily energy conservation and water conservation) and two more optional indicators. The planning and designing are based on planet oriented attributes. The evaluated indicators are as follows (Mak et al., 2015):

(1) Biodiversity includes the ecological network, biological habitat, plant diversity, soil ecosystem, etc. These components are mainly related to the planet oriented attributes in the triple bottom line theory. This indicator is mostly applied to large scale developments, and the sample in this study all belong to small scale residential buildings; therefore this indicator would not be applicable.

(2) Greenery facilitates CO2 absorption in built environments, including placing plants and vegetation in both the exterior and interior of buildings. A greener building means better ventilation which contributes to health and wellbeing in addition to planet oriented green attributes.

(3) Soil water retention is determined through the permeable design of buildings and the extensive storage of permeation pools. It has the function of naturally regulating the climate and slowing down the urban heat island effect. In the triple bottom line theory, soil water retention is mostly related to planet oriented attributes.

(4) Daily energy conservation is affected by the building envelope design, air conditioning and indoor lighting. However, the Taiwanese often rely on air conditioning to maintain a comfortable indoor environment due to the hot and humid climate of Taiwan. Therefore, it is hardly acceptable to save energy by reducing air conditioning usage. In addition, this indicator does not consider the design of large windows which does not accommodate preference for views of the external environment.

(5) More economical building materials used during construction result in lower CO_2 emissions and less damage to the global environment. However, 95% of the newly-built buildings in Taiwan are made of reinforced concrete, and the resultant waste cannot be easily recycled. This indicator

is also completely based on the consideration of planet oriented attributes. However, some design considerations are inconsistent with market demand, such as preference for high-ceilings and natural light-filled living spaces.

(6) Construction waste reduction is the reduction of excess earthwork, and building materials during construction. It focuses on reducing waste and air pollution, and using renewable resources. Obviously, it is also based on planet oriented green attributes.

(7) Indoor environment quality consists of sound insulation, lighting, ventilation, decorative materials, and indoor air quality. For example, interior decorations are encouraged to be made of environmentally friendly building materials. This is an indicator that considers both people and planet oriented green attributes. Although these criteria allow people to live healthier, developers mostly provide dwellings with inferior decors which conflict market needs. As such, this indicator is more difficult to implement.

(8) Water conservation focuses on the water-saving design of buildings, in anticipation of actively using rainwater, recycling domestic grey water, and using water-saving appliances. The specific ways of conserving water are to use a two-stage flush toilet, replace the bathtub with a shower, and store pool water for reuse. Chen (2017) indicates that taking profit into consideration, developers are willing to adopt these elements in both green and non-green buildings too.

(9) The focus of improving sewage and garbage disposal is to use pipeline systems to incorporate both municipal (public) and household (domestic) sewage into sewage treatment facilities to make public waste treatment spaces more compact and hygienic. For example, there should be waste sorting and recycling systems for the collection and utilization of food waste, and frozen and pressing waste machines have been stipulated in building codes, so most buildings have already been installed with these infrastructures.

The EEWH evaluation system was enhanced with two additional indicators of biodiversity and indoor environment quality. This new rating scheme for the nine indicators has been implemented since 2003 which rates projects as bronze, silver, gold and diamond. In 2008, the Regulations of Bulk Reward for Urban Renewal stipulated that buildings adopt the green building evaluation system of the Ministry of the Interior, and those who obtained a candidate green building certificate and passed the green building grading assessment at a silver level or higher are given a building bulk ratio bonus, with 10% as the upper limit. In addition, the New Taipei City stipulated that "Those applying for a base with an area of more than 6,000 m^2 and a total floor area of more than 30,000 m^2 should obtain a candidate green building certificate and pass the green building classification assessment with a silver level or above" in 2014 (New Taipei City Enforcement Rules for Urban planning law #46). This is the first mandatory requirement for private developers to build green buildings in Taiwan. Figure 1 shows the performance matrix of the EEWH indicators under the green building evaluation system.

These EEWH indicators can be analyzed by using the classifications defined in Robinson et al. (2016). Planet oriented green attributes have environmentally sustainable benefits, profit oriented green attributes have economic value, and people oriented green attributes directly benefit users. We only choose the one that most adheres to the definition in Robinson et al. (2016) for analysis purposes. As such, most of the EEWH indicators are planet oriented, while very few indicators are profit or people oriented. As shown in Table 2, the score for planet oriented green attributes is 65, while that for people and profit oriented green attributes is 21 and 14, respectively.

Table 1 EEWH categories, indicators and evaluated items

<table>
<tr><th>Category</th><th colspan="2">Indicator</th><th>Code</th><th>Evaluated Items</th></tr>
<tr><td rowspan="3">Ecology</td><td colspan="2">Biodiversity</td><td>RS1</td><td>Ecological network, biological habitat, plant diversity, soil ecosystem</td></tr>
<tr><td colspan="2">Greenery</td><td>RS2</td><td>Soil layer on the roof, balcony, outer walls, artificial site to plant all kinds of plants</td></tr>
<tr><td colspan="2">Soil water retention</td><td>RS3</td><td>Permeable design of the base and extensive storage of permeable pools</td></tr>
<tr><td rowspan="3">Energy Saving</td><td rowspan="3">Daily energy conservation (mandatory)</td><td>Building envelope design</td><td>RS41</td><td>Insulation of roofs and external walls, window opening ratio and shading design, energy-saving windows</td></tr>
<tr><td>Air conditioning</td><td>RS42</td><td>Energy-saving air conditioning, heating, ventilation, and air conditioning (HVAC) system</td></tr>
<tr><td>Indoor lighting</td><td>RS43</td><td>Efficiency and lighting power of public space lamps, solar water heaters, energy-saving gas stoves or induction heating (IH) stoves</td></tr>
<tr><td rowspan="2">Waste Reduction</td><td colspan="2">CO_2 emission</td><td>RS5</td><td>Lightweight main structure, durable building materials, durable construction</td></tr>
<tr><td colspan="2">Construction waste reduction</td><td>RS6</td><td>Reduction construction waste, demolition waste, construction air pollution</td></tr>
<tr><td rowspan="3">Health</td><td colspan="2">Indoor environment quality</td><td>RS7</td><td>Sound environment, natural lighting, natural ventilation environment, using green building materials for decor</td></tr>
<tr><td colspan="2">Water conservation (Mandatory)</td><td>RS8</td><td>Water saving mechanisms, reuse of grey water and rainwater</td></tr>
<tr><td colspan="2">Sewage and garbage improvement</td><td>RS9</td><td>Sewer plumbing, sanitary condition for garbage gathering, compost</td></tr>
</table>

Note: The EEWH indicators are cited from the Green Building Evaluation Manual (EEWH-BC, 2015 edition).

Figure 1 Performance Matrix of the EEWH Indicators

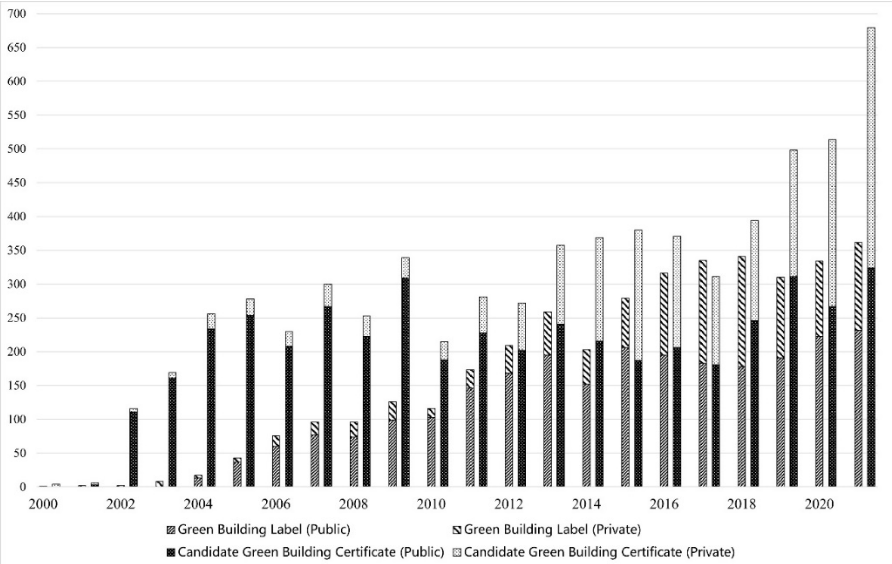


Table 2 Scoring of EEWH system

Category	Indicator		Planet oriented	Profit oriented	People oriented	Maximum points	Total points
Ecology	Biodiversity (RS1)		*			9	27
	Greenery (RS2)				*	9	
	Soil water retention (RS3)		*			9	
Energy Saving	Daily energy conservation (Required)	Building envelope design (RS41)	*			14	32
		Air conditioning (RS42)	*			12	
		Indoor lighting (RS43)		*		6	
Waste Reduction	CO_2 emission (RS5)		*			8	16
	Construction waste reduction (RS6)		*			8	
Health	Indoor environment quality (RS7)				*	12	25
	Water conservation (RS8) (Required)			*		8	
	Sewage and garbage improvement (RS9)		*			5	
Sub-total			65	14	21	100	100
Innovative Design for Green Building			Projects that EEWH cannot evaluate but deserve to be rewarded, such as: environmental aesthetics, etc.				

Note: The authors classify the EEWH system as planet, profit and people oriented in accordance with the classification in Robinson et al. (2016).

3. Research Design

The hedonic price theory claims that buyers determine the price that they are willing to pay for specific goods according to their characteristics. In this study, a semi-log model is adopted for the empirical analysis:

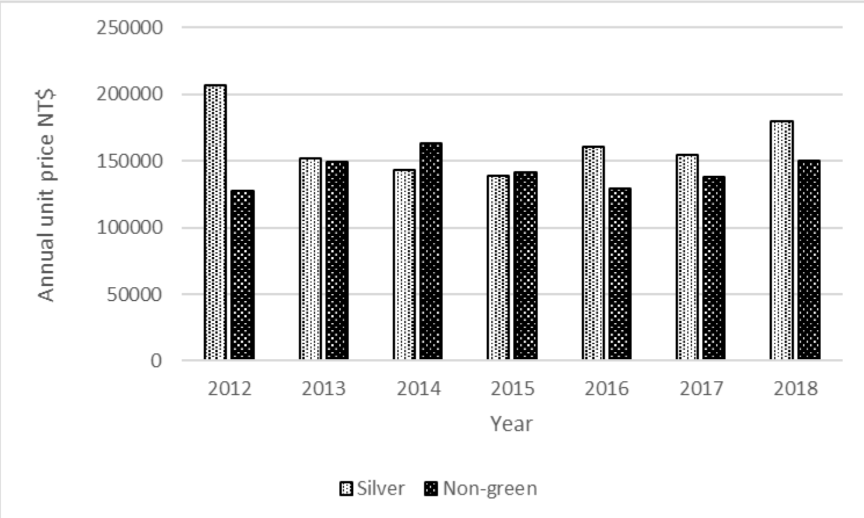
$$lnP_i = \alpha_0 + \sum_{j=1}^{m} \beta_j Y_{ji} + \sum_{k=m+1}^{n} \beta_k L_{ki} + \sum_{o=n+1}^{r} \beta_o BA_{oi} + \beta_{r+1} TR_i + \sum_{g=r+2}^{s} \beta_g G_{gi} + \varepsilon_i \tag{1}$$

where P_i is the total transaction price of i^th^ sample, α_0 is the intercept term, Y_{ji} is the j^th^ year attribute of the i^th^ sample, L_{ki} is the k^th^ location attribute of the i^th^ sample, BA_{oi} is the o^th^ building attribute of the i^th^ sample, TR_i is the transportation accessibility attribute of the i^th^ sample, G_{gi} is the attribute of the g^th^ green attribute as previously mentioned for the i^th^ sample, and ε_i is the residual of the i^th^ sample. The year and location attributes are dummy variables. The year variable is from 2012 to 2018, and takes 2012 as the base year. The annual average unit price is plotted in Figure 2. Building attributes include building area, transfer floor, whether there is a parking spot and the shortest distance from the Mass Rapid Transit (MRT)/bus station. With the exception of whether a parking spot is available, which is a dummy variable, the rest are continuous variables.

The advantage of transportation accessibility is considered to be an important indicator in Leadership in Energy and Environmental Design (LEED). This is because the proximity of public transit affects how much energy is saved and emission reduced. In addition to the features of EEWH, a variable TR is added, which represents the straight-line distance between the sample property and the public transportation system. In fact, its benefits are reflected in walking as a mean of healthy physical exercise. However, it is not practical to walk more than one kilometer. Therefore, this study uses a one-kilometer reverse distance (RDTR) for regression to calculate the impact of energy saved through transportation. The RDTR is the reverse distance variable which is the shortest distance between the point of origin and MRT or train station minus 1000 meters. A positive estimated coefficient value means houses that are closer to the MRT or train station have a higher price.

The location variable is also a dummy variable. In order to effectively control for the impact of location differences on real estate prices, most of the studies in the literature directly use administrative regions as a substitution variable for location. This paper refers to Tu et al. (2007) and considers submarkets, and uses a cluster analysis. The method divides green building projects with similar unit price and space into the same cluster as a representative of location variables. We adopt a two-stage cluster analysis. The cluster result and the price relationship of each cluster is shown in Table 3. The average unit price in Da'an/ Zhongzheng (Cluster 1) is the highest at 391,980 NT$ (12,390 USD), and in Danshui/Yingge (Cluster 11), the lowest at 74,850 NT$ (2,366 USD).

Figure 2 Annual average unit price



In this study, the information on green building features is sourced from the Taiwan Architecture and Building Center. The property transaction price data are extracted from the actual price registration in Taipei City and New Taipei City. From 2012 to 2018, the EEWH offered 5 rating levels: of certified, bronze, silver, gold and diamond, and private developers built 15, 7, 87, 21, and 1 such residential buildings respectively. Silver-level rated transactions accounted for 89.87% of the ratings, therefore, this study only selects silver rated green buildings for analysis. The details of the features of silver rated green buildings are outlined in Table 4. All 130 projects have the "required" indicators as follows: daily energy conservation (including building envelope design (RS41), air conditioning (RS42), indoor lighting (RS43)) and water conservation (RS8) Other designs with greenery (RS2), sewage and garbage improvement (RS9) are second and third most frequently found indicators in projects, with 127 and 123 respectively. Developers did not pay much attention to construction waste reduction (RS6) and the indoor environment quality (RS7). If we look further at the strength of the design, greenery (RS2) and water conservation (RS8) are most favored by developers, which account for 76.11% and 71.27% of the projects, respectively. Air conditioning (RS42), building envelope design (RS41) and construction waste reduction (RS6) may not be profit and people oriented so less focus is given to them in the design, with only 22.84%, 23.06% and 32.07% of the projects incorporating these three elements, respectively. In particular, even though air conditioning (RS42) and building envelope design

(RS41) are required for all construction projects, these two indicators have the lowest score. On the other hand, developers focus more on water conservation (RS8) which is mandatory and related to cost savings.

Table 3 Unit price description of clustered location

Cluster	District	Average	Min	Max	Std.
Cluster1	Da'an/ Zhongzheng	391.98	218.94	507.47	59.96
Cluster2	Zhongshan/Songshan/Xinyi	268.27	143.34	480.74	62.08
Cluster3	Neihu/Nangang	223.52	136.18	359.04	35.33
Cluster4	Datong/Shilin/Beitou	210.48	117.29	419.81	59.32
Cluster5	Wanhua/Yonghe	186.86	122.11	261.45	24.97
Cluster6	Wenshan/Banqiao/Zhonghe	162.08	91.84	245.74	24.72
Cluster7	Xindian/Xinzhuang/Sanchong	128.49	73.00	231.25	21.51
Cluster8	Xizhi	111.72	65.99	157.23	12.84
Cluster9	Sanxia/Shulin	94.57	66.18	121.64	11.61
Cluster10	Linkou/Taishan	85.14	60.94	115.87	9.03
Cluster11	Danshui/Yingge	74.85	44.69	157.82	19.14

Note: Transaction data used for cluster analysis, so counties without green building transaction data during the research period are excluded.
Unit: thousand NT$ (31.62 USD)

Table 4 Description statistics of silver rating features

Indicator	No. of projects	Average (a)	Max	Min	Std	Maximum points (b)	Percentage (a)/(b)
RS2	127	6.8495	9.00	1.50	2.2312	9	76.11%
RS3	100	5.7307	9.00	0.80	2.7402	9	63.67%
RS41	130	3.2281	9.54	1.50	1.5768	14	23.06%
RS42	130	2.7413	12.00	1.50	2.0311	12	22.84%
RS43	130	3.0195	6.00	1.50	1.5148	6	50.32%
RS5	70	3.9903	8.00	1.03	1.8009	8	49.88%
RS6	45	2.5658	4.78	1.02	0.6785	8	32.07%
RS7	58	5.7917	11.71	1.50	2.4174	12	48.26%
RS8	130	5.7019	8.00	1.50	1.8325	8	71.27%
RS9	122	3.2470	5.00	1.50	0.9318	5	64.94%

Note: The indicators are defined as follows: RS2: greenery, RS3: Soil water retention, RS41: building envelope design, RS42: air conditioning, RS43: indoor lighting, RS5: CO_2 emission, RS6: Construction waste reduction, RS7: Indoor environment quality, RS8: water conservation, and RS9: sewage and garbage improvement.

In order to conduct a premium analysis of green buildings, this study examines similar non-green buildings. Based on the characteristics of green building projects, the non-green buildings selected for the sample have more than 7 stories within 500 meters of a green building, and was built one year before and after the completion date of the green building. The description statistics of each attribute are listed in Tables 5 and 6. A total of 9,193 transaction samples, including 1,907 (20.73%) silver-level rated transactions, and 7,286 (79.23%) non-green building transaction samples within a range of 500 meters to a green building. Green buildings have slightly higher LN (price) than non-green buildings. The number of transactions each year is comparable, Cluster 7 has the most transactions in terms of location, and this area has the highest number of development projects in New Taipei City. As for parking spaces, whether there are green or non-green building transactions, a high percentage have parking spaces. This is especially interesting for green buildings, as 17.62% have no parking spaces. The shortest distance between these projects and public transportation is around 600 meters.

Table 5 Dummy description statistics of transaction samples

Variable	Total sample		Green sample		Non-Green sample	
	Amount	Percentage	Amount	Percentage	Amount	Percentage
Year 2012	698	7.59%	63	3.30%	635	8.72%
Year 2013	1446	15.73%	323	16.94%	1123	15.41%
Year 2014	1332	14.49%	164	8.60%	1168	16.03%
Year 2015	1197	13.02%	166	8.70%	1031	14.15%
Year 2016	1390	15.12%	329	17.25%	1061	14.56%
Year 2017	1827	19.87%	571	29.94%	1256	17.24%
Year 2018	1303	14.17%	291	15.26%	1012	13.89%
Cluster 1	29	0.32%	8	0.42%	21	0.29%
Cluster 2	754	8.20%	61	3.20%	693	9.51%
Cluster 3	480	5.22%	205	10.75%	275	3.77%
Cluster 4	505	5.49%	171	8.97%	334	4.58%
Cluster 5	427	4.64%	206	10.80%	221	3.03%
Cluster 6	1069	11.63%	283	14.84%	786	10.79%
Cluster 7	3568	38.81%	457	23.96%	3111	42.70%
Cluster 8	530	5.77%	115	6.03%	415	5.70%
Cluster 9	365	3.97%	83	4.35%	282	3.87%
Cluster 10	648	7.05%	165	8.65%	483	6.63%
Cluster 11	818	8.90%	153	8.02%	665	9.13%
Parking	6649	72.33%	1571	82.38%	5078	69.70%
No parking	2544	27.67%	336	17.62%	2208	30.30%
Sample	9193		1907		7286	

Notes: 1) Green samples only include silver-level rated green buildings.
2) Year attributes (Years 2013 to 2018), locational attributes (Clusters 1 to 10) and whether there is a parking space (parking) are dummy variables.

Table 6 Continuous description statistics of transaction samples

Variable	Green building				Non-green Building			
	Average	Std	Min	Max	Average	Std	Min	Max
LN(Price)	17.050	0.662	15.565	19.045	16.723	0.608	14.771	19.294
Area	212.582	96.410	49.980	573.400	169.395	87.462	31.400	749.810
Floor	11.273	6.616	2.000	29.000	8.550	4.907	2.000	29.000
RDTR	407.195	290.644	0.000	946.904	395.508	290.240	0.000	996.050
RS2	6.978	2.203	2.040	9.000	-	-	-	-
RS3	4.683	2.989	0.000	9.000	-	-	-	-
RS41	3.226	1.320	1.500	9.540	-	-	-	-
RS42	2.790	1.871	1.500	13.090	-	-	-	-
RS43	2.744	1.235	1.500	7.000	-	-	-	-
RS5	2.018	2.025	0.000	7.830	-	-	-	-
RS6	1.214	1.296	0.000	3.210	-	-	-	-
RS7	2.552	3.212	0.000	8.850	-	-	-	-
RS8	5.774	1.621	1.800	8.000	-	-	-	-
RS9	3.511	1.061	0.000	5.790	-	-	-	-
Sample	1907				7286			

Notes: 1. Green buildings only include silver-level rated green building.
2. Dependent variable (LN(price)), building attributes (Area, Floor and RDTR), and green attributes (RS2 to RS9) are continuous variables.
3. Area is building area. Floor is transfer floor. RDTR is the reverse distance variable which is the shortest distance from point of origin to MRT or train station minus 1000 meters.

4. Research Result

4.1 Green Premium

In Table 7, Model 1 shows the green premium effect, and Model 2 shows the feature premium effect. To observe the premium of green buildings and green attributes, this study uses year and locational attributes to control for time and spatial fixed effects, and building attributes as the micro factor. The results indicate that the premium rate of silver rated green buildings is approximately 4.3% compared with non-green buildings. Since 2014, New Taipei City has adopted silver rated green buildings as the basic requirement for large-scale developments. Therefore, it should be reasonable that the green premium is lower than the generally recognized urban renewal reward value of 6%. The premium rate of 4.3% is comparable to the empirical results in Deng et al. (2012)

of 4%, Kahn and Kok (2014) of 4.7%, and Shewmake and Viscusi (2015) of 5%. However, it is still lower than Bond and Devine (2016) at 8.9% and Chen et al. (2018) at 7.5%.

Table 7 Empirical results of silver rated green premium and silver rated green features premium

Variable		Silver rated premium Model 1			Silver rated features premium Model 2		
		Estimated β	Standardized Coefficient	Significant	Estimated β	Standardized Coefficient	Significant
Intercept		15.1253		0.0000	15.3015		0.0000
Year	Year 2013	0.0840	0.0483	0.0000	0.1030	0.0584	0.0000
	Year 2014	0.1197	0.0665	0.0000	0.1184	0.0502	0.0000
	Year 2015	0.1029	0.0547	0.0000	0.1230	0.0524	0.0000
	Year 2016	0.0272	0.0154	0.0021	0.0959	0.0548	0.0001
	Year 2017	0.0343	0.0216	0.0001	0.1086	0.0752	0.0000
	Year 2018	0.0709	0.0390	0.0000	0.1334	0.0725	0.0000
Location	Cluster 1	1.4442	0.1279	0.0000	1.4170	0.1384	0.0000
	Cluster 2	1.0082	0.4370	0.0000	0.9655	0.2568	0.0000
	Cluster 3	0.9686	0.3404	0.0000	0.8738	0.4091	0.0000
	Cluster 4	0.7706	0.2774	0.0000	0.5763	0.2489	0.0000
	Cluster 5	0.8180	0.2719	0.0000	0.6560	0.3078	0.0000
	Cluster 6	0.6767	0.3426	0.0000	0.4801	0.2580	0.0000
	Cluster 7	0.4549	0.3501	0.0000	0.3470	0.2239	0.0000
	Cluster 8	0.4093	0.1507	0.0000	0.2893	0.1041	0.0000
	Cluster 9	0.2196	0.0677	0.0000	0.0437	0.0135	0.0552
	Cluster 10	0.1501	0.0607	0.0000	0.1125	0.0478	0.0000
Building Attribute	Area	0.0051	0.7274	0.0000	0.0049	0.7150	0.0000
	Floor	0.0032	0.0275	0.0000	0.0044	0.0442	0.0000
	Parking	0.0796	0.0562	0.0000	0.0337	0.0194	0.0005
	RDTR	0.0002	0.1002	0.0000	0.0002	0.0874	0.0000

(Continued…)

(Table 7 Continued)

Variable		Silver rated premium Model 1			Silver rated features premium Model 2		
		Estimated β	Standardized Coefficient	Significant	Estimated β	Standardized Coefficient	Significant
Green	Silver	0.0433	0.0278	0.0000	-	-	-
	RS2	-	-	-	-.0317	-.1054	0.0052
	RS3	-	-	-	.0054	.0243	0.0995
	RS41	-	-	-	-.0056	-.0112	0.0037
	RS42	-	-	-	-.0088	-.0250	0.0000
	RS43	-	-	-	.0267	.0498	0.0000
	RS5	-	-	-	.0206	.0632	0.0000
	RS6	-	-	-	-.0552	-.1081	0.0000
	RS7	-	-	-	-.0222	-.1076	0.0000
	RS8	-	-	-	.0291	.0712	0.0000
	RS9	-	-	-	.0232	.0372	0.0000
Sample		9193			1907		
Adj R^2		0.9137			0.9604		

Notes: 1. The dependent variable of both models is LN (total price).
2. The base year is 2012, and the base location is Cluster 11. Cluster 11 has the lowest average unit price as shown in Table 3.
3. Building attributes (Area, Floor Parking, and RDTR) are the continuous variables. We find significant building variables through trial and error.
4. Area is building area. Floor is transfer floor. RDTR is the reverse distance variable which is the shortest distance from the point of origin to the MRT or train station minus 1000 meters. A positive estimated coefficient value means that houses that are closer to the MRT or train station have a higher price.

4.2 Green Attributes and Green Premium

Model 2[2] of Table 7 shows that not all indicators have a positive relationship with the transaction price. Greenery (RS2), building envelope design (RS41), energy conserving air conditioning (RS42), construction waste reduction (RS6), and indoor environment quality (RS7) have a negative impact on real estate prices, while soil water retention (RS3), energy conserving indoor lighting (RS43), CO_2 emission reduction (RS5), water conservation (RS8) and sewage and garbage improvement (RS9) have a positive impact. It can be seen from the standardized coefficients that greenery (RS2), construction waste reduction (RS6), and indoor environment quality (RS7) have the greater impact on prices

[2] The purpose of this study is to analyze the direction and degree of the impact of green features on price. The VIF value of 2017 is only slightly higher than 10. The problem of collinearity can be ignored.

for these indicators, but unfortunately it is a negative impact. Table 4 shows that almost all green building projects have adopted a greenery design (RS2), which has the highest points. But unfortunately, the impact on price is negative.

Developers are least invested in building envelope design (RS41), energy conserving air conditioning (RS42) and construction waste reduction (RS6). This is especially the case for RS41 and RS42, and although they are required to obtain the green building label, the point ratio obtained is less than 25%. The empirical results in Table 7 show that the impact of these indicators on prices is in line with expectations and all are negative. In addition, building envelope design (RS41), energy conserving air conditioning (RS42) and indoor environment quality (RS7) are indicators with high scores in green building label designs: 14, 12, and 12, respectively. However, their average points for silver rating features are only 3.2281, 2.7497 and 5.7917, or only 23.06%, 22.84%, and 48.26% (Table 4) correspondingly. The first two are required green attributes in the EEWH system, so all projects have incorporated these features, but the degree that they are incorporated in their design is very low. Although indoor environment quality is given a higher point, the developers do not pay too much attention; only 44.61% (58/130) of the developers focus on indoor environment quality (RS7), and the silver rating strength is only 48.26% (Table 4). Corresponding to the empirical results in Table 7, the impact on price is also negative.

The points for CO_2 emission reduction (RS5) and indoor environment quality (RS7) in green building designs are lower than 50% (Table 4), but their impact on price is positive. Both the government and developers should pay more attention to these two indicators in order to increase the marketability of green building features.

4.3 Green attributes premium in the Triple Bottom Line

According to Robinson et al. (2016), each indicator is assigned a unique classification, as shown in Table 2. Planet oriented green attributes have environmentally sustainable benefits, such as: soil water retention (RS3), building envelope design (RS41), energy conserving air conditioning (RS42), Co2 emission reduction (RS5), construction waste reduction (RS6), and sewage and garbage improvement (RS9). Profit oriented green attributes have economic value, such as: indoor lighting (RS43) and water conservation (RS8). People oriented green attributes have direct benefits to users, such as: greenery (RS2) and indoor environment quality (RS7). The sub-total scores for these three attributes are 65, 14 and 21, respectively. The standardized coefficients for each indicator are shown in Table 8.

Table 8 Premium for planet, profit and people oriented attributes

Variable		Estimated β	Standardized (Silver only)	Number of applications (a)	Quantity% (a/130)	Average point(b)	Max Score (c)	Degree% (b/c)
Planet	RS3	0.0054	0.0243	100	76.92%	5.7307	9	63.67%
	RS41	-0.0056	-0.0112	130	100.00%	3.2281	14	23.06%
	RS42	-0.0088	-0.0250	130	100.00%	2.7497	12	22.84%
	RS5	0.0206	0.0632	70	53.85%	3.9903	8	49.88%
	RS6	-0.0552	-0.1081	45	34.62%	2.5658	8	32.07%
	RS9	0.0232	0.0372	122	93.85%	3.2664	5	64.94%
Profit	RS43	0.0267	0.0498	130	100.00%	3.0272	6	50.32%
	RS8	0.0291	0.0712	130	100.00%	5.7096	8	71.27%
People	RS2	-0.0317	-0.1054	127	97.69%	6.8495	9	76.11%
	RS7	-0.0222	-0.1076	58	44.62%	5.7917	12	48.26%

Notes: The indicators are as follows: RS2: greenery, RS3: soil water retention, RS41: building envelope design, RS42: air conditioning, RS43: indoor lighting, RS5: CO2 emission, RS6: construction waste reduction, RS7: indoor environment quality, RS8: water conservation, and RS9: sewage and garbage improvement.

Planet oriented green attributes have the most indicators, with positive and negative standardized coefficients. Soil water retention (RS3), Co_2 emission reduction (RS5), and sewage and garbage improvement (RS9) have a premium effect. Among them, CO_2 emission reduction (RS5) has the best effect, and for every additional unit, the price increases by 2.06% (Table 8). On the other hand, building envelope design (RS41), energy conserving air conditioning (RS42), and construction waste reduction (RS6) have discounts on prices, that is, more investment in these indicators means a more disadvantageous price. In the design criterion for building envelope (RS41), a glass curtain wall and high window opening rate are prohibited, but these conflict with the demand of users for a view of the outside environment. When developers encounter this problem, most of them will choose to accommodate market demand. Therefore, although the indicator is required, and the allocation score is as high as 14, the average strength of the case design is only 23.06%. It appears that there is a large gap of expectation between this design criterion and the market demand.

Furthermore, there is the same problem for construction waste reduction (RS6) and energy conserving air conditioning (RS42). The specification of the former is to minimize basement excavation but the demand for parking spaces is very high. Properties with parking spaces have a high marketability. This can be seen from Table 8, and although this indicator is required, and the allocation score is as high as 12, the average strength of the case design is only 22.84%. As for energy conserving air conditioning (RS42), users generally report that the air conditioning is inadequate and the heat causes discomfort (Chen, 2017). Therefore, few developers are willing to provide such a design, and this is found in only 45 of 130 projects. The average strength of the design is only 32.07%.

Developers are inclined to follow the preference of buyers. However, in order to obtain green building certification, the most economical way is to follow the requirements of the green building indicators of the EEWH system. From the above analysis, it appears that although some indicators have low-weighing scores, they have positive impacts on transaction prices; on the contrary, some of the weight of the indicators are high, but they do not meet the needs of buyers, therefore their impacts on prices are negative. This gap between the government focus on the EEWH and demand of buyers should be addressed, so that developers are willing to provide these green building features to meet both the EEWH requirements and buyer expectations.

As profit has economic value, developers consider the most worthwhile investment (Chen, 2017) to be in energy conserving indoor lighting (RS43) and water conservation (RS8). The former uses automatic detection systems, energy-saving lamps and other similar designs, and the latter uses water-saving appliances, swimming pool water treatment systems, etc., to reduce the utility cost of users, which is a direct saving for buyers. In Table 8, both indicators have positive impacts on transaction price. In other words, developers are willing to invest in these green building features and buyers are willing to pay higher prices.

The indicators of people oriented green attributes include greenery (RS2) and indoor environment quality (RS7). Users enjoy the aesthetics associated with greenery, and the living environment with better ventilation and lighting. Interior decor that uses non-toxic recycled building materials contribute to overall health and wellbeing. It is supposed that buyers in the market would like these green attributes very much. However, as Table 8 shows, the estimated values of these two indicators are negative, -3.17% and -2.22%, and the standardized coefficients are relatively high. Obviously, the merits of these two indicators are not recognized by buyers. Greenery (RS2) is an indicator that developers are very willing to incorporate as a design element (127/130), and the strength of this indicator is quite high (76.11%). However, for the sake of profitability, developers will note the marketability of greenery before they are willing to invest a large amount of resources in this area. However, the empirical results in Table 8 show that there is a 3.17% discount for every additional unit of input. This may be due to the difference between the staged benefits of greenery to developers and buyers. Developers allow buyers to realize the benefits during the sales stage, but buyers see the maintenance costs during the operation stage. In addition, why is there a discount on indoor environment quality (RS7)? A possible reason is that in Taiwan, the design and installation of interior decorations are usually carried out by the buyers after occupation, and developers have less control over these criteria. This is especially the case for the high-end housing market in Taipei and New Taipei cities, so developers always provide dwellings without décor, in order for the price of dwellings to be reduced, which explains why only 58 of 130 projects focus on indoor environment quality as shown in Table 8.

The sewage and waste disposal improvement (RS9) indicator is generally regarded as a practical green design for users in Chen (2017); however, this indicator contributes very little to the price of green buildings because it is a basic requirement for most constructions, therefore, its premium rate only reaches 2.32%.

Chen (2017) infers that the possible reasons might be poor impressions of air conditioning energy control systems and thermal insulation facilities since most occupants may have the misunderstanding that the living environment in ecological buildings can tend to be hot. In addition, the relevant green design features like increasing window to wall ratio and sunshade devices often reduce the scenery attractiveness of the buildings, and this sort of green attribute marketing is hardly acceptable to the developers. Hence, the high weight score points allocated by the government for these two sub-indicators would not accurately reflect the amount of green premium. The authorities should advocate for planning mechanisms in relation to the energy saving benefits of building appearance and air conditioning in the future. When it comes to water conservation, its competitiveness might be reduced due to common installation of water saving devices in most buildings. Furthermore, because of high maintenance costs of reclaimed water systems and low water usage charges in Taiwan, residents do not reap the benefits of water conservation directly. This results in a premium rate decrease of 2.91% per point.

5. Conclusion

The EEWH system of green building certification system has been in effect for over two decades in Taiwan already; however, the promotion of ecological constructions is not quite effective due to the gaps in expectation amongst buyers, developers and the government. In this study, the influence of green ratings, energy savings in terms of public transit and considerations of the developers in terms of green premium are analyzed through regression models. With reference to the effect of green attributes on premium for ecological structures, a people oriented green attribute - indoor environment quality has the highest contribution to green premium, but developers do not really incorporate this attribute and its application is found in only 48.26% of the projects. Based on the findings of this study, it is recommended that the weighing of indoor environment quality in EEWH systems should be increased in order to convince developers to put more effort in design features that focus on indoor environment quality.

The price discounting effect on water-preservation to the green premium amount is ascribed to the popularity of installing water saving devices in most buildings, the low water usage fees, and high expenditures of maintaining a reclaimed water system (Chen, 2017). In addition, in the design phase, developers may have installed water saving equipment, but then transferred the cost to the operation phase so that buyers face high costs of maintenance. It is recommended that water conservation features should be incorporated in the property management plan of green buildings at the design stage so that the water-saving practice will be reflected in the green building prices.

The findings of this study suggest that such indicators need to be modified so that they are in line with buyer preferences, which will incentivize developers to build more buildings that incorporate green attributes that are more valued by buyers.

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