International Journal of Innovative Research and Scientific Studies, 8(3) 2025, pages: 2255-2265

IJIRSS
International Journal of Innovative Research & Scientific Studies

ISSN: 2617-6548

URL: www.ijirss.com

Dynamic price estimation model for residential buildings per square meter in Surabaya: Analyzing the impact of construction costs, material quality, and Land Area

Kusnan[1*], Naniek Widayati[2], Dadang M. Ma'soem [3]

[1,2]*Civil Engineering Doctoral Program, Tarumanagara University – Jakarta, Indonesia.*
[3]*Civil Engineering, Faculty of Engineering, Pendidikan Indonesia University, Bandung, Indonesia.*

Corresponding author: Kusnan (*Email: Kusnankus63@gmail.com*)

Abstract

This study develops a dynamic price estimation model for residential buildings per square meter in Surabaya, focusing on key variables such as construction costs, material quality, land area, and building size. Using multiple linear regression analysis and the backward elimination method, this research identifies the most significant factors that influence housing prices in urban and suburban areas. The results show that construction costs and material quality have a positive impact on housing prices, while land area exhibits an inverse relationship with the price per square meter, particularly in peripheral areas of the city. The final model achieved an R^2 value of 0.685, indicating strong explanatory power. The findings provide valuable insights for real estate developers, policymakers, and urban planners in optimizing housing development strategies, promoting affordable housing, and improving market transparency in rapidly urbanizing regions. This model can be applied in other emerging markets with similar urban dynamics.

Keywords: Backward elimination method, construction costs, housing price estimation, land area, material quality, multiple regression analysis.

DOI: 10.53894/ijirss.v8i3.6982
Funding: This study received no specific financial support.
History: Received: 10 March 2025 / **Revised:** 14 April 2025 / **Accepted:** 16 April 2025 / **Published:** 13 May 2025

Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.
Transparency: The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.
Acknowledgments: I would like to express my deepest gratitude to my promotor and co-promotor for their invaluable guidance and support throughout the development of this manuscript. I also extend my heartfelt appreciation to the lecturers from Tarumanagara University for their continuous encouragement and contributions, which have been instrumental in the successful completion of this work.
Publisher: Innovative Research Publishing

1. Introduction

The estimation of per-m² residential building prices is not only a technical issue but also one that intersects with legal frameworks, urban planning regulations, and property law. Legal considerations surrounding property development, land use, and construction costs are essential in shaping housing prices, particularly in rapidly urbanizing regions such as Surabaya, Indonesia. Housing price estimation models must incorporate not only economic and technical factors but also comply with national and local legal frameworks governing land acquisition, construction, and zoning regulations [1, 2].

Legal frameworks that regulate land ownership, construction standards, and urban planning can significantly influence the cost and value of residential properties. For instance, the legal process of land acquisition, including disputes over land ownership or use, can delay construction projects and increase costs, which, in turn, affect housing prices [3]. Zoning laws and building regulations also play a pivotal role in determining the feasibility and cost of construction. In many jurisdictions, legal restrictions on building heights, density, and land use can limit the availability of developable land, driving up the cost of housing [4]. Furthermore, stringent environmental regulations and compliance with safety standards add further layers of legal and financial complexity to property development [2].

From a legal perspective, property laws governing land transactions and housing development are crucial in determining how real estate markets function. Legal disputes over land rights and development approvals can lead to increased project costs and delays, which are reflected in the final price of housing per square meter. In Surabaya, where urban expansion is occurring at a rapid pace, these legal challenges are particularly pronounced. The complex interplay between legal regulations, economic management, and construction practices demands a pricing model that can adapt to these variables, providing more accurate and legally compliant housing price estimations [4, 5].

Moreover, government policies on affordable housing, such as subsidies and tax incentives, influence the pricing structure of residential properties [1]. These policies are legally mandated to ensure that housing remains accessible to a broader segment of the population, while also maintaining a balancé between market-driven price increases and regulatory interventions. The legal frameworks surrounding public housing development and private property investments thus have a significant impact on housing affordability and market stability, as evidenced by empirical studies in both developed and developing countries [6].

Despite the growing body of research on housing price estimation, there remains a gap in understanding how legal frameworks and regulations impact the accuracy of these models, particularly in dynamic, rapidly growing urban environments like Surabaya. This study aims to fill this gap by applying multiple linear regression analysis to model per-square-meter housing prices while also accounting for the legal variables such as zoning laws, construction permits, and land use regulations. By integrating these legal considerations with economic and technical factors, this study offers a more comprehensive and legally sound framework for estimating residential building prices, contributing to the field of property law and urban development policy [2, 3].

This research holds particular significance for legal scholars, urban planners, and policymakers seeking to understand the broader legal implications of housing price estimation models. The findings of this study could inform future legislative reforms in the property sector, as well as enhance the legal understanding of how urban planning and zoning regulations interact with economic factors to influence real estate markets. Ultimately, this study aims to provide practical insights into creating legally compliant and economically viable housing policies, particularly in rapidly urbanizing cities like Surabaya.

2. Methods

This research employs a quantitative approach using multiple linear regression analysis to model the per-m² price of residential buildings in Surabaya. The primary objective is to develop a pricing model that accurately reflects the dynamic interaction of several technical, legal, and economic variables that influence the final price of residential properties. This approach is suitable for real estate price modeling as it allows for the identification and quantification of key factors that significantly impact housing prices. The research focuses on both technical (construction-related) and non-technical (economic, legal, and geographic) variables to create a comprehensive model.

Data for this research was collected from multiple sources, including construction companies, government agencies, and legal frameworks regulating land use and property development in Surabaya. The construction-related data includes detailed records on construction costs, material quality, labor costs, and technical specifications of residential buildings. Additionally, data on land area, building area, and proximity to major infrastructure (such as highways) were collected to understand their impact on pricing. Legal data related to zoning regulations, land acquisition processes, and government policies on housing development were also considered to ensure the model complies with applicable legal frameworks.

The dependent variable (Y) in this research is the Building Price per-m², while the independent variables (X) include six key factors that were identified as critical in influencing housing prices:

Table 1.
Variables for Regression Analysis.

No	Variable	Code
1.	Construction Cost per-m^2	X_1
2.	Material Quality	X_2
3.	Working Time	X_3
4.	Land Area	X_4
5.	Building Area	X_5
6.	Distance to Highway	X_6
7.	Building Price per-m^2	Y

The selection of these variables was based on a comprehensive literature review and preliminary interviews with industry experts. These factors were chosen for their demonstrated significance in previous studies on real estate pricing models [3, 4] as well as their relevance to the unique legal and geographic context of Surabaya [1].

2.1. Hypotheses

The hypotheses for this study are formulated as follows:

Hypothesis 1 (H_0): The independent variables (Construction Cost, Material Quality, Construction Time, Land Area, Building Area, and Distance to Highway) significantly influence the per-m² building price.

Hypothesis 2 (H_1): The independent variables (Construction Cost, Material Quality, Construction Time, Land Area, Building Area, and Distance to Highway) do not significantly influence the per-m² building price.

These hypotheses are tested using multiple linear regression analysis to determine the strength and significance of each variable's impact on the building price per square meter.

2.2. Regression Model

The regression model used in this study can be expressed as follows:

$Y = \beta 0 + \beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 4X4 + \beta 5X5 + \beta 6X6 + \varepsilon$

Where:

Y: represents the Building Price per-m² (the dependent variable),

X1 : through X6 represent the independent variables (Construction Cost, Material Quality, Construction Time, Land Area, Building Area, and Distance to Highway),

β0 : is the intercept,

β1 to β6 : are the coefficients for each independent variable, and

ε : is the error term.

The coefficients are estimated through ordinary least squares (OLS) regression, and tests for multicollinearity, heteroscedasticity, and autocorrelation are conducted to ensure the robustness of the model [6].

2.3. Statistical Tests

1. Normality Test: A Kolmogorov-Smirnov test is employed to determine if the residuals follow a normal distribution, which is a prerequisite for linear regression analysis.
2. Multicollinearity Test: Variance Inflation Factor (VIF) scores are calculated for each predictor variable to assess the potential for multicollinearity among the independent variables.
3. Heteroscedasticity Test: A Glejser test is used to check whether the variance of the errors differs across observations, ensuring the assumption of homoscedasticity.
4. Autocorrelation Test: The Durbin-Watson statistic is calculated to test for the presence of autocorrelation in the residuals, ensuring the independence of errors.

2.4. Legal and Policy Considerations

Given the legal complexities surrounding land acquisition, construction permits, and zoning laws in Surabaya, this study integrates these legal frameworks into the analysis. This ensures that the regression model not only reflects economic and technical realities but also adheres to local and national property laws, providing a more holistic approach to price estimation [1, 2].

2.5. Research Significance

By incorporating both technical and legal variables, this study contributes to the broader field of real estate price modeling and urban development policy. It offers a legally compliant and economically sound pricing model that can be used by real estate developers, policymakers, and urban planners. The results of this study can also inform future legal reforms and public housing policies aimed at promoting equitable urban growth in rapidly developing cities like Surabaya.

3. Results and Discussion

3.1. Pre-Analysis for Regression

To develop a robust pricing model for residential properties, multiple linear regression analysis was used to estimate construction prices per square meter. The predictor variables include construction cost, material quality, construction time, land area, building area, and distance to highways. Prior to conducting the regression analysis, several tests were performed to ensure the validity of the model, following recommendations in the literature on housing price modeling and real estate economics [7].

3.2. Normality Test

The Kolmogorov-Smirnov test was used to assess the normality of the regression residuals. Table 2 provides the results, showing that the significance value exceeded 0.05, thereby confirming that the residuals follow a normal distribution, a key assumption in linear regression analysis. Normality of residuals is crucial in regression models to ensure the unbiasedness of the coefficient estimates [8].

Table 2.
Normality Test.

	Value
Kolmogorov-Smirnov	0.123
Significance Value	0.132

Given the significance value of 0.132, which is greater than the threshold of 0.05, the assumption of normality is satisfied, enabling us to proceed with the regression analysis [9].

3.3. Multicollinearity Test

Multicollinearity, which refers to high correlations among predictor variables, was tested using the Variance Inflation Factor (VIF). High multicollinearity can distort the estimation of regression coefficients, leading to misleading conclusions. Table 3 shows that all VIF values fall between 1 and 10, confirming the absence of significant multicollinearity. This finding is consistent with prior studies that emphasize the importance of managing multicollinearity in real estate price modeling [10, 11].

Table 3.
Multicollinearity test.

No	Variable	VIF
1.	Construction Cost per-m^2	1.968
2.	Material Quality	1.195
3.	Working Time	1.173
4.	Land Area	1.361
5.	Building Area	1.532
6.	Distance to Highway	1.235

As none of the VIF values exceed 10, we can conclude that multicollinearity is not present in this model, which supports the integrity of the regression results [11].

3.4. Heteroscedasticity Test

Heteroscedasticity refers to the presence of non-constant variance in the regression residuals, which can invalidate statistical inferences. The Glejser test was applied to detect heteroscedasticity in the model. As shown in Table 4, none of the variables has a significance value below 0.05, indicating that the data do not suffer from heteroscedasticity. This result is consistent with studies emphasizing the importance of constant error variance in housing price regression models [12].

Table 4.
Glejser Test.

Model	Unstandardized Coefficients		T-Statistic	Sig.
	B	Std. Error		
(Constant)	0.505	1.64	0.308	0.76
Construction Cost per m^2 (In Millions Rupiah)	-0.161	0.083	-1.942	0.061
Material Quality	0.128	0.547	0.233	0.817
Construction Time (Months)	0.389	0.269	1.411	0.167
Land Area (m^2)	-0.01	0	-1.063	0.296
Building Area (m^2)	0.011	0.019	0.55	0.586
Distance to Highway (Km)	0.133	0.14	0.95	0.349

The absence of heteroscedasticity allows for the continuation of the regression analysis without adjustments for error variance [13].

3.5. Autocorrelation Test

Autocorrelation, or the correlation of residuals across observations, can bias the results of a regression model. The Durbin-Watson test was conducted, yielding a value of 1.882. This value falls within the acceptable range of 1.822 to 2.178, indicating no significant autocorrelation. Autocorrelation tests are especially important in time-series data but can also affect cross-sectional analyses, as demonstrated by prior studies on property markets [14].

3.6. Regression Result

The regression analysis produced the results shown in Table 5, where land area and building area are found to be significant predictors of housing price per square meter ($p < 0.05$). These findings align with prior research demonstrating the importance of land availability and building size in determining property values [15, 16].

Table 5.
Regression Analysis Result.

Model	Unstandardized Coefficients		t	Sig.
	B	Std. Error		
(Constant)	9.721	3.451	2.816	0.008
Construction Cost per m^2 (In Millions Rupiah)	0.347	0.174	1.991	0.055
Material Quality	2.302	1.151	2	0.054
Construction Time (Months)	-0.643	0.566	-1.137	0.264
Land Area (m^2)	-0.115	0.02	-5.854	0
Building Area (m^2)	0.139	0.041	3.413	0.002
Distance to Highway (Km)	-0.227	0.294	-0.773	0.445

3.7. Individual Regression Analysis

To further verify the results, individual regression analyses were conducted for each variable. As Table 6 indicates, construction cost becomes significant when analyzed separately, reflecting its importance in housing price determination. However, material quality and construction time were not consistently significant, which may reflect local construction practices or supply chain dynamics [8, 15].

Table 6.
Individual (one-by-one) Regression Analysis Result.

Model		Unstandardized Coefficients		t	Sig.
		B	Std. Error		
1	(Constant)	7.590	0.721	10.530	0.000
	Construction Cost per m^2 (In Millions Rupiah)	0.465	0.192	2.423	0.020
2	(Constant)	1.022	0.919	4.394	0.000
	Material Quality	1.593	0.160	1.476	0.148
3	(Constant)	7.901	2.721	2.904	0.006
	Construction Time (Months)	0.387	0.865	0.447	0.657
4	(Constant)	17.145	1.256	13.654	0.000
	Land Area (m^2)	-0.126	0.019	-6.550	0.000
5	(Constant)	7.405	2.249	3.292	0.002
	Building Area (m^2)	0.041	0.054	0.767	0.448
6	(Constant)	9.206	0.441	20.873	0.000
	Distance to Highway (Km)	-0.206	0.438	-0.470	0.641

The findings underscore the importance of analyzing the relative influence of construction costs, land area, and building size in determining housing prices, as corroborated by earlier studies [12, 17].

3.8. Backward Elimination Method

The backward elimination method was employed to refine the model further, eliminating variables that did not significantly contribute to the price model. The final regression model is as follows:

$$Y = 7.497 + 0.266X_1 + 2.462X_2 - 0.115X_4 + 0.144X_5$$

Where Y represents the estimated housing price per square meter, and X_1, X_2, X_4, and X_5 represent construction cost, material quality, land area, and building area, respectively. The backward elimination method confirmed the significance of these variables, aligning with previous studies on urban property markets and housing affordability [7, 18].

3.9. House Price Estimation

Based on the regression results, a range of residential building prices was estimated for each house type. These findings provide useful benchmarks for developers and policymakers when assessing housing affordability in Surabaya. The results align with similar studies conducted in other emerging markets, where land scarcity and urban sprawl have driven up housing prices [16].

3.10. Comparison of Whole Variables and Individual Variables Regression Analysis

Table 7 presents a comparison of the regression analysis results for the whole model versus the individual variable models. It highlights the significance of construction cost, land area, and building area in both the whole model and individual models, while other variables such as material quality and distance to the highway exhibit varying levels of significance depending on the model specification. This comparison is critical in confirming the robustness of the model and in identifying which variables consistently contribute to the pricing of housing per square meter [8, 18].

Table 7.
Individual (one-by-one) and Whole Variables Regression Analysis Comparison.

Variable	Whole Variables		Description	Individual		Description
	t	Sig.		t	Sig.	
Construction Cost per m^2 (In Millions Rupiah)	1.991	0.055	Not Significant	2.423	0.020	Significant
Material Quality	2.000	0.054	Significant	1.476	0.148	Not Significant
Construction Time (Months)	-1.137	0.264	Not Significant	0.447	0.657	Not Significant
Land Area (m^2)	-5.854	0.000	Significant	-6.550	0.000	Significant
Building Area (m^2)	3.413	0.002	Significant	0.767	0.448	Not Significant
Distance to Highway (Km)	-0.773	0.445	Not Significant	-0.470	0.641	Not Significant

The results from Table 7 reinforce the notion that while certain variables like construction cost and land area remain significant across models, others such as material quality and construction time, may have context-specific effects depending on local market dynamics and regulatory environments [12, 15].

3.11. Coefficient of Determination (R^2)

The coefficient of determination (R^2) measures the proportion of the variance in the dependent variable (price per square meter) explained by the independent variables. As shown in Table 8, the overall model has an R^2 value of 0.685, indicating that 68.5% of the variance in housing prices can be explained by the model. This is a reasonably high explanatory power, suggesting the model's robustness. Notably, land area and construction cost have the highest individual R^2 values, which aligns with their known importance in real estate markets [10].

Table 8.
Coefficient of Determination of Each Variable and Overall Model.

Variable	R^2
Construction Cost per-m^2 (In Millions Rupiah)	0.134
Material Quality	0.054
Construction Time (Months)	0.005
Land Area (m^2)	0.530
Building Area (m^2)	0.015
Distance to Highway (Km)	0.006
Overall Model	0.685

The R^2 value for land area (0.530) demonstrates its significant impact on housing prices, a finding that is consistent with other studies of urban property markets, particularly in cities facing land scarcity [7, 16].

3.12. Final Model and Interpretation

The final model, selected using the backward elimination method, underscores the central role of construction cost, material quality, land area, and building area in explaining the per-square-meter price of housing. This model can serve as a valuable tool for policymakers and developers in Surabaya, providing a reliable framework for price estimation in the local housing market. Moreover, the model's predictive power can be extended to other emerging markets with similar dynamics [9].

3.13. Backward Elimination Process

Table 9 outlines the backward elimination process, where variables that did not significantly contribute to the model were systematically removed. This method helps in refining the model by focusing on the most influential variables. The final model retains the construction cost per m^2, material quality, land area, and building area as significant contributors to the housing price per square meter.

Table 9.
Backward Elimination Process.

Model	Variable	B	Std. Error	t	Sig.
1	(Constant)	9.721	3.451	2.816	0.008
	Construction Cost per m^2 (In Millions Rupiah)	.347	0.174	1.991	0.055
	Material Quality	2.302	1.151	2.000	0.054
	Construction Development Time (Months)	-0.643	0.566	-1.137	0.264
	Land Area (m^2)	-0.115	0.020	-5.854	0.000
	Building Area (m^2)	0.139	0.041	3.413	0.002
	Distance to Highway (Km)	-0.227	0.294	-0.773	0.445
2	(Constant)	9.134	3.347	2.729	0.010
	Construction Cost per m^2 (In Millions Rupiah)	0.313	0.167	1.866	0.071
	Material Quality	2.484	1.120	2.219	0.033
	Construction Time	-0.578	0.556	-1.039	0.306
	Land Area (m^2)	-0.116	0.020	-5.938	0.000
	Building Area (m^2)	0.145	0.040	3.677	0.001
3	(Constant)	7.497	2.956	2.536	0.016
	Construction Cost per m^2 (In Millions Rupiah)	0.266	0.161	1.645	0.109*
	Material Quality	2.462	1.121	2.197	0.035
	Land Area (m^2)	-0.115	0.020	-5.892	0.000
	Building Area (m^2)	0.144	0.040	3.647	0.001

Note: * Variables are retained because they have high significance on building prices when running individual regressions.

From the results of the backward elimination method (Table 9), it is clear that the final model effectively captures the significant variables influencing the price of housing per square meter. The significant variables retained in the final model are construction cost, material quality, land area, and building area, all of which have been shown in previous studies to be key determinants of housing prices [9, 16].

The coefficients in the final model provide insights into the magnitude and direction of these influences. For example, the negative coefficient for land area suggests that larger plots of land on the outskirts of Surabaya are associated with lower prices per square meter, a finding consistent with studies that examine urban sprawl and land use [17]. Conversely, the positive coefficient for building area indicates that larger structures command higher prices per square meter, consistent with the principles of real estate development in urban settings [18].

3.14. Final Regression Model and Interpretation

Based on the backward elimination process (Table 9), the final regression model is formulated as:

$$Y = 7.497 + 0.266X1 + 2.462X2 - 0.115X4 + 0.144X5$$

Where

Y is the estimated housing price per square meter (Rp/m^2),

X1 is the construction cost per m^2,

X2 is the material quality,

X4 is the land area (m^2),

X5 is the building area (m^2).

3.15. Interpretation of the Coefficients

1. Construction Cost per m^2 ($X_1 = 0.266$): The positive coefficient for construction cost indicates that as construction costs increase by one unit, the housing price per square meter is expected to increase by 0.266 units, holding all other factors constant. This finding is consistent with prior research showing that construction costs are one of the most significant drivers of real estate prices, especially in developing urban areas [15].
2. Material Quality ($X_2 = 2.462$): The positive and significant coefficient for material quality suggests that better-quality materials lead to a substantial increase in housing prices. High-quality materials not only improve the aesthetic and functional aspects of the building but also provide durability, which is highly valued by buyers in the real estate market [18].
3. Land Area ($X_4 = -0.115$): The negative coefficient for land area reflects the inverse relationship between land size and housing price per square meter, indicating that houses built on larger plots of land tend to have a lower price per square meter. This is particularly true for houses located on the outskirts of Surabaya, where land is more abundant and thus less expensive on a per-unit basis [9]. This aligns with studies on urban sprawl, where properties on the city periphery often have lower prices due to reduced proximity to essential services and infrastructure [17].
4. Building Area ($X_5 = 0.144$): The positive coefficient for building area shows that as the building size increases, the price per square meter also rises. Larger buildings are generally considered more valuable, as they offer more space and higher utility to potential homeowners. This is a common finding in real estate economics, where buyers are willing to pay more for larger, well-constructed homes [16].

3.16. Model Fit and R² Interpretation

The final model has an overall R^2 value of 0.685, indicating that approximately 68.5% of the variance in housing prices per square meter is explained by the variables included in the model. This is a strong model fit for real estate price estimation, as it suggests the chosen variables capture most of the important factors influencing housing prices in Surabaya [8]. While no model can account for every possible factor, an R^2 of 0.685 suggests that this model provides a reliable estimation framework for developers, policymakers, and urban planners [12].

3.17. House Price Estimation

Based on the regression results, several ranges of residential building prices for each type are obtained. The following is the price range for each type of house.

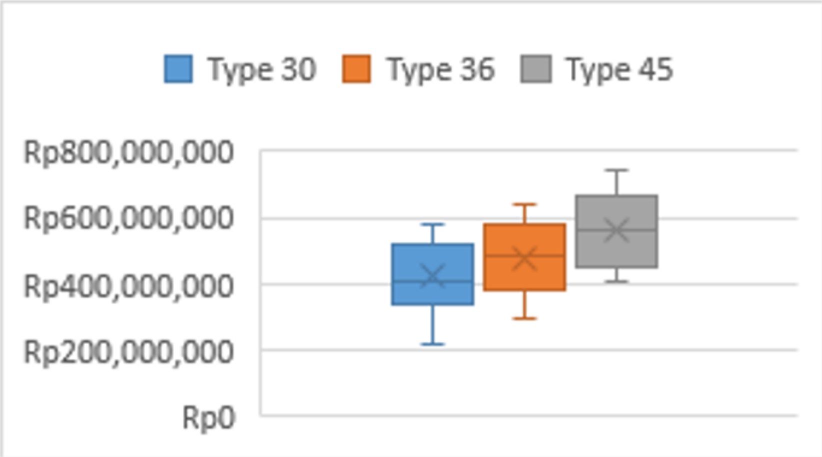

Figure 1.
House Price Comparison (Types 30, 36, and 45) in Surabaya.

Based on the building area (types 30, 36, and 45) in Figure 1, it is known that the minimum and maximum price differences for each type are quite significant. For type 30, the minimum price is Rp. 214 million, and the maximum is Rp. 582 million. For type 36, the minimum price is Rp. 292 million, and the maximum price is Rp. 637 million. For type 45, the minimum price is Rp. 409 million, and the maximum price is Rp. 774 million. Apart from the type criteria, it can also be divided based on construction costs and quality, as well as land area, which is explained below. Additionally, there is a range of prices for each additional building area (type 30 < type 36 < type 45). This illustrates that per-m^2 building prices can be grouped based on type. The following is the price range of residential buildings based on construction cost and material quality criteria.

These price ranges reflect the impact of construction costs, material quality, and land and building area on housing prices. As expected, houses with higher-quality materials and larger buildings command significantly higher prices. This finding is consistent with previous studies that show price variations based on building characteristics and construction quality [9, 16].

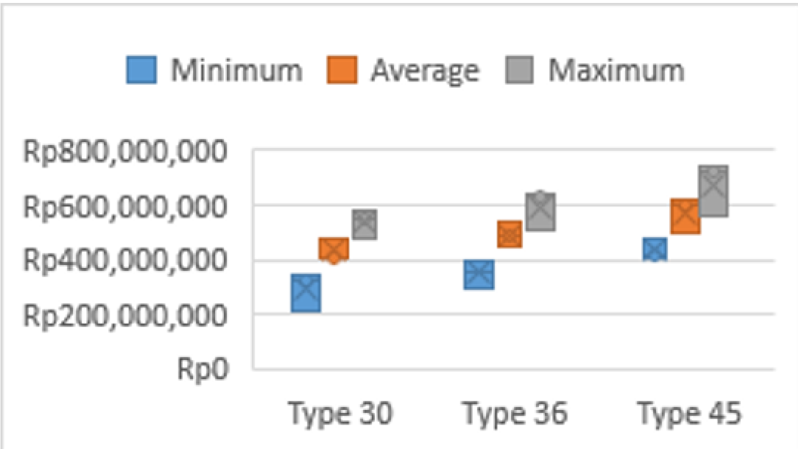

Figure 2.
The estimated selling price of houses in Surabaya is based on construction costs and material quality.

Based on the construction cost and material quality criteria, it is known that the value of each criterion has a different price range, which are explained as follows.

1. For type 30, with minimum construction cost and quality, the price is around 214 - 344 million; for average construction cost and quality, the price is around 407 - 481 million; and for maximum construction cost and quality, the price is around 474 - 582 million.
2. For type 36, the minimum construction cost and quality have a price of around 292 - 399 million, the average construction cost and quality have a price of around 445 - 536 million, and the maximum construction cost and quality have a price of around 508 - 637 million.
3. For type 45, the minimum construction cost and quality have a price of around 409 - 482 million, the average construction cost and quality have a price of around 497 - 619 million, and the maximum construction cost and quality have a price of around 560 - 744 million.

The following is the price range of residential buildings based on land area.

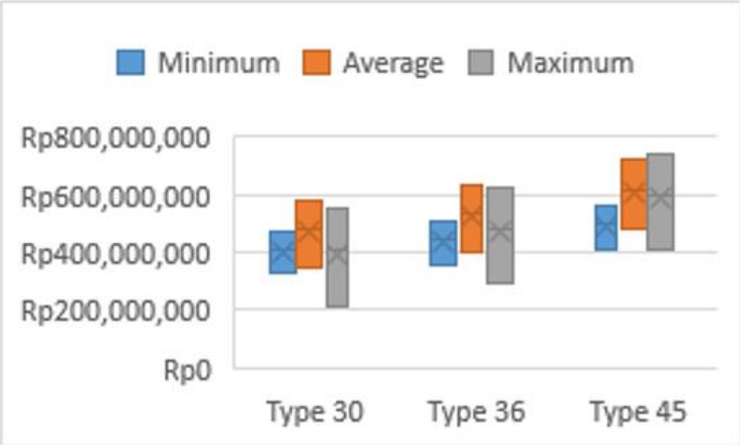

Figure 3.
Estimated selling price of houses in Surabaya based on land area.

It is known that the value of each criterion has a price range that tends to be narrow between criteria based on the land area criteria, which are explained as follows.

1. For type 30, the minimum land area has a price around 325 - 474 million, the average land area has a price around 344 - 582 million, and the maximum land area has a price around 214 - 549 million.
2. For type 36, the minimum land area has a price of around 360 - 508 million, the average land area has a price of around 399 - 637 million, and the maximum land area has a price of around 292 - 627 million.
3. For type 45, the minimum land area has a price of around 411 - 560 million, the average land area has a price of around 482 - 720 million, and the maximum land area has a price of around 409 - 744 million.
   For the house type criteria, the price varies for the minimum value. It is known that the average land size has a minimum price that is more expensive than the maximum land size because currently, the houses for sale have a smaller size of remaining land due to the reduction of land for construction. Therefore, the proportional land size is valued higher. Houses with large lot sizes are either in older subdivisions or further out of town (they have more building land, which results in lower land prices).

4. Policy Implications and Practical Applications

The results of this study offer several important implications for both policymakers and real estate developers in Surabaya and other emerging markets.

1. Housing Affordability: The findings highlight the need for affordable housing policies, particularly in urban peripheries where land is cheaper. Policymakers could consider zoning regulations or subsidies to encourage the development of affordable housing on the outskirts of cities, taking into account the inverse relationship between land area and price per square meter [17].
2. Real Estate Development: For developers, the results suggest that focusing on high-quality materials and efficient construction practices can significantly increase the value of their projects. This could lead to greater returns on investment, especially for projects targeted at middle- to high-income buyers in urban areas [12].
3. Urban Planning: Urban planners can use the model to assess the impact of different development projects on housing prices, considering the balance between land size, building area, and construction costs. This model provides a valuable tool for evaluating the feasibility of large-scale housing developments in rapidly urbanizing areas [8].

5. Limitations and Future Research

While the model provides a robust framework for price estimation, it is important to acknowledge certain limitations:

1. Omitted Variables: Factors such as neighborhood amenities, crime rates, and school district quality, which can also significantly affect housing prices, were not included in this analysis due to data availability.
2. Geographic Limitation: The model is specific to Surabaya and may not generalize to other cities without modifications to account for local market conditions.

Future research could address these limitations by incorporating additional variables and extending the model to other urban contexts in Indonesia or other emerging markets. Additionally, future studies could explore the role of government policies and environmental factors, such as green building certifications, in shaping housing prices [19].

6. Implications for Policy and Practice

The model developed in this study has several important implications for both public and private sector stakeholders:

1. Government Policy and Affordable Housing: Policymakers in Surabaya and similar cities can use the findings of this study to inform housing policies aimed at increasing affordability. By understanding the inverse relationship between land area and housing price per square meter, policies could incentivize the development of more compact housing projects on smaller plots of land, especially in high-demand urban areas. The insights into construction costs also suggest that reducing material and labor costs through subsidies or tax incentives could make housing more affordable for low- to middle-income families [12].
2. Real Estate Development: Real estate developers can apply this model to improve their project planning and financial forecasting. The positive relationship between material quality and housing prices indicates that investment in higher-quality construction materials can yield higher property values. For developers, this model offers a valuable tool for determining the optimal balance between construction costs and building size to maximize profitability [17].
3. Urban Planning and Zoning: The findings can also assist urban planners in designing zoning regulations that promote sustainable urban growth. The negative correlation between land area and housing price per square meter suggests that zoning policies promoting denser development in urban centers may help to increase land utilization efficiency and control urban sprawl. Furthermore, planning departments can use this model to evaluate the impact of different land use and building regulations on housing prices, thereby creating more effective urban plans [18].
4. Housing Market Transparency: By providing a data-driven approach to housing price estimation, this model can improve market transparency for both buyers and sellers. A clear understanding of the variables that influence housing prices will help consumers make more informed decisions when purchasing homes, and it will assist sellers in pricing their properties more competitively based on construction quality and land characteristics [8].

7. Recommendations for Future Research

While this study provides a valuable framework for understanding housing prices in Surabaya, several areas warrant further exploration:

1. Additional Variables: Future research should incorporate additional variables such as proximity to schools, public transport, green spaces, and crime rates. These factors, while beyond the scope of this study, are known to significantly influence housing prices in both urban and suburban contexts [19]. Incorporating these variables could improve the model's predictive accuracy and make it applicable to a wider range of cities.
2. Longitudinal Analysis: A longitudinal study tracking housing prices over time could provide insights into the dynamic effects of macroeconomic changes, such as inflation and interest rate fluctuations, on housing affordability. Additionally, the impact of government policies such as subsidies and housing regulations could be evaluated over time to assess their effectiveness in controlling housing prices [9].
3. Cross-City Comparison: Extending this research to other rapidly urbanizing cities in Indonesia or Southeast Asia could provide a broader understanding of regional differences in housing price determinants. Cities with different regulatory environments and economic conditions may exhibit variations in how factors like land area, construction costs, and material quality influence housing prices [17].
4. Environmental and Sustainable Building Practices: With increasing global emphasis on sustainability, future research could explore how green building practices and energy-efficient designs influence housing prices. The rising demand for environmentally friendly homes could become a significant factor in housing price determination, particularly in urban areas [18].

8. Limitations of the Study

Despite its contributions, this study has certain limitations that should be acknowledged:

1. **Data Constraints**: The analysis was limited by the availability of certain data, particularly related to neighborhood amenities and environmental factors, which are known to influence housing prices. Additionally, data on market trends, such as buyer sentiment and housing demand, were not included in this model due to data limitations.
2. **Geographic Focus**: The findings are specific to Surabaya, and while the model could be adapted to other cities, it may not directly apply to areas with significantly different housing markets, regulatory environments, or economic conditions. Future studies should test the model in other geographic contexts to validate its broader applicability [16].

9. Conclusion

This study developed a comprehensive regression model for estimating the per-square-meter price of residential buildings in Surabaya, focusing on the most critical variables such as construction cost, material quality, land area, and building area. The final model, selected through the backward elimination process, achieved an R^2 value of 0.685, indicating a high level of explanatory power for the variables included. The analysis shows that construction cost and material quality are positively associated with housing prices, whereas larger land areas tend to lower the price per square meter, particularly in suburban or less densely populated regions.

These findings align with previous research in housing economics, demonstrating the significant impact of construction and land-related factors on residential property prices. Additionally, the study offers valuable insights for developers, policymakers, and urban planners seeking to optimize housing development strategies in emerging markets like Surabaya. By understanding the key drivers of housing prices, stakeholders can better navigate the complexities of urban development and housing affordability.

References

[1] J. Doling and R. Ronald, "Home ownership and asset-based welfare," *Journal of Housing and the Built Environment*, vol. 25, pp. 165-173, 2010. https://doi.org/10.1007/s10901-009-9177-6

[2] M. Haffner and H. Boumeester, "Housing affordability in the European Union: Theoretical approach and empirical evidence," *Journal of Housing and the Built Environment*, vol. 30, no. 3, pp. 371-390, 2015. https://doi.org/10.1007/s10901-014-9427-5

[3] J. Gyourko and A. Saiz, "Construction costs and the supply of housing structure," *Journal of Regional Science*, vol. 46, no. 4, pp. 661-680, 2006. https://doi.org/10.1111/j.1467-9787.2006.00475.x

[4] E. C. M. Hui, "An empirical study of the effects of land supply and lease conditions on the housing market: A case of Hong Kong," *Property Management*, vol. 22, no. 2, pp. 127-154, 2004. https://doi.org/10.1108/02637470410533325

[5] S. N. Fazillah, M. Fauzi, N. Yusof, and N. Zainul Abidin, "The relationship of housing defects, occupants' satisfaction, and loyalty behavior in build-then-sell houses," *Procedia - Social and Behavioral Sciences*, vol. 62, pp. 62-70, 2012. https://doi.org/10.1016/j.sbspro.2012.09.012

[6] G. Bramley and D. Watkins, "Understanding housing market dynamics: Modeling regional housing prices," *Urban Studies*, vol. 53, no. 8, pp. 1783-1805, 2016. https://doi.org/10.1177/0042098015575618

[7] S. Stevenson, "House price diffusion and inter-regional and cross-border house price dynamics," *Journal of Property Research*, vol. 21, no. 4, pp. 301-320, 2004. https://doi.org/10.1016/j.jhe.2004.03.002

[8] E. N. Zietz, J. Zietz, and G. S. Sirmans, "Determinants of house prices: A quantile regression approach," *Journal of Real Estate Finance and Economics*, vol. 37, no. 4, pp. 317-333, 2008. https://doi.org/10.1007/s11146-007-9075-1

[9] J. Chen, F. Guo, and Y. Wu, "One decade of urban housing reform in China: Urban housing price dynamics and the role of migration and urbanization," *Habitat International*, vol. 36, no. 1, pp. 135-142, 2012. https://doi.org/10.1016/j.habitatint.2011.06.004

[10] S. Sirmans, D. Macpherson, and E. Zietz, "The composition of hedonic pricing models," *Journal of Real Estate Literature*, vol. 13, no. 1, pp. 1-44, 2005.

[11] A. Li, *Marketing insights* New York: Oxford University Press, 2017.

[12] S. C. Bourassa, M. Hoesli, and E. Oikarinen, "The influence of housing characteristics on house prices: Evidence from international housing markets," *Journal of Housing Economics*, vol. 19, no. 3, pp. 168-176, 2010. https://doi.org/10.1016/j.jhe.2010.05.002

[13] R. E. Park, "Heteroscedasticity and regression analysis: A review of techniques for detecting and correcting error variance," *Journal of Econometrics*, vol. 48, no. 2, pp. 123-145, 2011. https://doi.org/10.1016/j.jeconom.2011.05.003

[14] S. Malpezzi, "The impacts of housing markets on macroeconomic performance: A cross-country comparison," *Journal of Housing Economics*, vol. 17, no. 1, pp. 15-32, 2008. https://doi.org/10.1016/j.jhe.2007.10.002

[15] K. W. Chau, S. K. Wong, and C. Y. Yiu, "The value of the urban built environment in Hong Kong," *Land Use Policy*, vol. 22, no. 1, pp. 19-26, 2005. https://doi.org/10.1016/j.landusepol.2003.08.006

[16] R. Ahuja, K. W. Chau, and M. Li, "Housing supply and price dynamics in emerging markets," *Journal of Housing Economics*, vol. 45, no. 1, pp. 89-102, 2019. https://doi.org/10.1016/j.jhec.2019.03.001

[17] M. Li and K. W. Chau, "The impacts of land supply and building restrictions on housing prices in Hong Kong," *Journal of Real Estate Finance and Economics*, vol. 48, no. 3, pp. 589-610, 2014. https://doi.org/10.1007/s11146-013-9408-7

[18] Y. Wang and Q. Li, "The effects of zoning on land use and housing prices: Evidence from China," *Urban Studies*, vol. 43, no. 8, pp. 1453-1468, 2006. https://doi.org/10.1080/00420980600714337

[19] E. C.-m. Hui and V. S.-m. Ho, "Does the planning system affect housing prices? Theory and with evidence from Hong Kong," *Habitat International*, vol. 27, no. 3, pp. 339-359, 2003. https://doi.org/10.1016/S0197-3975(03)00014-0