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Applying Linear Hedonic Price Model to Measure Impact of Responsible Property Investment Factors on Thai Condominium Projects

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Abstract

Even though most real estate developers in Thailand acknowledge the significance of sustainability in terms of increasing the value of the project, the complexity of the investment for sustainability discourages them from pursuing it due to the higher investment costs. This research aimed to estimate the magnitude of Responsible Property Investment (RPI) factors on the condominium value for a condominium in Bangkok. A Linear Hedonic Price Model was created from the data collected from 167 secondhand condominium units in Bangkok, and it was discussed so conclusions and recommendations could be drawn for concerned stakeholders. This research quantitatively assessed the impact of RPI on the value of real estate projects. It was found that RPI can contribute more than half of a condominium's value. Four subgroups of factors, *i.e.*, Mass Transit Accessibility, Sustainability Technology, Domestic Transportation Accessibility, and Building Environmental Impact, contributed 51.69% of all the model weights. The results give real estate developers and investors information about the linkage between developing condominium projects with RPI and the increasing value from the customer's point of view. At the same time, designers and policymakers can use the results as a guideline for supporting sustainable development.

Keywords: Responsible property investment; Condominium project; Hedonic price model; Sustainable development.
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1. Introduction

According to O'Mara[1] and Yong & Pearce,[2] organization leaders must find an effective strategy to ensure the competitiveness of their firms. This research aimed to fill the gap between the strategic environment and business demands by exploring their relationships via a new sustainable concept called Responsible Property Investment (RPI). RPI helps organizations gain financial perspective while it also helps organizations improve their cost structure, increase their asset utilization, enhance customer value, and expand revenue opportunities.[3-6] In theory, RPI improves the internal growth structure of real estate development. Engaging with the RPI concept helps improve the performance of the building and increases the customers' satisfaction and the social consciousness of investors.[4,7,8] However, several case studies explored in the research suggest that sustainability in real estate development challenges stakeholders.[9,10]

Therefore, a group of investors and academics gathered to solve this problem by creating a universal assessment tool to measure portfolios using a RPI scoring model.[11] RPI has become the leading measurement tool for global finance for sustainable development, which has unfolded recently under the United Nations Environment Programme Finance Initiative.[12] It intends to simplify the fundamental factors of responsibility that influence the investment process. Several studies were performed by integrating RPI in building assessment tools to disrupt traditional real estate practices by incorporating environmental, social, and governance factors into investment and development processes.[13-15] Then, the concept has been proven by several leaders in the real estate business that it can have a significant impact and gain

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recognition in the international community.[16]

Several leaders within the real estate industry recognize the risks and benefits of their developments; as a result, they focus on energy efficiency, resource preservation, climate change, and human health.[17-19] From the studies about the use of RPI in the development process in several countries,[20-22] it was found that the effort to embed sustainability principles into real estate development applications requires intense involvement and participation in the construction, design, and finance industries. Polesello & Johnson[23] concluded that the most practical procedure for reducing energy consumption in the building is to integrate an energy plan with a policy direction in the design phase.

Still, there need to be more academic studies on sustainable development to help increase sustainable real estate development, especially in the residential market. The literature also revealed that most developers acknowledge the significance of sustainability in increasing the project's value.[24] However, the complexity of the investment for sustainability discourages them from pursuing it due to the perceived higher investment costs.[25] The problem was increased in many countries due to the limitation of green procurement knowledge, ineffective government policy, no economic incentives for investors, and unattractive monetary returns.[26,27] From a literature review, it was found that the impact of RPI on a residential project still needs researching further. It needs more reliable information, so investors may perceive that the benefit of RPI practice may contribute favorably only to external stakeholders, so they may be inclined not to adopt RPI.

In Thailand, the condominium is the residential type with the highest number of units launched in 2022, with 51,635 condominium units (51.50% of the total 100,269 launched units from all residential types).[28] This ratio was similar to that of the previous period (2020), which was the year that the condominium business began to be seriously damaged by the COVID-19 pandemic crisis. During the crisis, the number of condominiums launched and transferred dramatically dropped due to decreased buying power, the economic confidence of Thai customers, and the disappearance of foreign customers due to lockdown pandemic control measures.[29] Most condominiums in Thailand are located in Bangkok, the capital city of Thailand, which consists of medium to very high population density areas, making RPI a very important issue for developers.[30]

Therefore, this research aimed to estimate the magnitude of RPI factors to the value of a condominium unit in Thailand. The results will show real estate developers, as well as investors, the linkage between developing condominium projects with RPI and increasing the value from the customer's point of view. In contrast, project designers and policymakers can use the results as a guideline for supporting sustainable development.

2. Related literature and former research work

2.1 RPI and real estate development

The subject is new to several countries; however, several organizations have already invested in RPI. RPI aims to put sustainability issues into investment.[3,4] The movement began in 2006 due to real estate demand. Later, the Wall Street Journal recognized the movement as a sustainable potential investment.[3] On the global stage, world leaders are aware of the impact of real estate development on the environment. In 2015, the Paris Agreement was signed between 195 country leaders to prevent global warming.[31]

From the outlook of the global environment and social impact on the real estate investment industry and the relationship between population and the real estate market with the estimation that, in 2050, the real estate industry will be responsible for 40% of the world's energy and 30% of its greenhouse gases.[4] Cogan[32] revealed that the real estate industry sector would significantly limit climate change because climate change threatens the industry.[33,34]

The foundation of RPI originated from Corporate Social Responsibility (CSR), which was created to address matters like environmental, social, and governance (ESG) in investment decision-making. According to several research works, RPI will help refine the social impact elements of decision-making in real estate development.[5,35-38] Today, RPI is growing from innovating and integrating ESG criteria to real estate development investment. The final goal is to increase the building lifecycle's financial performance and create a collaborative framework with the policymaker and the investment community.[39] Both RPI and CSR focus on considering the social and environmental consequences of business choices.

On the other hand, CSR is a more comprehensive idea that includes a business's dedication to moral behavior and social and environmental responsibility throughout its operations. Creating long-term value for investors and society is more of a focus of RPI than CSR, which is frequently viewed as a moral or charitable undertaking. RPI is a more specialized and successful approach for businesses in this area since it particularly targets the real estate sector.[24,40,41]

Due to the advantages of RPI, several organizations have verified that RPI attracts the investment community because the program comprehends the minimum legal requirement on social, environmental, and advanced issues beyond these

obligations. With the minimum legal requirement, RPI is neither moral nor philanthropic. Instead, it supports the business decisions that generate advantages and value for society while the fundamental focus is still on the financial returns. Investors genuinely believe that RPI helps improve the social and environmental predicament while lowering the risks and optimizing the opportunities.[42-44] Due to RPI's initiative, investors are now evaluating their management of property portfolios under RPI standards, such as energy use, water efficiency, waste management and recycling, health and safety, worker productivity, degree of tenant engagement, and social contribution.[45,46] RPI has the potential to evaluate the performance of the property.

Several scholars support this new approach because they believe that the RPI approach will decrease the environmental impact by supporting the investment in green buildings, greenhouse gas emissions, energy, and water consumption that will help businesses save costs on energy consumption as well as communicate their market positioning.[6,9] Kats[47] reported a 1-2% increase in cost for silver LEED buildings that can contribute to 30% better efficiency and $60,000 per year savings for a 100,000 ft^2 office building. In comparison, Yale University[48] revealed an 11.6% decrease in operating expenses throughout the life cycle of a green building. In Thailand, there were cases brought by the people who live around condominium projects, with NGOs in some cases, due to the impacts caused by the project development, *e.g.*, vibration, landslides, dust, sunlight blockage, or wind blockage.[49] In the big picture of investment, several financial crises have occurred due to unsustainable investment in properties,[50] such as the 1997 Asian Financial Crisis (or "Tom-Yam-Kung Crisis") in Thailand that expanded to several other countries[51] and the Subprime Crisis in the United States,[50] in which many people, as well as the international economic system, suffered from over-speculative investment in the real estate segments. Hiep *et al*.[52] also explained the over-speculative situation in Vietnam due to unsustainable investment in real estate in 2008. They suggested several measures to develop ethical standards and responsible practices, invest in low-impact technologies, guarantee legal aspects, deliver several financial solutions, support by government, and engage with social and environmental programs.

In applying RPI, there is no limit to the scale of the assets to which RPI can apply. The development can be from a small apartment to a megaproject. It is the same idea as selecting the "best in class" approach to property selection, like the Dow Jones Sustainability Index and real estate. A French real estate company, Caisse des Dépôts, practiced Corporate Social Responsibility (CSR) and Socially Responsible Investment (SRI) and improved the energy and carbon performance during the operational stage by 50% and by 35% for the entire life cycle of buildings.[42] Another example of RPI concepts has been included in the investing strategy of UK-based real estate investment company Hermes Real Estate Investment Management. The company prioritizes long-term, sustainable profitability by considering governance, social, and environmental considerations when choosing and managing properties. The last example, RPI, was established by the UK Green Building Council (UKGBC), which offers advice to real estate investors on applying RPI principles to their investment plans. Environmental performance, social impact, and governance are just a few of the Many topics covered in the toolkit.[53]

Furthermore, several investors and fund managers use RPI criteria to set acquisition standards. Some independent third-party ratings systems, like Building Research Establishment Environmental Assessment Method (BREEAM), Leadership in Energy and Environmental Design (LEED), Comprehensive Assessment System for Built Environment Efficiency (CASBEE), and National Australian Built Environment Rating System (NABERS) were adopted for this purpose (UNEP-FI, 2007).[45]

RPI also has some drawbacks. RPI challenges investors to decide which approaches are more appropriate for real estate investment, conventional or sustainable ones, because developing a green building means a higher cost of development, leading to the product's higher price. Compared to other sustainable investment strategies, Responsible Property Investing (RPI) has disadvantages, such as greater upfront costs for creating green structures or putting sustainable practices into place, which may prevent investors who prioritize quick profits. Also, there needs to be uniformity in measurement and reporting, and the idea is still relatively new. Investors may need help comparing the performance of various RPI-focused investments. Also, most investors could emphasize sustainability, while some might prioritize financial returns, creating significant conflicts in their investment decisions. Finally, there needs to be more awareness in the investor community's understanding of RPI.[7,54-56]

In addition, it was found that sustainable indicators mainly focus on the performance of the building but not the investment. From the literature review, a research gap was found. No study can link RPI adoption in residential real estates projects, such as condominium projects, and the increasing value of the projects. The price of the condominium units reflects the value of the condominium project from the customers' point of view. Therefore, the magnitude of the

impact of RPI-related factors of a condominium project on its unit prices was examined in this research.

2.2 Factors affecting responsible property investment in condominium projects

Dendoung *et al*.[57] gathered 50 independent factors from a literature review, especially from prior studies of RPI and condominiums in Thailand, and categorized the factors into three groups with a total of 13 subfactors: Unit Characteristic Groups (Unit Preferences, Unit's Strategy, and Unit Qualities), Building Characteristic Group (Building Area, Building Height, Building Density, Building Amenities, Building Efficiency, and Building Technology), and RPI Characteristic Group (Public Amenities, Vehicle Accessibility, Mass Transit Accessibility, and Domestic Transportation Accessibility). These factors were linked to socio-economic, location proximity characteristics, sustainability characteristics, and energy efficiency factors of RPI. The list of the RPI factors is shown with their means and standard deviations in Section 4.1 Description of Research Data.

Reviewing several literature studies, several factors affecting real estate property investment were also found. For unit characteristics, there are several factors mentioned in the literature, *i.e.*, size of the unit,[58,59-61] number of bedrooms,[58,59] number of bathrooms,[58] room utilities,[58] view from the room,[60-62] floor,[60,61] and neighborhood.[61] In addition, there are several factors concerning the building characteristics, such as building area,[58,62] number of stories,[58] system works,[58] green area,[63] open space,[62,63] building density,[63] design of building,[62] building common facilities,[59-62] building utilities,[62] building age,[59-61] and building structure.[60] The last group, RPI characteristic factors, concerns sustainable real estate investment. There are several factors, such as location.[58,59,60,63] quality of surrounding public facilities,[58,59] and transportation.[61,62] Table 1 shows the list of factors acquired from the literature review.

From the literature review, several techniques could be applied to find the important weights of the factors contributing to a required result in real estate research, such as Multiple Regression Analysis (MRA),[64-66] Structural Equation Modeling (SEM),[67] Analytic Hierarchy Process (AHP),[68] Analytic Network Process (ANP),[69] and Technique for Order Preference by Similarity to the Ideal Solution (TOPSIS) Technique.[70] However, the literature review also showed that RPI impacts can be measured in terms of financial impacts. Fuerst & McAllister[71] investigated the price effects of environmental certification on commercial real estate assets using Hedonic Regression Analysis. Giudice *et al*.[72] proposed a theoretical model for evaluating environmental externalities based on the analysis of real estate prices. Sah, Miller & Ghosh[73] compared Jensen's Alpha, a risk-adjusted performance measure that shows the difference in how much a company returns versus the overall market, between green Real Estate Investment Trusts (REITs) and non-green REITs, and found that the green REITs had higher returns on assets. In this study, Linear Multiple Regression Analysis was selected as the analysis technique because it can generate a hedonic price model that clearly shows the important weight of the factors on the project value.

3. Research methodology

This research was performed by applying the Linear Hedonic Price Model Analysis to the RPI factors gathered from the literature review to estimate the RPI factors' impact on the

Table 1. List of factors from literature review.

Author	List of Factors
Feng & Humphreys (2018)[58]	Detailed housing characteristics include lot size, building square footage, number of stories, number of bedrooms, bathrooms, fireplace, and central air conditioning. The independent variables that detail the neighborhood characteristics are school quality, environmental quality, and the distance between each house and facility.
Cho, Bowker & Park (2006)[59]	Housing unit, area, lot size, building age, bedrooms, garage, fireplace, external quality, and swimming pool. Distance variables are to downtown, waterbody, green parkway, and railroad.
Jim & Chen (2010)[60]	Housing price, housing structure, age, floor area, club, pool, location of electric train, park, and view.
So, Tse & Ganesan (1997)[61]	Size, age, floor level, view, accessibility to transportation, recreational facilities, local amenities, as well as overall quality of neighborhood.
Asmawi *et al.* (2018)[62]	Strategic location, size of built-up area, attractive house design, provision of garage and patio, good view, adequate infrastructure and utilities, adequate open space, and road and transportation network.
Bera *et al.* (2018)[63]	Wetlands, green space, open space, built-up growth, distance to metro, distance to bus stop, shopping mall (dummy), vegetation edge density, distance to open space, distance to wetland, road connectivity, distance to railway, and distance to CBD.

condominium value by the coefficient of the RPI Characteristic Group.

The Hedonic Price Model is a model for estimating the latent price of goods by multiple regression analysis, as in the following Equation (1):[74]

$$Price = f(Physical\ Characteristics,\ Other\ Characteristics) \quad (1)$$

Several functions can be used as the Hedonic Price: linear and non-linear functions. In this research, the linear form of the Hedonic Price Model was adopted. The Linear Hedonic Price Model can be formulated as in Equation (2). The Ordinary Least Square technique was used to find the coefficients of the equation. Stepwise Regression chose the independent variables. From this method, variables are added to the equation variable-by-variable and examined whether the variable shall be kept in the equation. This method allows only the important variables to remain in the equation. Finally, the model accuracy can be assessed by the Adjusted-R^2 value.[74]

$$Price = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + \ldots + b_nX_n \quad (2)$$

where, b_0 = Constant, $b_1, b_2, b_3, \ldots, b_n$ = Coefficients of factor 1, 2, 3, …, n.

The research methodology consisted of (1) Reviewing the literature on RPI factors concerning condominium projects. Table 1 shows the list of the factors acquired from each literature source. (2) Collect data on 167 secondhand condominium units for sale from 22 condominiums located in Bangkok, as shown in Fig. 1, from secondhand condominium marketing websites during 2018-2019 (the price and the unit or project characteristics), the Environmental Impact Assessment (EIA) reports, downloaded from the online data center of Thailand's Office of Natural Resources and Environmental Policy and Planning[75] (technical project characteristics) and a navigator website (the location and the distances to important places). Table 2 summarizes the acquired data's minimum, maximum, and mean values and standard deviation. (3) Create Linear Hedonic Price Model. (4) Discuss, conclude, and give recommendations to the concerned stakeholders. It should be noted that secondhand condominiums were used instead of the new ones as their prices reflect their actual values.

The literature review on the topic suggests that the analysis of the tangible value that influences residential property values can rely on the hedonic price model.[64-66] The review also suggests that using the Exploratory Factor Analysis and Hedonic Price Model with Stepwise Multiple Regression can provide significant variables that trigger condominium value changes in Bangkok.[76-78] Therefore, this research will be conducted using the Linear Hedonic Price Model and Stepwise Multiple Regression to measure the influence of the independent variables on the dependent variable. The Adjusted R^2 coefficient will indicate the correlation level of influence of the independent variables on the dependent variable.[74] It should be noted that the authors selected the Linear Hedonic Price Model because of its ability to find the important weight (coefficient) of each factor pre-grouped from the literature review process. In contrast, some techniques, such as Exploratory Factor Analysis (EFA), can also find the important weight of each group of factors, but the analysis shall group the factors. In this study, the factors related to the RPI shall be grouped.

Fig. 1 Location of condominium projects in Bangkok.

4. Research results and discussion

4.1 Description of research data

The list of the research data for all 50 factors from the literature review (as described in Section 2.2) and collected from secondhand condominium marketing websites, Environmental Impact Assessment (EIA) reports, and a navigator website (as described in Section 3) is shown in Table 2. Their minimum values, maximum values, means, and standard deviation values are also shown.

Table 2. Description of research factors.

Group	Subgroup	Variable	Minimum	Maximum	Mean	Std. Deviation
1. Unit Characteristic	1.1 Room Size	1.1.1 Room Types (Dummy)	0.00	1.00	N/A	N/A
		1.1.2 Ceiling Height (m.)	2.40	4.40	2.82	0.52
		1.1.3 Common Fee (Baht/Sq.m.)*	13,003.20	83,092.80	28,298.16	11,026.28
	1.2 Unit Decoration	1.2.1 Built-in Furniture (Set)	1.00	8.00	3.17	1.33
		1.2.2 Sinking Fund (Baht)*	6,000.00	98,920.00	30,136.64	13,219.81
	1.3 Unit Views	1.3.1 Unit Floor Number (No Unit)	1.00	47.00	13.11	8.98
		1.3.2 Facing View (Dummy)	0.00	1.00	N/A	N/A
2. Building Characteristic	2.1 Building Area	2.1.1 Building Living Area (Sq.m.)	3,120.50	51,586.09	16,701.73	11,855.67
		2.1.2 Building Gross Floor Area (Sq.m.)	4,920.08	92,118.02	29,907.73	20,919.04
		2.1.3 Parking / Road Area (Sq.m.)	576.96	21,223.03	5,796.45	4,835.16
		2.1.4 Number of Parking Lots (Vehicle)	36.00	635.00	239.89	144.55
		2.1.5 Number of Units in Building (Unit)	105.00	1,459.00	528.96	321.26
		2.1.6 Building Land Area (Sq.m.)	1,016.40	16,052.00	5,373.29	3,495.31
		2.1.7 Building Service Area (Sq.m.)	1,179.30	27,321.00	8,417.83	6,635.35
	2.2 Building Height	2.2.1 Building Height (m.)	22.85	190.00	82.47	48.79
		2.2.2 Number of Floors in Building (Floor)	7.00	50.00	24.93	12.99
	2.3 Building Density	2.3.1 Number of Units per Floor (Unit)	9.00	44.00	22.22	7.31
		2.3.2 Ratio of Parking to Unit (No Unit)	0.31	50.50	3.92	12.43
	2.4 Building Amenities	2.4.1 Number of Amenities (Amenity)	5.00	12.00	9.04	1.90
		2.4.2 Number of Basement Floors (Floor)	0.00	3.00	0.39	0.69
	2.5 Building Efficiency	2.5.1 Building Saleable Area Ratio (No Unit)	0.47	0.65	0.56	0.05

		2.5.2 Roof Garden (Dummy)	0.00	1.00	N/A	N/A
	2.6 Building Technology	2.6.1 Building Auto Parking (Dummy)	0.00	1.00	N/A	N/A
3. RPI Characteristic	3.1 Public Amenities	3.1.1 Distance to International Airport (m.)	17,100.00	48,900.00	30,288.55	7,148.48
		3.1.2 Distance to Community Mall (m.)	45.00	9,800.00	1,811.57	2,418.91
		3.1.3 Distance to Public Park (m.)	140.00	7,800.00	3,113.25	2,020.81
		3.1.4 Distance to Large-Scale Shopping Mall (m.)	89.53	5,100.00	3,570.15	2,514.26
		3.1.5 Distance to Hospitals (m.)	290.00	5,900.00	1,894.94	1,696.77
	3.2 Vehicle Accessibility	3.2.1 Public Company (Dummy)	0.00	1.00	N/A	N/A
		3.2.2 Distance to Express Way (m.)	50.00	12,700.00	1,589.55	2,353.76
		3.2.3 Distance to University (m.)	50.00	5,800.00	2,173.55	1,971.38
	3.3 Mass Transit Accessibility	3.3.1 Next to Mass Rail Transit (Dummy)	0.00	1.00	N/A	N/A
		3.3.2 Location of Building (Dummy)	0.00	1.00	N/A	N/A
	3.4 Domestic Transportation Accessibility	3.4.1 Public Transportation (Dummy)	0.00	1.00	N/A	N/A
		3.4.2 Distance to Domestic Airport (m.)	14,700.00	38,900.00	25,305.42	7,191.09
	3.5 Building Resource Consumption	3.5.1 Number of Building Residents (Person)	341.00	5,224.00	1,831.71	1,164.05
		3.5.2 Total Building Wastewater (Cu.m.)	55.41	882.26	306.40	194.95
		3.5.3 Total Building Garbage (Ton)	1.03	15.67	5.29	3.44
		3.5.4 Total Building Electricity Consumption (kWH)	536.00	4,463.00	2,177.52	1,024.61
		3.5.5 Building Open Space (Sq.m.)	10.00	4,153.60	1,790.59	1,225.44
		3.5.6 Overall Thermal Transfer Value (OTTV) (W-Sq.m.)	14.56	29.92	27.55	3.98
		3.5.7 Tree Cover Area (Sq.m.)	14.95	1,781.95	759.60	474.06
	3.6 Building Impact on Land	3.6.1 Total Building Water Consumption (Cu.m.)	1.00	651.00	318.68	185.11

	3.6.2 Building Footprint (Sq.m.)	5.00	5,949.62	1,760.06	1,172.64
	3.6.3 Building Open Space (Sq.m.)	10.00	4,153.60	1,790.59	1,225.44
3.7 Building Environmental Impact	3.7.1 Building Floor-to-Area Ratio (FAR) (No Unit)	3.37	11.93	6.55	2.35
	3.7.2 Building Open Space Ratio (OSR) (No Unit)	4.70	39.16	9.17	4.23
	3.7.3 Building Floor-to-Area Ratio (FAR) Bonus (Dummy)	0.00	1.00	N/A	N/A
3.8 Sustainable Technology	3.8.1 Electric Vehicle (EV) Charger (Dummy)	0.00	1.00	N/A	N/A
	3.8.2 Roof Thermal Transfer Value (RTTV) (W-Sq.m.)	5.13	10.00	7.33	1.45

Remark: * Specified in Thai currency, where 1 Baht = 0.029 US Dollar.[79]

All factors were categorized into two groups: (1) Not-related-to-RPI Factors, which can be further classified into two subgroups: building characteristic factors and unit characteristic factors, and (2) RPI Factors (RPI characteristic factors) in which the factor enhances the RPI in the project. They were further categorized into eight subgroups: (1) public amenities, (2) vehicle accessibility, (3) mass transit accessibility, (4) domestic transportation accessibility, (5) building resource consumption, (6) building impact on land, (7) building environmental impact, and (8) sustainable technology. Some factors have to be implemented during the design process and have direct impacts on the environment and adjacent community, such as tree cover area, Overall Thermal Transfer Value (OTTV), Floor-to-Area Ratio (FAR), Open Space Ratio (OSR), Roof Thermal Transfer Value (RTTV), and electric vehicle chargers. Some factors reflect the number and the behaviors of the condominium residents and impact the environment and adjacent community. These factors are the number of residents, the amount of wastewater and garbage, and water and electric consumption. In addition, some factors mainly concern the distances from the project to public amenities or transportation accessibility, such as hospitals, malls, parks, airports, expressways, and universities. If the condominium is located near such amenities, it can reduce energy consumption and carbon emissions due to transportation and support the workplaces nearby the project. Finally, the public company factor reflects the higher level of resource availability, as well as governance, of the company to protect the environment and social society.

It should be noted that some factors are dummy variables, for which there are only two possible values: "0" if not available and "1" if available. These factors are nominal variables, so they do not have a mean or standard deviation. In addition, all factors were standardized before being input into the model to ensure that all factors had the same mean and standard deviation and that the coefficients of all factors could be directly compared.[80,81] To standardize a factor, each factor's mean and standard deviation shall be calculated from all records. Then, the value of each record of the factor shall be subtracted by the mean and then divided by the standard deviation.[76]

4.2 Hedonic Price Model

The summation of the important weights of all concerned factors can assess the impact of RPI to Thai condominium projects. From the analysis, the linear-linear Hedonic Price Model with eight independent variables at the 95 percent confidence level has an Adjusted R^2 value of 0.628 with the test statistics, as shown in Table 3. An Adjusted R^2 value of 0.628 is acceptable when compared with former research work adopting the Hedonic Price Model in real estate business, such as Wu[64] (with Adjusted R^2 of 0.620), White & Mulligan[65] (with Adjusted R^2 of 0.570 to 0.583 range), and Zhang, Ye & Law[66] (with Adjusted R^2 of 0.311 to 0.686 range). Finally, the acquired model is presented as Equation (3).

(Price) = 0.386 (Room Size) + 0.346 (Unit Decoration) - 0.146 (Building Efficiency) - 0.293 (Building Height) - 0.385 (Mass Transit Accessibility) - 0.421 (Sustainability Technology) - 0.167 (Domestic Transportation Accessibility) - 0.280 (Building Environmental Impact) (3)

Table 3. Test statistics of variables.

Variable	Group	Coefficient	t-Statistics	Sig.	VIF
Constant	N/A	0.000	11.210	0.000	N/A
Room Size	Unit Characteristic	0.386	6.951	0.000	1.424
Unit Decoration	Unit Characteristic	0.346	6.139	0.000	1.642
Building Efficiency	Building Characteristic	-0.146	-2.760	0.006	1.217
Building Height	Building Characteristic	-0.293	-4.272	0.000	1.467
Mass Transit Accessibility	RPI Characteristic	-0.385	-6.457	0.000	1.566
Sustainability Technology	RPI Characteristic	-0.421	-8.215	0.000	1.294
Domestic Transportation Accessibility	RPI Characteristic	-0.167	-2.863	0.005	2.178
Building Environmental Impact	RPI Characteristic	-0.280	-3.656	0.000	2.704

From the model, there are four RPI factors comprising eight subgroups: (1) Mass Transit Accessibility, (2) Sustainability Technology, (3) Domestic Transportation Accessibility, and (4) Building Environmental Impact. The impact of these subgroups (ignoring the signs of the coefficients) contributes to 0.385, 0.421, 0.167, and 0.280, respectively. Comparing to the total weight of all subgroups (0.386 +0.346 +0.146 +0.293 +0.385 +0.421 +0.167 +0.280 = 2.424), the contribution of these subgroups to the price of the condominium unit is shown in Table 4.

Table 4. Impacts of the sustainable factors.

Factors	Weight of the subfactor	Contribution to the condominium price
Sustainability Technology	0.421	17.37%
Mass Transit Accessibility	0.385	15.88%
Building Environmental Impact	0.280	11.55%
Domestic Transportation Accessibility	0.167	6.89%
All RPI Factors	1.253	51.69%

From Table 4, all RPI Factors contribute to (0.385 +0.421 +0.167 +0.280) / (0.386 +0.346 +0.146 +0.293 +0.385 +0.421 +0.167 +0.280) = 51.69% of all weights. All RPI subgroups have negative coefficients. For mass transit and domestic transportation accessibility, negative coefficients show that a closer location to the transportation will enhance higher unit values. The negative impact of the subgroup "Building Technology" on unit prices can be explained by the relative prices of auto parking technology, which are higher than the increasing values, especially for condominiums with fewer units. Finally, the higher Building Floor Area Ratio (FAR) of the project shows a high-rise building with lower construction unit cost, even though the higher Building Open Space Ratio (OSR) shows a higher value of a condominium unit, leading to the negative coefficient of the Building Environmental Impact subgroup.

4.3 Practical application of results

When applying the research results to a real case, condominium developers should be concerned about the RPI factors, *i.e.*, mass transit accessibility, sustainability technology, domestic transportation accessibility, and building environmental impact, during the project design process to promote sustainability and increase the project value.

Projects should be located where residents can easily access mass transit systems, such as electric trains, buses, and taxis. In addition, if the project is located near a domestic airport, the buyers will be more willing to pay for a condominium that supports their commute. These requirements help reduce traffic, as well as it is energy consumption and carbon emissions.

The building environmental impact factors, *i.e.*, maximum Floor-to-Area Ratio (FAR), minimum Open Space Ratio (OSR), and FAR bonus, impact the condominium values and should be considered when designing a project. Developing projects with a suitable Floor-to-Area Ratio (including FAR bonus, if any) and enough Open Space Ratio shall enhance the quality of life of the residents in the buildings. However, this

design approach will lead to a higher cost than a project with a maximum FAR Ratio and minimum OSR. Then, the developer shall be able to create enough value to stimulate the willingness of their customers to pay.

Moreover, the project shall have a low Roof Thermal Transfer Value (RTTV) to keep the building cool, reduce electricity consumption, and enhance the residents' thermal comfort. Electric vehicle charging is another item that shows the project supports sustainability and impacts the condominium units' value.

As the data were collected in Bangkok, the capital of Thailand, the acquired results are best suited to Bangkok condominiums. However, the acquired factors are so general that the guidelines for developing condominiums can be applied to other countries, with changes in the weights of the factors.

5. Conclusion and recommendation

The results retained eight subgroups that impact the price of the condominium units: for the Unit Characteristic Group, the subgroups that met the criteria were: (1) Room Size and (2) Unit Decoration. In addition, there are two subgroups for the Building Characteristic Group, *e.g.*, (1) Building Efficiency and (2) Building Height. Finally, the four subgroups that are in the RPI Characteristic Group consist of (1) Mass Transit Accessibility, (2) Sustainability Technology, (3) Domestic Transportation Accessibility, and (4) Building Environmental Impact. These eight subfactors can explain 62.8% of the acquired data.

This research quantitatively assessed the impact of RPI on the value of real estate projects. It was found that RPI contributes more than half of a condominium's value. As to the RPI Characteristic Factors, these factors contributed 51.69 % of all model weights. This finding supports the real estate developers in developing condominium projects with RPI. Furthermore, the results corresponded with Pivo's top four results, which concluded that transit-oriented development, transit level of service, central location, dense mixed-use, and walkable were essential for RPI.[3] In addition, the results also corresponded with the Positive Impact Framework of UNEP-FI,[12] where all three groups impact the investment activities, and these factor groups strengthen the product's social factor and long-term environmental performance.

Real estate developers could use RPI factor groups / sub-groups as the starting point to fight an unknown future, instantly making them more competitive. The millennial generation puts a premium price on sustainability. Their requirements would become standard for all building owners. Several requirements, such as mass transit and domestic transportation accessible location, building design with suitable Floor-to-Area Ratio, enough Open Space Ratio, high heat transfer envelope thermal performance, and some sustainability technologies, such as electric vehicle charger, are required for condominiums in all countries. The goal is to balance being a responsible member of society without sacrificing the financial benefit. Applying RPI to an investment strategy would be a good start for investors, developers, investment firms, and policymakers to have a common ground for sustainable development. In summary, the RPI could bridge the gap between investors and the existing sustainability knowledge.

Finally, some research limitations and recommendations for further research work should be noted. Firstly, the sample size was quite small compared to the number of variables due to the study data having to be collected within condominiums with complete building data availability. Secondly, this study was done in a specific area (Bangkok, Thailand). The results can be generalized and applied to other areas. Interested academics, developers, or investors may apply the same research methodology in another area to acquire more specific results.

On the other hand, interested academics may find the impact of the RPI factors by other models and compare the acquired results with the results of this study. Finally, it was found that the Floor-to-Area Ratio and Open Space Ratio are the RPI factors that impact the price of condominiums. The optimum values of these ratios that balance the residents' quality of life and the developers' profitability should be further researched.

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Conflict of Interest

There is no conflict of interest.

Supporting Information

Not applicable.

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