

Assessing the effect of housing attributes and green certification on Malaysian house price

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Abstract

Purpose – Sustainability represents innovative elements in determining the profitability of real estate investments, among other factors, including the green component in real estate. Evidence from the literature has pointed out that incorporating green features into residential buildings can reduce operational costs and increase the building's value. Although green real estate is considered the future trend of choice, it is still being determined whether prospective buyers are willing to accept the extra cost of green residential investment. Therefore, this study aims to investigate the effect of housing attributes and green certification on residential real estate prices.

Design/methodology/approach – The impact of the housing attribute and green certification in the residential sectors was assessed using a transaction data set comprising approximately 861 residential units sold in Selangor, Malaysia, between 2014 and 2022. Linear and quantile regression were used in this study by using SPSS software for a robust result.

Findings – The findings indicate that the market price of residential properties in Malaysia is influenced by housing attributes, transaction types and Green Building Index certification. The empirical evidence from this study suggests that green certification significantly affects the sales price of residential properties in Malaysia. The findings of this research will help investors identify measurable factors that affect the transaction prices of green-certified residential real estate. These identifications will facilitate the development of strategic plans aimed at achieving sustainable rates of return in the sustainable residential real estate market.

Practical implications – Specifically, this research will contribute to achieving area 4 of the 11th Malaysia Plan, which pertains to pursuing green growth for sustainability and resilience. This will be achieved by enhancing awareness among investors and homebuyers regarding the importance of green residential buildings in contributing to the environment, the economy and society.

Originality/value – The regression model for housing attributes and green certification on house price developed in this study could offer valuable benefits to support and advance Malaysia in realising its medium and long-term goals for green technology.

Keywords Sustainability, Housing, Property, Real estate, Housing prices, Residential property

Paper type Research paper



Introduction

The concept of the sustainable residential properties has garnered considerable attention in real estate development, notably in the Malaysian market. This phenomenon stems from the growing global awareness of environmental issues and the demand for energy-efficient and environmentally favourable living spaces. The Malaysian Government's commitment to sustainable development and the promotion of green building projects has led to the emergence of green real estate as a vital field of study in the Malaysian real estate market. Malaysia's dedication to attaining carbon neutrality by 2050 is evident via the execution of several programmes specified in the Green Technology Master Plan Malaysia 2017 to 2030 and the 12th Malaysian Plan (2021 to 2025). This commitment encompasses the implementation of tax incentives and financial aid to support the procurement or development of residential dwellings that adhere to environmentally sustainable practices. In a survey report, [PwC \(2023\)](#) highlighted the importance of achieving net-zero carbon status, which has become a critical component of numerous regional investment initiatives. This subject is influenced by a combination of factors, including the acceptance of Paris Accord targets by governments, the needs of prospective tenants, and the recognition that building owners may face the risk of stranded assets if their properties do not align with investor mandates, both presently and in the future. Consequently, the significance of adhering to international reporting standards, including the European Union's sustainable finance disclosure regulation of 2021, is growing in importance.

However, it is essential to note that real estate carbon efficiency standards still need improvement at a regional level. Countries like Australia and Singapore are at the forefront of the market, exhibiting a significant lead over other nations. In contrast, the responsibility for compliance typically lies within international funds that primarily focus on purchasing properties at the higher end of the market. Unfortunately, there is a lack of emphasis on converting the numerous older buildings in Asia with high carbon emissions. Nevertheless, the notion has recently started to garner attention in certain regions, notably Japan and China. The compliance rate is expected to increase as the deadlines for 2030 draw nearer, particularly in emerging markets such as the Malaysian residential market. Therefore, this study seeks to examine the empirical evidence concerning the existence and magnitude of the price in the Malaysian residential sector. This study aims to quantify the impact of green features on property prices by analysing sales data, property attributes and environmental certifications while also considering other housing attribute implications for homeowners, developers and policymakers. As reported by [Jang *et al.* \(2018\)](#). A higher certification grade did not increase potential renters' desire to rent, however, possible tenants with higher levels of eco-friendliness were more eager to rent green-certified properties. Since 2010, [Pivo \(2010\)](#) study shows owners are collaborating through green leasing, incentives and instructional programmes. As Malaysia strives to strike a balance between rapid urbanisation and ecological preservation, comprehending the dynamics of the sustainable features has implications for the future trajectory of the real estate industry and the nation's sustainable growth. This research ultimately contributes to a greater understanding of consumer preferences, market trends, and the economic viability of incorporating environmentally sustainable elements into Malaysian residential properties.

Green real estate, or green building, is sustainable construction designed, constructed, operated and maintained with efficient use of resources, such as energy, water and materials, to reduce environmental and human health impacts ([Kim *et al.*, 2020](#)). This definition encompasses the concepts of prioritising efficient energy and water consumption and addressing environmental concerns from building impacts. Accordingly, the United Nations Environment Programme defines "green" in real estate as a complete commitment to both social and environmental aspects that result in low-carbon development or

sustainable development [United Nation Environment Programme (UNEP), 2011]. Green real estate investment is projected to grow steadily in the coming years, as evidenced by the increase in green real estate development projects since 2009 and the rising trend in the number of certified green construction projects (Ajibola *et al.*, 2019).

Environmental sustainability in Malaysia

The publication of the Brundtland Commission report heightened legislators' and policymakers' concerns about sustainability. Triple bottom line sustainability encompasses a spectrum of social, environmental and economic concerns [Royal Institution of Chartered Surveyors (RICS), 2011]. The Brundtland Commission (1987) defined sustainable development as "development that meets the needs and aspirations of the present without compromising the capacity of future generations to meet their own needs". Consequently, socioeconomic development objectives must be defined in terms of sustainability. Other prominent international professional bodies, including the Vancouver Valuation Accord, are committed to integrating sustainability into valuation practices and mainstreaming sustainability (RICS, 2011).

The Malaysian Government presented the 12th Malaysian Plan (2021–2025) on 27 September 2021, with advancing sustainability as one of the three central themes. Environmental sustainability, including the blue economy, green technology, renewable energy and climate change adaptation and mitigation, is a component of the 12th Malaysian Plan. Among the critical performance indicators are a reduction of up to 45% in the intensity of greenhouse gas emissions to gross domestic product by 2030 in accordance with the Paris Agreement and the proportion of renewable energy in Malaysia's total installed capacity reaching 31% by 2025. In accordance with becoming a carbon-neutral nation, the focus will also be on devising instruments for climate action, including introducing carbon pricing, such as a carbon tax and emission trading scheme (Economic Planning Unit, 2021).

Green rating system in Malaysia

Numerous developed nations have adopted the green building concept. According to the World Green Building Council (2021), 56 rating tools have been developed to evaluate the environmental performance of buildings. These rating tools include leadership in energy and environmental design and Energy Star in the USA, building research establishment environmental assessment method in the United Kingdom, Green Star in Australia, BOMA-Best in Canada, the Green Mark scheme in Singapore and the green building index (GBI) in Malaysia. The climate, economy, and culture of a location influence the adoption of distinct building guidelines and rating systems. GBI is Malaysia's environmental design and building performance evaluation system. The Pertubuhan Arkitek Malaysia and the Association of Consulting Engineers Malaysia created the rating system in 2009 to steer the Malaysian real estate industry towards greater environmental consciousness. Since 2013, up to 389 GBI projects have been certified as green, including mixed developments, commercial properties, office towers and residential buildings.

GBI offers developers guidelines for incorporating sustainable elements into residential and commercial development. GBI rating systems prioritise energy efficiency, internal environmental quality, sustainable site planning and management, materials and resources, water efficiency and innovation for residential green buildings (GBI, 2020). The elements and maximum points for residential new construction criteria are displayed in Table 1. If the criteria for the sustainability elements have been met, GBI will issue a green certification. Some of the approved initiatives have received green township certification. A green or sustainable community must be planned and constructed using efficient resources that address environmental, social and economic concerns (GBI, 2020). Six fundamental categories have been developed to address the

delivery of a more sustainable community: Climate, Energy and Water, Ecology and Environment, Community Planning and Design, Transportation and Connectivity, Building and Resources and Business and Innovation are the categories included in the GBI classification: Platinum (86–100 points), Gold (76–85 points), Silver (66–75 points), Certified (50–65 points).

Multiple completed green residential communities in Malaysia are primarily located in Selangor (central region), Johor (southern region) and Penang (Northern region). With certification, purchasers can verify the sustainability features of their home, allowing them to determine whether investing in certified green residential property is a wise decision. The rising trend of green real estate investment parallels investors' rising ownership of green buildings.

Literature review

The housing market in Malaysia plays a crucial role in the country's economy, making significant contributions to economic expansion and fulfilling the housing needs of a substantial population. Based on data provided by the National Property Information Centre, the aggregate value of property transactions in Malaysia in 2022 is RM179.07bn, of which 52.6% is residential property with RM94.28bn. The number of transactions of residential property experienced an increased by 22.3% from 198,182 in 2021 to 243,190 in 2022 [National Property Information Centre (NAPIC), 2023], implying increasing demand for housing market in Malaysia. Furthermore, rapid population growth in Malaysia has increased the need for more housing, commercial structures, social spaces and infrastructure. Thus, the Malaysian Government is committed to providing suitable, affordable and high-quality housing. The occurrence of a surplus of housing amidst high demand for housing strongly indicates that the existing supply does not align with the housing preferences of potential buyers, implying the importance of the actual conditions and trends in housing demand prior to introducing new supply to the market (Yip *et al.*, 2021). In Malaysia, the green residential market is gaining momentum, and there is a growing awareness of the significance of sustainability features in residential properties. In the future, the market is anticipated to expand, creating opportunities for investors seeking high returns.

Determinants for price of residential properties

Globally observed in real estate markets, several factors have a direct bearing on the Malaysian house price. Factors that contribute to the house price include:

- Types of properties (landed vs strata);
- Housing attributes (number of storeys, built-up area and land area);
- Transaction types (new sales from developers); and
- Green certification.

No.	Item
1	Energy efficiency (EE)
2	Indoor environmental quality (EQ)
3	Sustainable site planning and management (SM)
4	Material and resources (MR)
5	Water efficiency (WE)
6	Innovation (IN)

Table 1. Assessment criteria for residential new construction (RNC)

Source: GBI (2020)

These factors influence the dynamics of the house price in the Malaysian real estate market. Government incentives and regulations, along with the growing environmental consciousness and desire for sustainable living spaces among purchasers, contribute to the premium. As the market evolves, real estate professionals, developers and policymakers seeking to capitalise on the potential benefits of sustainable development must grasp these factors. Green products are often associated with features like energy efficiency, recyclability, reduced emissions, as well as consumer preferences and the potential trade-offs consumers are willing to make in exchange for health benefits (Zhang and Dong, 2020).

Types of properties

Landed vs strata. In recent years, the global shift towards sustainable development has spurred increased interest in the implementation of the sustainable features within the real estate sector. The house price is significantly influenced by the category of property. The adoption of sustainable practices within landed properties, such as single-family residences, typically has greater potential for incorporating green elements, such as gardens, solar panels and rainwater collection systems. Studies indicate that the adaptability of sustainable technologies to different property types can significantly contribute to resource efficiency and reduce environmental impact (Abdulai and Awuah, 2021). Condominiums and other strata properties may prioritise energy-efficient building designs. According to Ghazali *et al.* (2017), the vertical orientation of high-rises offers the potential for efficient energy utilisation through strategies like vertical photovoltaic systems. Hence, the high population density of these properties can amplify the impact of energy-saving initiatives. The distinctive environmentally friendly characteristics of each property type can influence purchasers' perceptions of sustainability and, consequently, property values. Elaouzy and El Fadar (2022) revealed that most passive strategies have proven to be effective in reducing the energy demand and footprint of buildings when they are well-designed. Research suggests that energy-efficient materials and integrated green technology can be effectively used to enhance sustainability in tall structures.

Housing attributes

Housing attributes influence the decision to buy a green home. Buyers consider the specific features and characteristics of the housing itself when making their decision to choose a green home. The study by Chuweni *et al.* (2022a, 2022b) confirms that housing features are an important factor for green homebuyers, in addition to location, finances and neighbourhood considerations. The study by Abdullah *et al.* (2016) highlights that several attributes influence the price of green properties. These include structural characteristics, location and neighbourhood factors, as well as time-related attributes. As indicated by Shafiei *et al.* (2013), most respondents are inclined to pay a premium cost of less than 5% when purchasing green homes that offer specific green features. Consequently, they express a preference for paying a higher price for green homes that are equipped with the particular green features they desire.

Number of storeys. The number of storeys in a building is a key attribute that influences both architectural design and the overall energy consumption of a property. High-rise buildings and low-rise structures differ significantly in terms of energy use, construction materials and the potential for incorporating sustainable technologies (Mostafavi *et al.*, 2021). Apart from that, high-rise buildings often have a greater potential for incorporating renewable energy systems and advanced ventilation systems due to their large footprint and height (Liu *et al.*, 2023). The taller structures of high-rise buildings require careful consideration of insulation and shading to optimise energy performance, as agreed by

Ahmadian *et al.* (2021) that taller buildings with greater depth are more energy efficient. Advanced ventilation systems can help regulate indoor temperature and reduce the need for excessive cooling in buildings. Similarly, low-rise buildings, due to their smaller area, lend themselves to greater efficiency through passive design such as natural ventilation and daylighting (Elaouzy and El Fadar, 2022). According to Jim and Chen (2006), the number of storeys is one of the green features considered when purchasing a green home, especially in multi-storey buildings, where high floors contribute implicitly to a 9.2% increase in the selling price. In this context, the number of storeys is an important factor taken into account by green homebuyers, particularly when considering purchases in multi-storey buildings, where high floors add value to the selling price.

Built-up area. Built-up area also influences the house price in the residential market, with some researchers using terms like living space, size area and floor area. Kempf and Syz (2022) used living space as one of the important determinants in the residential property market in Switzerland. Their findings revealed that the city living space is significantly associated with the selling price and rental value for certified green residential properties. Similarly, floor area is also found to be significant in price of residential properties in Singapore, implying that an increase of one square metre in a dwelling's surface adds a premium of 0.6% to the total price of the property (Dell'Anna and Bottero, 2020). However, larger built-up areas may reduce the quantity of green space available on a residential property, thereby potentially lowering the property's price (Bockarjova *et al.*, 2020). According to Karlen *et al.* (2021), the environmental footprint of housing is significantly impacted by the size of residential dwellings.

Land area. The integration of green features varies based on housing characteristics. Energy-efficient elevators and lighting may be installed in multi-storey buildings, while larger built-up areas provide space for energy-saving appliances. In addition, properties with ample land areas can include sustainable landscaping and outdoor green spaces, which may contribute to the green features due to their improved aesthetic appeal and quality of life. According to Kondo *et al.* (2018), urban green spaces have positive impacts on physical health by encouraging physical activity levels and improving cardiovascular health.

Transaction types

New sales from developers. Typically, the house price on brand-new transactions from developers is higher. Developers can strategically design and market green features, positioning these properties as contemporary, eco-friendly options. According to Gluszek *et al.* (2019), the demand for smart and green spaces is growing as new technologies create modern and attractive spaces, thus positively influencing the internal rate of return of development investments (Mangialardo *et al.*, 2019). The initial investment in sustainable technologies and materials may be passed on to purchasers, thereby enhancing the property's perceived value.

Green certification

In the field of real estate, properties with the GBI certification are internationally recognised for their unwavering commitment to sustainable construction and operational practices. This highlights a strong dedication to environmental responsibility and provides an important aspect that affects market dynamics, particularly the potential influence of green certification on the price of residential properties. Certification can indicate reduced energy consumption, environmental impact and improved indoor air quality. Due to reduced long-term operating costs and alignment with eco-conscious values, buyers may be willing to pay a premium for certified properties.

Previous research shows the importance of environmental concern as one of the main motivations for green residential investment. Zhang and Dong (2020) suggest that informational campaigns, such as eco-labelling and corporate sustainability reports, can significantly impact consumers' perceptions of green products and their willingness to make environmentally responsible choices. According to Chuweni *et al.* (2022a, 2022b), environmental benefits and environmental degradation play significant roles in influencing homebuyers to select green residential property. In Chuweni *et al.* (2023), the motivations for green residential investment were ranked using descriptive analysis, namely, the Relative Importance Index. In the study, they found that the most important motivations are environmental concern, followed by social and economic benefits (Chuweni *et al.*, 2023). Fauzi *et al.* (2021a, 2021b) also found that environmental elements are motivators for people to embrace green practices. Additionally, the positive reputation of green-certified buildings in communities further appeals to tenants seeking association with environmentally responsible spaces. Jang *et al.* (2018) discovered that green building certification increased potential tenants' willingness to rent. Kempf and Syz (2022) investigated the green certified residential properties in Canton and the city of Zurich, Switzerland. They discovered that the green price is driven by lower energy consumption, higher quality and increased comfort, as well as the retention of value due to the superior quality of building materials and longer life cycle. According to the Chinese Green Building Label (CGBL), housing units in certified projects are projected to fetch approximately 6.9% higher prices than units in projects without the certification (Zhang *et al.*, 2017). Zhang *et al.* (2017) further added that the green price increases with the rating level of the certification. Furthermore, the findings presented by Fesselmeyer (2018) support the idea that green certification has a positive impact on property prices, leading to an increase of approximately 3%. This increase in price is attributed to buyers placing value on certification, likely because it signals the presence of environmentally friendly features. This observation is consistent with the findings corroborated by Hui and Yu (2021), who found buyers typically exhibit a greater willingness to pay higher price for properties situated within certified buildings. This trend held true if the certification genuinely represented tangible and discernible enhancements in the overall environmental or energy performance of the properties, rather than mere simulated or superficial improvements.

Research methodology

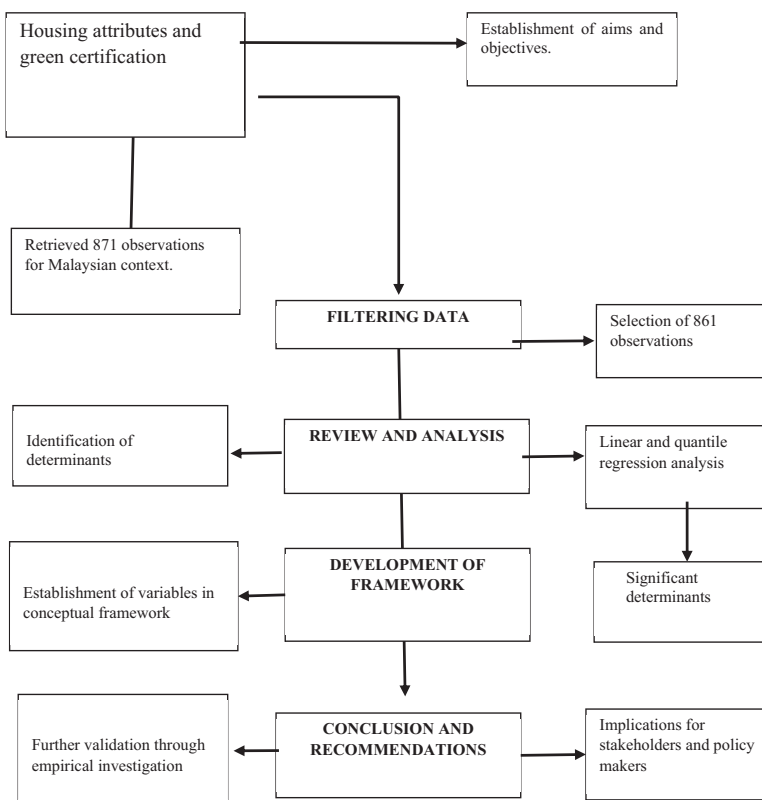
Data and sample

The GBI was used as a quantitative measure to establish the certification standards applicable to sustainable investments or residential properties with environmentally conscious features. Chen *et al.* (2015) stated that passive design criteria such as building layout, envelope thermophysics, building geometry, airtightness and infiltration performance have been shown to be an effective way to reduce building energy budgets, and this approach has been recognised in the most recent versions of green building rating tools. For a property to be considered "green", it had to be certified under the GBI scheme, which is the main certification programme in Malaysia. According to the indicators provided by GBI, the analysis found certified residential homes that meet green building standards in three distinct states within Malaysia: Johor, Penang and Selangor. The selection of Selangor as a research site was motivated by the availability of data on the house price was chosen for this study due to the availability of data for a green-certified neighbourhood township consisting of both landed and strata residential properties.

In the initial phase, data on 871 residential properties were collected in Township A, Selangor, Malaysia, between 2014 and 2022. After the removal of outliers, our sample

consisted of 861 observations. These observations include the market transaction prices of properties taken from the valuation management system, where most transacted data are obtained from the valuation and property management department. Figure 1 illustrates the research process used in this study.

Through a discussion of previous research, this paper identified the determinants of the house price and the impact of the adoption of green certification in the residential township, which were used as independent variables in the regression analysis. The explanatory variables in the regression are defined in Table 2. This includes housing attributes, property type, transaction type and green certification. Three dummy variables are used in the model. Firstly, dummy variables were used to accommodate the differentiation between various property types. The choice of the case study as the research location was motivated by the availability of data and its designation as an environmentally certified neighbourhood township, which includes both landed houses and strata buildings, thus offering a comprehensive set of data for research. To be precise, two dummy variables were generated to indicate the property types: one for landed properties and another for stratum properties. The adoption of this approach allowed for a more detailed analysis of how the kind of property affects the additional cost associated with green features in the research area.



Source: Authors' own work (2023)

Figure 1. Flowchart of the research process

Variable	Description
<i>Dependent variable</i>	
Log Price	
Ln Price	Natural logarithm of the residential properties' price
<i>Independent variables</i>	
<i>Housing attributes</i>	
BU_Area	Built-up area in square feet
Land_Area	Land area in square feet
No of storey	The floor area where the apartment is located
<i>Property type</i>	
Landed	Equal to 1 if the property is landed, 0 if it is strata
<i>Transaction type</i>	
Developer	Equal to 1 if the sale is made directly by a developer after completion, 0 otherwise
<i>Green certification</i>	
Green	Equal to 1 if the property is green certified by GBI, 0 otherwise

Table 2.Variable description **Source:** Authors' own work (2023)

Furthermore, our investigation focused on examining the transaction type within the model to provide valuable insights into the behaviours of homebuyers. To accomplish this, we incorporated dummy variables into the regression analysis. The objective of this variable was to determine whether homebuyers prefer buying properties directly from the developer after they are completed, or if they are more inclined towards other methods of purchase. By using this dummy variable, we can evaluate and measure the influence of transaction type on the house price. Our objective is to analyse the distinctions between purchases made from developers after completion and other types of transactions. This analysis will help us uncover trends and preferences in homebuyer behaviour, providing insights into the factors that impact decisions regarding green-certified properties. This refined approach improves our comprehension of the issues that impact the real estate market within the framework of sustainable and approved residential developments.

Another contribution of the paper is on the effect of green certification on house price. This could be done by conducting an analysis on the effects of GBI certification on the residential real estate market pricing over time, starting from its introduction in 2017. Therefore, dummy variables of green certification were used in this study to capture the certification effect on house price. Adding these dummy variables to the regression model improves our capacity to analyse the determinants that affect property price within the framework of environmental sustainability. Consequently, this provides vital perspectives to the wider discussion on the economic consequences of green certification in the residential real estate sector. The descriptive statistics are presented in [Table 3](#), and the correlations are shown in [Table 4](#).

[Table 3](#) conveys the descriptive statistics of the determinants of residential property prices. Firstly, the mean price of residential properties is 13.12, with the lowest price being 10.86 and the highest price being 14.73, with a standard deviation of 0.63. Regarding housing attributes, the mean built-up area is 1,552.9 square feet, with the lowest being 753.47 square feet and the highest being 3,670 square feet, with a standard deviation of approximately 690.7. Under the same category of housing attributes, the mean land area is 7,330.22 square feet, with a minimum of 753.5 square feet and a maximum of 7,330.22 square feet. Interestingly, the average number of storeys is 9.43, with the minimum number of

Variable	Mean	Minimum	Maximum	Std dev
Log Price	13.1237	10.8590	14.7318	0.6268
<i>Housing attributes</i>				
BU_Area	1,552.9055	753.47	3,670.00	690.6510
Land_Area	7,330.22	753.47	7,330.22	737.7855
No of storey	9.43	2	19	8.374
<i>Property type</i>				
Landed	0.56	0	1	0.497
<i>Transaction type</i>				
Developer	0.84	0	1	0.369
<i>GBI certification</i>				
Green	0.99	0	1	0.096

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Table 3.
Descriptive statistics

Source: Authors' own work (2023)

storeys being two and the maximum number of storeys being 19. In general, property type, transaction type and green certification are represented by dummy variables. Regarding property type, the mean for landed area is 0.56, indicating a preference for landed property among buyers. Concerning transaction type, on average, transactions conducted by developers account for 0.84, with a standard deviation of 0.37. Finally, most of the properties have green certification, as indicated by a mean green certification value of 0.99.

Pearson's correlation coefficient analysis

The primary purpose of correlation analysis is to measure the strength of the relationship between two variables. Using SPSS software, Pearson's correlation coefficient was used to assess the degree of association between two variables. If the correlation coefficient is positive, it indicates a positive relationship (also known as a positive correlation) between the two variables. If the correlation coefficient is negative, it suggests an inverse relationship between the variables (known as a negative correlation). If the correlation coefficient equals zero, it means there is no relationship between the variables. [Table 4](#) provides details about the degree of Pearson's correlation between market price and other variables.

Correlations	Ln price	Storey	Built-up area	Landed property	Green certification	Developer	Land area
Ln price	1	-0.841**	0.889**	0.850**	0.023	-0.062	0.927**
Storey	-0.870**	1	-0.858**	-0.994**	-0.012	0.277**	-0.863**
Built-up area	0.851**	-0.874**	1	0.868**	0.011	-0.140**	0.961**
Landed property	0.878**	-0.994**	0.879**	1	0.011	-0.266**	0.873**
Green certification	0.040	-0.012	-0.016	0.011	1	-0.43	0.006
Developer	-0.124**	0.277**	-0.172**	-0.266**	-0.43	1	-0.142**
Land area	0.807**	-0.741**	0.854**	0.745**	-0.51	-0.117**	1

Notes: Pearson (below diagonal) and Spearman (above diagonal) correlations of Ln price and all variables; **Correlation is significant at the 0.01 (two-tailed)

Source: Authors' own work (2023)

Table 4.
Pearson and
Spearman correlation

The regression analysis

The ordinary least squares (OLS) method was used to determine the regression line that minimises the squared distance between the observed value and the value of the dependent variable as predicted by the multiple regression model. To assess the validity of the findings, the coefficient of determination (adjusted R^2) was examined to evaluate the fit of the regression model.

Typically, a regression model is expressed as a straightforward equation, as shown below:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \dots + \beta_k X_k + \varepsilon \quad (1)$$

where:

- Y = dependent variable
- X_1, X_2, \dots, X_k = explanatory variables
- β_0 = constant
- $\beta_1, \beta_2, \dots, \beta_k$ = regression coefficient
- ε = random error

In our empirical model, the dependent variable will represent the market price of residential properties, while the explanatory variables will include “green” factors. It is believed that green buildings have a positive impact on market prices. A similar outcome was also shown in the study conducted by [Tan and Goh \(2018\)](#), where the influence of environmental concerns on customer purchasing intentions towards green residential structures in Malaysia was identified as a significant factor. Furthermore, green housing, which has been certified with the CGBL, commands a 6% higher price compared to non-green housing when it is resold ([Jiang et al., 2021](#)). Following [Dell’Anna and Bottero \(2020\)](#), the dependent variable (transaction price) underwent a logarithmic transformation. The use of logarithmic transformation simplifies the interpretation of the impact of predictors on the dependent variable. Specifically, for a unit increase in the independent variable, the dependent variable varies by a certain percentage as indicated by the β coefficient.

Therefore, the regression model for the dependent variables is as follows:

$$\begin{aligned} \text{Log Price}_t = & \text{Types of properties}_t + \text{Housing attributes}_t + \text{Transaction type}_t \\ & + \text{Green Certification}_t + \varepsilon \end{aligned} \quad (2)$$

Robustness check: Quantile regression

Quantile regression enables researchers to estimate coefficients for specified quantiles and additional quantiles if necessary. This observation is significant as it contributes to a more comprehensive understanding of how predictor factors influence distinct segments within the distribution of the response variable. An illustration of this phenomenon may reveal that the impact of a predictor variable varies in strength when comparing the 25th percentile to both the median and the 75th percentile. In the context of quantile regression, the expressions “quantile 0.25”, “quantile 0.5” and “quantile 0.75” represent percentiles within the conditional distribution of the response variable. These quantiles hold significant importance as they define distinct segments of the distribution, each with its unique characteristics.

Through the process of estimating quantiles at multiple locations within the distribution, scholars can offer valuable insights into conditional relationships that may remain concealed when solely focusing on the mean, as is typically done in conventional linear regression analysis. The flexibility proves to be especially advantageous when analysing data sets that show varying relationships between variables across different quantiles. As a result, quantile regression emerges as a powerful methodology for investigating intricate patterns within data.

Quantile regression is a statistical methodology used to evaluate the relationship between a dependent variable (Y) and one or more independent variables (X) at various quantiles of the conditional distribution of Y. In contrast to the conventional approach of linear regression, which primarily seeks to estimate the conditional mean of the dependent variable Y given the independent variable X, quantile regression focuses on estimating the multiple independent variables (X_1, X_2, \dots, X_k), the equation extends as follows:

$$Y(\tau) = \beta_0(\tau) + \beta_1(\tau)X_1 + \beta_2(\tau)X_2 + \dots + \beta_k(\tau)X_k + \varepsilon(\tau) \quad (3)$$

These coefficients were estimated using statistical methods designed for quantile regression, such as minimising the sum of absolute deviations (instead of squared deviations used in OLS regression). This minimisation process yields estimates for the β parameters specific to the chosen quantile τ , which represents the conditional quantiles of Y.

Quantile regression offers a more comprehensive perspective on the association between variables by enabling the estimation of various segments of the conditional distribution. Researchers commonly perform quantile regressions at various quantile levels (such as $\tau = 0.25, 0.5, 0.75$) to gain insights into the variations in associations across the complete range of the dependent variable.

By using the technique of estimating quantile-specific coefficients, it is possible to gain valuable insights into the varying effects of independent variables across different quantiles. This approach proves particularly useful when analysing data that displays heteroscedasticity or when seeking a comprehensive understanding of the conditional relationships within a data set.

Results and discussion

The parameter estimate displayed in Table 5 includes both OLS and quantile regression (Q) using SPSS software. The regression results indicate a good fit based on the goodness-of-fit criteria. The R^2 statistic suggests that the collection of explanatory variables explains approximately 83% of the sample variation in transaction prices. Table 5 presents the results of OLS regression and quantile regression at different quantiles (0.25, 0.50 and 0.75) for various independent variables. The factors considered in this study include storey, built-up area, landed, green, developer and land area, all of which serve as independent variables.

In general, Table 5 also illustrates the distribution model of housing attributes (storey, built-up area, land area), property type (landed), transaction type (developer) and green certification (green). At the lower quantiles ($Q = 0.25$), all explanatory variables have a positive and significant effect on pricing. This suggests that storey, built-up area, land area,

Variables	OLS	Q(0.25)	Q(0.50)	Q(0.75)
Constant	11.499*** (0.211)	10.770*** (0.2163)	11.287*** (0.0827)	12.028*** (0.0103)
Storey	0.013 (0.010)	0.052*** (0.0103)	0.041*** (0.0039)	0.001 (0.0005)
Built-up area	6.302E-5* (0.000)	0.000*** (3.4923E-5)	2.768E-5** (1.3347E-5)	-7.612E-6*** (1.6655E-6)
Landed	0.988*** (0.171)	1.406*** (0.1753)	1.410*** (0.0670)	0.993*** (0.0084)
Green	0.351*** (0.091)	0.430*** (0.0938)	0.147*** (0.0359)	0.162*** (0.0045)
Developer	0.147*** (0.025)	0.056** (0.0257)	0.153*** (0.0098)	0.250*** (0.0012)
Land Area	0.000*** (0.000)	0.000*** (2.3539E-5)	0.000*** (8.9967E-6)	0.000*** (1.1226E-6)

Notes: The parentheses are standard errors; *, ** and *** indicate significance at 10, 5 and 1% level, respectively

Source: Authors' own work (2023)

Table 5.
Result of OLS and quantile regressions

landed property, developer, and green certifications are determinants of relatively lower residential property prices. Similarly, at the medium quantiles ($Q = 0.50$), all explanatory variables show a positive and significant effect on pricing. This implies that storey, built-up area, land area, landed property, developer and green certifications are determinants of medium residential property price.

The upper quantiles ($Q = 0.75$) show some anomalies compared to the lower and medium quantiles. Notably, the built-up area has a negative and significant impact on pricing in the upper quantiles. This contrasts with the positive effects of the built-up area for the medium and lower quantiles. Interestingly, the number of storeys in the upper quantiles is also found to be insignificant, consistent with the OLS result. Additionally, land area, landed property, developer and green certification continue to be determinants of relatively expensive residential property prices.

The findings indicate that the coefficients of the independent variables vary across different quantiles. The coefficient for the built-up area shows a positive and statistically significant relationship across all quantiles. Our results suggest that the built-up area significantly influences the house price. Similar results have been observed in the Singaporean market (Dell'Anna and Bottero, 2020) and the Swiss market (Kempf and Syz, 2022) for green-certified residential properties. However, the magnitude of this coefficient decreases as the quantile value increases. This implies that the impact of the built-up area on the dependent variable is more pronounced for lower quantiles than for higher ones.

The use of OLS and quantile regression techniques can yield different perspectives on the association between dependent and independent variables. OLS estimation is used to estimate the conditional mean of the dependent variable, while quantile regression is used to estimate the conditional quantiles of the dependent variable. The OLS method assumes that errors follow a normal distribution and exhibit constant variance. In contrast, quantile regression does not impose any assumptions regarding the distribution of the errors. OLS provides an overall estimate of the relationships between independent variables and the dependent variable, whereas quantile regression allows us to understand how these relationships change at various points along the distribution of the dependent variable. The results indicate that the effects of independent variables vary across quantiles, providing a more nuanced understanding of their influence on the distribution of the dependent variable.

Conclusion

The residential real estate sector in Selangor, Malaysia, is undergoing constant change. There are myriad causes for these changes, including shifts in social and cultural attitudes and technology advancements. This study aims to contribute to the understanding of the evolving dynamics of residential real estate pricing, especially in the context of sustainable real estate. While the Malaysian sustainable residential real estate market is growing rapidly, there is limited published research identifying the drivers of this growth. This study addresses these aspects to fill the theoretical gap in the real estate sector. The determinant factors for the price in Malaysian residential properties can be observed in terms of property type, housing attributes, transaction type and GBI certification. This paper presents empirical evidence on price of residential properties and emphasises the need to establish a framework for green residential properties. We found housing attributes, transaction type and GBI certification to be significant determinants of residential sales prices in Selangor. As outlined in the 11th 2030 Agenda for Sustainable Development, the 12th Malaysia Plans, the findings of this study could provide significant support and assistance for Malaysia's medium-to-long-term green technology objectives. In line with this objective, the government could consider several incentive programmes, such as grants and financing for

green infrastructure and construction. The GITE services incentive is accessible exclusively to individuals or organisations included in the MyHIJAU Directory, offering green technology services to clients engaged in green technology-related projects. The MyHIJAU Directory and the MIDA Guidelines outline a comprehensive range of green technology services that are considered eligible. These services encompass system design, feasibility studies, advisory, consultancy, testing and commissioning services across various sectors, including, but not limited to, renewable energy, energy efficiency, green building and green township.

Malaysia has demonstrated a heightened commitment to achieving carbon neutrality by 2050, as evidenced by the implementation of several initiatives outlined in the Green Technology Master Plan Malaysia 2017 to 2030 and the 12th Malaysian Plan (2021 to 2025). This commitment includes the provision of tax incentives and financial assistance for the acquisition or construction of environmentally sustainable residential dwellings. In other words, homebuyers who acquire green homes may be eligible for monetary compensation in lieu of the substantial investment required. An example of a green incentive fund is the green investment tax allowance, which is designed to support sustainable residential development. Funds have been allocated for financing environmentally sustainable activities and projects. The government should place a greater emphasis on promoting green and resilient cities and communities as it progresses towards becoming a low-carbon nation. In addition, this research is essential for conveying the message to the real estate industry, particularly property developers, in the development of green residential initiatives, thereby reducing future uncertainty and risk. Moving forward, information about green construction, particularly green residential properties should actively be disseminated among the public through the development of a comprehensive understanding of these structures to create a market environment dominated by homebuyers. For instance, the government could provide homebuyers with access to accurate information regarding green buildings through the establishment of an official database and system.

Exploring the determinants of green real estate investment, particularly the benefits of selecting a specific level of green certification, can influence the future decisions of developers and investors, promoting more green-certified residential and township developments. In addition, this study aims to assist relevant parties and organisations in providing incentives, recognition, and actions to increase the awareness of green residential buildings among investors and purchasers. Finally, this study will contribute to filling a void in previous research and will encourage future research in the field of green residential building development, both locally and internationally. The conceptual framework developed in this investigation could be further tested and validated using robust regression analysis. The validated model could then promote greener real estate development, especially in Malaysia's emerging market. Additional empirical research could be conducted to explore the motivating factors associated with green residential properties in Malaysia. Further considerations and recommendations include conducting surveys or interviews with real estate developers and relevant stakeholders. The use of a comprehensive and multidimensional research approach can lead to a more complete understanding of the factors driving the adoption of environmentally friendly residential homes in Malaysia. Consequently, this can facilitate the process of making informed decisions and promoting sustainable development within the real estate sector. The research findings will ultimately contribute to the advancement of strategies, policies, and collaborations aimed at encouraging investment in environmentally sustainable residential properties by individuals and organisations.

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