Optimum: Jurnal Ekonomi dan Pembangunan
Vol. 15, No. 2, September 2025, pp. 164-173
DOI:10.12928/optimum.v15i2.11478
ISSN 2613-9464

Model development for estimating sales adjusment magnitude in real estate appraisal using hedonic price model and paired data analysis

Bagaskara [a,1,*], Fatima Putri Praviti [a,2]

[a] Property Management and Appraisal, Vocational College, Universitas Gadjah Mada, Indonesia
[1] bagas.kara@mail.ugm.ac.id*; [2] fatimaputri94@mail.ugm.ac.id

* corresponding author

ARTICLE INFO

Received : 30-08-2024
Revised : 10-01-2025
Accepted : 15-01-2025
Published : 08-07-2025

Keywords:
Sales comparison approach
Hedonic price model
Paired data analysis
Appraisal

JEL Classification:
R30; R31; R32

ABSTRACT

This study aims to develop a model that can identify a reference for determining the adjustment magnitude in the market approach used in appraisal practice. Currently, it is challenging for appraisers to accurately determine the extent of these adjustments. Data collection in this study employed purposive sampling, ensuring that the criteria and specifications closely mirrored the data collection process in appraisal practices. The researcher selected three districts to capture any possible variations in location affecting the adjustment magnitude. The collected data was regressed to build a hedonic price model, which was later analyzed using the paired data analysis method to meet ideal model conditions and specifications. The results of this study demonstrate that the adjustment magnitude in the market approach can be identified from price differences resulting from variations in a single attribute. The highly heterogeneous housing market conditions in Indonesia present significant challenges for conducting paired data analysis in a practical context. Artificial conditions were required to meet the specifications for paired data analysis. The implication of the study that appraisers in determining adjustments in the market approach. Additionally, the model/procedure developed in this study can be applied in research across different contexts and objects, contributing to the advancement of real estate valuation science.

1. Introduction

Asset or property appraisal has become a critical part of the financial system and economic development. Referring to POJK (2018), appraisers have a very significant role in the credit market– especially in the money market where the interest rate is the price of money. Collateral may only be appraised by an independent appraiser or internal appraiser depending on the credit scale. The amount of credit that can be given by the bank is largely determined by the results of the appraisal of collateral– the credits distributed to creditors are based on market value and liquidity value indication of the collateral. Therefore, the accuracy of the appraisal become very critical in collateral context. In addition, appraisers also have an increasingly significant role in economic development because in Permendagri No 19 of 2016, from various phases of asset life cycle, appraisers are needed to determine the market value or fair value of these public assets. Appraisal is becoming increasingly critical, this is in line with Şipoş & Crivii (2008), Moreira et al (2014) and Tabar & Sisman (2019) concluded that appraisers also have an increasingly significant role in economic development through determine the true market value of properties which essential for banks or financial institutions and investors to assess risks and returns.

In practice, the value generated by the appraiser has enormous significance to interested parties. For example, in the context of auctions that occur due to default by creditors. the appraiser must be able to determine the liquidation value of the assets used as collateral for auction purposes. The results of this appraisal are very important for the bank because if the resulting value is overvalued then the possibility of the asset not being sold will be very high. Another example, the results of the appraisal for the purpose of land acquisition for the public interest have a very high sensitivity. An inaccurate (overvalued or undervalued) fair replacement value is extremely risky for the appraiser. Dmytrów (2019) argued there are situations in the real estate market in which a large number of properties have to be valued at the same time and even though the optimisation of the MSE improves the quality of valuations, it also narrows down their volatility, which might make the valuation of properties from the outside of a given database more problematic.

Inaccurate appraisal results can arise from the process itself. Vaz (2015) argues that the discretionally and the appraisers' subjectivity that characterizes traditional real estate valuation are still allowed to take part in the formation of the asset price even when respecting international standards (EVS, IVS) or Appraisal Institution´s regulations (TEGOVA, RICS, etc. In Indonesia itself, efforts at standardization have been made through the establishment of relevant standards and regulations (KEPI SPI, Minister of Finance Regulations). However, these standards are not enough to reduce the subjectivity of appraisal. Real estate appraisal practice in Indonesia can still be far from being objective. The inaccuracy and subjectivity happen because in the appraisal process, there are still many dimensions of analysis that are judgmental and subjective. This process was not done on purpose but rather the lack of availability of data related to real estate and the lack of development in the science of real estate appraisal in Indonesia.

Inaccurate appraisal results can refer to different values generated by each appraiser. This phenomenon is explained by Millington (2000) defining appraisal as a science and art. This view departs from the complex nature of the value itself. Several appraisers conducted appraisals on the same asset can produce different values (Shapiro et al., 2019). The science and art part of appraisal cannot be separated from appraisers. Mooya (2016) explains that appraisal is both a science and an art. This definition provides clues to the complexity of the nature of value (particularly market value) and how that value can be measured. In the context of Economics, the measurement of a variable or indicator requires that value can be measured in an objective sense, but the reality of value (in common sense) implies a subjective phenomenon. The scientific aspect of appraisal can justify the objectivity element of values and reflect a positivist methodological orientation. Thus, on a philosophical level, appraisers generally use the scientific (as opposed to predictive) method to estimate values, but it is more practical to adopt a "scientific approach" in data analysis and mathematical calculations to estimate values.

The art of appraisal arises from acknowledging the fundamentally subjective nature of values and how they are formed in individual perceptions or attitudes. Art in this case is personal and relative. The tension between these two aspects of judgment has not been completely resolved by conventional theory. The conventional solution is to describe appraisal as an inexact science, an opinion based on an assessment of the market influence that appraisers consider significant in the determination of real estate values. It is recognized that certain properties may have different (or subjective) values to different people but this is expected to coalesce at the (objective) exchange price in the market. Thus, for every property, there is a single, fixed market price (and by extension a single market value). Appraisal is an estimate (opinion) of this exchange price with certain assumptions which is a natural thing in issuing an opinion between appraisers may differ from one another. Nguyen & Huy (2025) states that high-performance work practice (HPWP) in appraisal are significantly associated with both types of employee voice behaviors. Challenge appraisal partially mediates the impact of HPWPs on promotive voice, while hindrance appraisal acts as a partial mediation in the HPWPs-prohibitive voice linkage.

One source of differences in the values generated by appraisers comes from adjustments in the sales comparison approach/market approach. Vaz (2015) argues that traditional appraisal methods tend to limit to the maximum appraiser's arbitrariness or subjectivism when adjusting comparable property's characteristics, aiming to maximize the objectivity of the appraisal process. According to the Appraisal Institute (2020) and MAPPI (2018) in real estate appraisal, there are three approaches used to appraise a property, namely market (sales comparison), income, and cost approaches. The market approach is one of the most popular approaches in appraisal. The market approach provides an indication of value by comparing an asset with other identical or comparable assets where price

information is available. The market approach should be applied and given significant weight in the condition of the asset being assessed as having recently been sold in a transaction that is appropriate for the consideration contained in the basis of value used, the asset being valued or assets of substantially similar nature are actively traded in the public and/or there are multiple transactions and/or observable recent transactions for substantially similar assets.

The heterogeneous nature of assets on the market makes it very difficult to obtain evidence of identical and similar transactions on the market. When the information related to market comparisons is not identical, the appraiser must carry out a qualitative and quantitative comparative analysis of the similarities and differences between the comparable assets and the assets to be valued. Then adjustment is a way to adjust so that the comparison property can be adjusted to the property to be assessed so that the value issued is accurate and can be accounted for. Kronenwett & Rigotti (2022) found that emotional demands and time pressure exert positive effects on work engagement when people expect resource gain (challenge appraisal), independent of actual resource gain (achievement). The attributes used in the customization elements are very broad and vary according to market preferences. However, in the real context, this adjustment is made very subjectively due to the lack of data pooled by an appraiser so the adjustment becomes a professional judgment (relatively subjective). There are many pros and cons related to this professional judgment which question the background of the emergence of the amount of adjustment in the assessment, it is necessary to have an academic basis on how to determine the adjustment that can be used in the appraisal practice.

Conceptually this method can be used but according to Šnajberg (2015) that appraisers can use comparison methods and matched paired analysis techniques but in practice, it is almost impossible to do. Paired data analysis is increasingly difficult to carry out in neighbourhood areas in Indonesia because of the heterogeneous characteristics of housing. Houses in Indonesia have very varied physical characteristics. Finding suitable and paired data is almost impossible. Therefore, this research introduces a novel methodology that proxy paired data analysis by forming a hedonic price model so that they can estimate house prices with certain specifications. The hedonic price model enables researchers to estimate and compare two houses with the exact same specifications and differing in only one attribute. that way the amount of adjustment can be identified. This research aims to identify the magnitude of adjustments for several attributes of residential homes The contribution of the study are expected to provide reference to appraisers in determining the magnitude of adjustment in the context of conducting an appraisal using a market approach. So far, appraisers still rely on professional judgment in determining the amount of adjustment, which cannot be proven empirically and tends to be subjective. The model formulated in this study can also be used to determine adjustments to other attributes or other objects (personal property). The model developed in this study look and identify at how different houses with different specification. For instance, how house with area of 100 m2 and 150 m2 are different and reflected in the bid price or transaction price. This is still difficult to determine by appraisers in Indonesia. Specifically, this study aims to develop a model to determine the magnitude of adjustments in the market approach.

2. Literature Review

Previous studies that are close to determining the magnitude of the adjustment are more towards the use of regression to find out what factors affect real estate prices (Benjamin et al., 2004; Reichert, 2002; Isakson, 1998; Kang & Reichert, 1991; Alenany et al (2021); Malaman & Amorim, 2017; Şipoş & Crivii, 2008). The hedonic pricing model (HPM) has emerged as a pivotal tool in property appraisal, enabling a nuanced understanding of how various attributes contribute to property values. Hedonic pricing models operate on the premise that the price of a property can be understood as a function of its characteristics, which include both structural attributes (e.g., size, number of rooms) and locational factors (e.g., proximity to amenities) (Lisi, 2022; Kim et al., 2016; Jiang et al., 2015). Lisi (2019) emphasizes that these models quantitatively represent the valuation process of property appraisers, allowing for a systematic allocation of value to individual property components. This aligns with the findings of Kim et al (2016) who demonstrate that the spatial patterns of urban landscapes significantly influence housing prices, reinforcing the idea that environmental attributes are integral to property valuation. The methodological rigor of hedonic models is further supported by Bax et al (2019) who argue that hedonic regression serves as a quality-adjusted methodology, distinguishing between pure price changes and shifts in sample composition over time. The hedonic price model is an economic model that breaks down goods or services into multiple attributes to estimate their prices (Yang et al., 2025). Ihlanfeldt & Yang (2025) found by using hedonic price that large percentage increases in the

marginal willingness to pay for interior and exterior space after COVID, continuing through 2023. This is particularly relevant in dynamic markets where property characteristics evolve.

Yazdani (2021) argued that underscores the versatility of hedonic models, noting their widespread application across various research fields and their utility for policymakers in analysing differentiated goods like housing. This study focuses more on how to determine the magnitude of adjustment in the sales comparison approach using the paired data comparison method/analysis. Paired data analysis is the most ideal way to determine adjustments. Paired data analysis, often referred to as matched pairs analysis, allows for a more precise estimation of the impact of specific characteristics on property values by controlling for confounding variables. This approach is particularly useful in hedonic pricing models, which rely on the relationship between property attributes and market prices. Numan Jamal & Mohamad (2024) highlights that matched model indexes, which are averages of price changes for goods that remain on sampled shelves, can provide a more accurate reflection of price dynamics than traditional hedonic models that may be influenced by the disappearance of lower-value goods. This suggests that paired data analysis can enhance the reliability of property appraisals. Ideally, to do paired data analysis, appropriate data is needed. Below are some previous studies that can support this research in terms of theory and determining the variables that influence real estate prices. These studies do not specifically determine the magnitude of adjustment.

3. Method

The Market Approach is an appraisal approach that provides an indication of value by comparing an asset with other identical or comparable assets where price information is available (MAPPI, 2018). Appraisal Institute (2020) explain that the appraiser develops an opinion on value by analyzing closed sales, pending sales, active selling listings, and selling lists of cancelled or expired properties like the property being appraised. The comparative techniques of analysis applied in the market approach are fundamental to the appraisal process. According to several previous studies such as Pagourtzi et al (2003), Isakson (1998), Lentz & Wang (1998) and Lisi (2019) stated that market approach is the most widely used method and is often used to estimate the market value of residential property. The market approach is the approach that best reflects market value because in this approach all aspects of the analysis are derived directly from the market. However, the main issue in the market approach regarding methodology (which is often subjective) is the problem of determining the "adjustment factor" (Lisi, 2019).

The determination of this adjustment is still a major obstacle in the practice of property appraisal in Indonesia. According to Pagourtzi et al (2003) that each country has a different culture and experience, this will affect the determination of the method adopted for appraisal practice. The comparison method is the most frequently used method, but in this method, adjustments are required which are highly dependent on the availability, accuracy, completeness, property transaction data. This is not found in Indonesia, so that the determination of adjustments is still very subjective and judgmental. The appraiser needs to determine the adjustments in the comparison method because the properties of the comparisons cannot be identical. The difference between the subject property and the comparison property must be adjusted so that it is assumed that the value of the subject property can be represented by the adjusted comparison property. The highly heterogeneous nature of properties means that even when appraiser refer to comparison targets that are very similar to the subject properties assessed, or the collected income or cost data are highly credible, many elements still require adjustment (Lee et al., 2020). The customized attributes are basically a reflection of the market. What things do buyers consider when they are going to buy a property and what things do sellers consider when they are going to sell a property. According to Pagourtzi et al (2003) the attributes compared include: differences in size, age, quality of construction, date of sale, surrounding environment, and others. Appraisal Institute (2020) argued for these comparison attributes are referred to as comparison elements. Adjustments are made in order of adjustments to transactions, funding, market conditions, location, and physical factors. MAPPI (2018) also describes the elements of comparison including location aspects (market area), economic aspects, legal aspects, and physical aspects.

One technique that is often used in many countries is paired data analysis method. In Indonesia, this technique cannot be used optimally in appraisal practice because there are indeed limitations (availability of data and methods). Paired data analysis method requires that sales are similar in all but one characteristic. For example, two very similar parcels of land in the same neighbourhoods were

being sold—one with a view and one without. The monetary difference (price) between these two sales is considered one of the market indications for the scene. One sale does not create a market, so a series of matched pairs is needed to validate the scene adjustment (Oregon, 2017). Suppose a market value adjustment is sought for a particular attribute. In paired data analysis method, pairs of sales are identified in such a way that the properties in the pairs are similar in all major respects (particularly in location, market conditions, financing, and all-important physical attributes) except the main attribute being analysed. one of the properties in the pair has the main attribute and the other does not. sale price difference between traits in this highly matched pair is attributed to the presence of the main attribute in one of the properties (Lipscomb & Gray, 1995).

Table 1. Definition of Variables

No	Variable	Definition of Variables
1.	Transaction Price Indication	Housing offer prices that have been adjusted using the bargaining process so that the offer price is close to the transaction price
2.	Lot Size	The area of land where the house is built, this variable contributes to the utility of the house where the larger the land area, the higher the utilization and the higher the utility
3.	Building Size	The building area of the house, the wider the building, the more space that can be utilized and can even affect the number of bedrooms, bathrooms, and family rooms
4.	Frontage	Front width of the house, basically this variable is preferential in nature, but in general the wider the front of the house, the more flexible the use of front space will be
5.	Anterior Road Width	Width of the road in front of the house, this variable is a proxy for accessibility, the wider the road in front of the restaurant, the easier it is to access
6.	Travel Distance to Educational Facilities	The distance required to travel to the nearest facility for education
7.	Travel Distance to Worship Facilities	The distance required to travel to the the nearest facility for worship
8.	Travel Distance to Shopping Facilities	The distance required to travel to the the nearest facility for shopping
9.	Travel Distance to Health Facilities	The distance required to travel to the the nearest health facilities

Source: Author Calculation

Malpezzi (2002) presents an excellent review of the theoretical development behind hedonic pricing models. As he points out, the hedonic model is a way to estimate the value of individual characteristics of the house. Hedonic equations have also been used to measure the effect of various factors of special interest on house prices. Malpezzi (2002) discusses, the hedonic model arises because of a heterogeneous housing stock and heterogeneous consumers. Not only does each house contain different housing characteristics, but those characteristics may be valued differently by different consumers. Hedonic models are typically estimated as single-stage equations. That is, the model simply estimates the effect of characteristics on price and does not examine the structural parameters of the individual characteristics. Hedonic models also are estimated various ways regarding the dependent variable, the house price. Price may be specified as an absolute amount (unlogged) or as a logged variable. The most typical model structure historically has been the semi-log form, with the price specified in natural logs and regressed against unlogged independent variables. This allows for variation in characteristic prices across different price ranges within the sample.

Using hedonic price model, a house is considered a comprehensive commodity entitled with structural, accessibility and neighbourhood attributes; and the value of a house is the realization of these attributes (Rosen, 1974). The hedonic pricing model Chau & Chin (2003) can be expressed as $P = f(S, A, N)(1)$. Where P is the housing prices, S is the structural attributes, A is the accessibility attributes, and N is the neighbourhood attributes Rosen (1974) presented the theoretical contribution of the hedonic price theory and argued that a single good has various attributes, and each character has a value contributing to the price of the item in an equilibrium market Various studies have

identified structural attributes as one of the internal factor as price determinants of residential property (Li et al., 2019; Chiang et al., 2015; Oloke et al., 2013).

Table 1 shows the definition of each variables used in this study through field survey. The dependent variable of this study is transaction price indication which refers to adjusted offer price. The adjustment carried out through data validation by phone and carry out direct investigations into the field. The enumerator bargains so that the offer price of housing is adjusted until it is close to the transaction price This study used purposive sampling because the purpose of this study was to determine the magnitude of the adjustment in appraisal practice. So that data collection had to be carried out as closely as possible to the practice of appraisal. After data collection and cleaning, the data collected amounted to 105 housing samples which were collected based on similarity. Most of the data was collected from Sleman, Kota and Bantul districts, where the areas are already sufficiently developed and settled.

4. Results and Discussion

Table 2 shows the Hedonic Price Model identifies and quantifies the factors affecting property prices. This model helps to understand how different characteristics contribute to the overall value of a property. The model formed has shown that most of the results align with previous studies. For instance, lot size is often considered a significant determinant of residential property values, reflecting the general market sentiment that larger lots provide more utility and potential for development. A larger lot size significantly increases property value. This effect is statistically significant, indicating a high confidence level in this result. Economically, larger lots provide more space for landscaping, expansion, or recreational activities, making them more attractive to buyers. Abelson et al (2013) conducted a comprehensive analysis of house prices across Sydney, utilizing spatial hedonic models to assess various factors influencing property values. Their findings indicate that both house and lot sizes are positively correlated with median house prices, suggesting that larger lot sizes contribute to higher property values. Similarly, a larger building size also has a positive and significant impact on property prices.

Table 2. Hedonic Price Model Estimation

Variables	Coefficient	Prob
Constanta	-2.510	0.055*
Lot Size	4073966.98	0.000***
Building Size	3796267.40	0.000***
Frontage	-8095196.0	0.260
Anterior Road Width	35738662.5	0.009***
Travel Distance to Educational Facilities	94774603.9	0.023**
Travel Distance to Worship Facilities	-85978760.0	0.062*
Travel Distance to Shopping Facilities	-86995774.0	0.045**
Travel Distance to Health Facilities	78102118.3	0.018**

Source: data processed

This highlights the importance of interior space, as larger buildings can accommodate more rooms and amenities, increasing their appeal to potential buyers. Hoxha et al (2022) conducted a study on apartment prices in Prishtina, Kosovo, and found that building size has a strong positive correlation with apartment prices. Their analysis indicates that larger apartments command higher prices, which aligns with the general market perception that size enhances the desirability of residential properties. Anterior road width positively impacts property values and is statistically significant. Wider roads can improve accessibility and traffic flow, making properties more desirable. From an economic perspective, good road infrastructure can enhance connectivity and reduce travel time, thereby increasing property value. Puspitarini & Devianto (2021) conducted a study in Tangerang, Indonesia, which identified road width as a significant factor affecting land value. Their research indicates that properties located on wider roads tend to have higher market values due to improved accessibility and

visibility. This finding aligns with the understanding that road infrastructure plays a crucial role in determining property desirability and, consequently, its price.

Table 3. Simplified Market Data Grid with Lot Size as Isolated Attribute

		Appraisal Object	Comparable 1	Comparable 2
Lot Size		101	115	80
Transaction Indications	Price	Rp 716,146,100.00	Rp. 773,505,637.90	Rp. 630,916,793.60
Level			Superior	Inferior
Difference			Rp. -57,035,537.72	Rp. 85,553,306.00
Percentage			-7.3%	13.5%

Source: data processed

The economic analysis of the Hedonic Price Model helps us understand how various factors influence property prices. Larger lot and building sizes, better road infrastructure, and proximity to certain facilities play a crucial role in determining the value of a property. These insights can aid real estate developers, investors, and buyers in making informed decisions. Based on the hedonic price model above, transaction prices with certain attributes can be estimated. This is important as a foundation for paired data analysis, where the data being compared must be similar except for one attribute. Keep in mind that some variables are not significant (5% significance). Table 3 shows a house with lot size specifications of 101, building size of 50, anterior road width of 2.17, and travel distances to education, shopping, and health facilities of 0.3, 1.6, and 1.9, respectively, will have an indicated transaction price of IDR 716,470,100. In this way, paired data analysis can be carried out by changing one of the attributes.

Table 4. Simplified Market Data Grid with Anterior Road Width as Isolated Attribute

		Appraisal Object	Comparable 1	Comparable 2
Anterior Road Width		2.17	5	3
Transaction Indications	Price	Rp 716,470,100.00	Rp. 817,610,515.90	Rp. 746,133,190.60
Level			Superior	Inferior
Difference			Rp. -101,035,537.72	Rp. -29,663,089.00
Percentage			-12.3%	3.9%

Source: data processed

Considering a scenario where there is an assessment object with attributes as explained in the previous paragraph. There are two comparable that we want to adjust because they have lot sizes of 115 and 80. To identify the magnitude of the adjustment, we need to enter these numbers into the hedonic price model that was developed previously. It is important to emphasize that all attributes are the same except for lot size. Table 4 shows the adjustment of the anterior road width. the appraisal object has an anterior road width of 2.17. for example, comparable 1 has an anterior road width of 5 and comparable 2 has an anterior road width of 3. the combination of the hedonic price model and paired data analysis can identify and show the magnitude of adjustments in the market approach.

5. Conclusion

Based on the results of the study, the magnitude of the adjustment can be identified from the price differences that arise from variations in one attribute. The very heterogeneous housing market conditions in Indonesia make it challenging to carry out paired data analysis in a practical context. Artificial conditions are required to meet the specifications of paired data analysis. The hedonic price model is needed to isolate the identified attributes. The magnitude of the difference from one isolated attribute becomes the reference magnitude of the adjustment. This aligns with what was explained by Oregon (2017) that the paired data analysis method requires that sales are similar in all but one characteristic. For example, two very similar parcels of land in the same neighbourhood were sold—one with a view and one without. The monetary difference (price) between these two sales is considered one of the market indications for the view. One sale does not create a market, so a series of matched pairs is needed to validate the view adjustment.

This study only demonstrates the combination of using hedonic price models and paired data analysis on a relatively small scale. A large database will make the analysis more comprehensive. This

study suggests that future research use the same model/procedure to identify the amount of adjustment for various more complex attributes, such as externality factors. The hedonic price model is based on regression, so it is very possible to use multiple regression dummy variables to identify the amount of adjustment for attributes that are non-ordinal but categorical, such as hook position, cul-de-sac, ownership, and so on, in the context of real estate. This study can serve as a reference for appraisers to determine adjustments in the market approach. Furthermore, the model/procedure formulated in this study can be used in research in different contexts and objects, thereby contributing to the development of real estate valuation science.

Acknowledgment

The authors deliver sincere appreciation to UGM Vocational College which has fully supported this research. It is hoped that the results of this research can contribute to both vocational college and the financial industry, especially real estate appraisal practices.

Declarations

Author contribution	:	This study is the results from the contribution of all authors.
Funding statement	:	This research did not receive funding from any external parties.
Conflict of interest	:	The author declares no conflict of interest.
Additional information	:	No additional information is available for this paper.

References

Abelson, P., Joyeux, R., & Mahuteau, S. (2013). Modelling house prices across Sydney. *The Australian Economic Review*, *46*(3), 269–285. doi: 10.1111/j.1467-8462.2013.12013.x

Alenany, E., Lekham, L. A., & Lu, S. (2021). *Integrated clustering regression for real estate valuation* (No. 1).

Appraisal Institute. (2020). *The appraisal of real estate* (15th ed.). Appraisal Institute.

Bax, D., Zewotir, T., & North, D. (2019). A gamma generalised linear model as an alternative to log linear real estate price functions. *Journal of Economic and Financial Sciences*, *12*(1). doi: 10.4102/jef.v12i1.476

Benjamin, J., Guttery, R., & Sirmans, C. (2004). Mass appraisal: An introduction to multiple regression analysis for real estate valuation. *Journal of Real Estate Practice and Education*, *7*(1), 65–77. doi: 10.1080/10835547.2004.12091602

Chau, K. W., & Chin, T. L. (2003). A critical review of literature on the hedonic price model. *International Journal for Housing Science and Its Applications*, *27*(2), 145–165.

Chiang, Y., Peng, T.-C., & Chang, C.-O. (2015). The nonlinear effect of convenience stores on residential property prices: A case study of Taipei, Taiwan. *Habitat International*, *46*(6), 82–90. doi: 10.1016/j.habitatint.2014.10.017

Dmytrów, K. (2019). Calibration of attributes influence in the process of real estate mass appraisal by using decision-making methods. *Przegląd Statystyczny. Statistical Review*, *66*(4), 287–308. doi: 10.5604/01.3001.0014.0953

Hoxha, V., Hoxha, D., & Hoxha, J. (2022). Study of factors influencing apartment prices in Prishtina, Kosovo. *International Journal of Housing Markets and Analysis*, *15*(5), 1242–1258. doi: 10.1108/IJHMA-08-2021-0086

Ihlanfeldt, K., & Yang, C. F. (2025). Single-family home spaciousness and COVID-19. *Annals of Regional Science*, *74*(1). doi: 10.1007/s00168-025-01356-8

Isakson, H. (1998). The review of real estate appraisals using multiple regression analysis. *Journal of Real Estate Research*, *15*(2), 177–190. doi: 10.1080/10835547.1998.12090922

Jiang, L., Philips, P. C. B., & Yu, J. (2015). New methodology for constructing real estate price

indices applied to the Singapore residential market. *Journal of Banking & Finance*, *61*(2), 121–131. doi: 10.1016/j.jbankfin.2015.08.026

Kang, H.-B., & Reichert, A. K. (1991). An empirical analysis of hedonic regression and grid-adjusment techniques in real estate appraisal. *Real Estate Economics*, *19*(1), 70–91. doi: 10.1111/1540-6229.00541

Kim, J.-H., Li, W., Newman, G., Kil, S.-H., & Park, S. Y. (2016). The influence of urban landscape spatial patterns on single-family housing prices. *Environment and Planning B: Urban Analytics and City Science*, *45*(1), 26–43. doi: 10.1177/0265813516663932

Kronenwett, M., & Rigotti, T. (2022). All's well that ends well!? Moderating effects of goal progress on the relation between challenge and hindrance appraisal and well-being. *Journal of Managerial Psychology*, *37*(5), 444–466. doi: 10.1108/JMP-11-2019-0618

Lee, M.-H., Peng, C.-W., & Liao, H.-F. (2020). An analysis of objectivity in the real estate appraisal process. *International Real Estate Review*, *23*(4), 483–504. doi: 10.53383/100311

Lentz, G. H., & Wang, K. (1998). Residential appraisal and the lending process: A survey of issues. *Journal of Real Estate Research*, *15*(1), 11–40. doi: 10.1080/10835547.1998.12090912

Li, H., Wei, Y. D., Wu, Y., & Tian, G. (2019). Analyzing housing prices in Shanghai with open data: Amenity, accessibility and urban structure. *Cities*, *91*, 165–179. doi: 10.1016/j.cities.2018.11.016

Lipscomb, J. B., & Gray, J. B. (1995). A connection between paired data analysis and regression analysis for estimating sales adjusments. *Journal of Real Estate Research*, *10*(2), 175–184. doi: 10.1080/10835547.1995.12090781

Lisi, G. (2019). Sales comparison approach, multiple regression analysis and the implicit prices of housing. *Journal of Property Research*, *36*(3), 272–290. doi: 10.1080/09599916.2019.1651755

Lisi, G. (2022). Education Briefing Property valuation: the hedonic pricing model: the application of search-and-matching models. *Journal of Property Invesment & Finance*, *40*(1), 99–107. doi: 10.1108/JPIF-12-2020-0138

Malaman, C. S., & Amorim, A. (2017). Method for determining values in real estate appraisal: Comparing between linier regression model and fuzzy logic. *Bulletin of Geodetic Sciences*, *23*(1).

Malpezzi, S. (2002). Hedonic pricing models: A selective and applied review. In *Housing Economics and Public Policy*. Wiley. doi: 10.1002/9780470690680.ch5

MAPPI. (2018). *Kode etik penilai Indonesia dan standar penilaian Indonesia* (7th ed.). MAPPI.

Millington, A. (2000). *Property development* (1st ed.). Taylor & Francis.

Mooya, M. M. (2016). *Real estate valuation theory* (1st ed.). Springer Berlin Heidelberg. doi: 10.1007/978-3-662-49164-5_1

Moreira, A. C., Tavares, F. O., & Pereira, E. T. (2014). Real estate appraisal: The income approach in Portuguese municipalities. *Revista Galega de Economia*, *23*(1), 187–202.

Nguyen, T. C., & Huy, P. T. (2025). Value and appraisal: human resource management practices and voice behaviors. *Management Decision*, *63*(5), 1657–1673. doi: 10.1108/MD-05-2024-1062

Numan Jamal, A. A., & Mohamad, Y. I. (2024). Identifying the current status of real estate appraisal methods. *Real Estate Management and Valuation*, *32*(4), 12–27. doi: 10.2478/remav-2024-0032

Oloke, O., Simon, F., & Adesulu, A. F. (2013). An examination of the factors affecting residential property values in Magodo neighbourhood, Lagos State. *International Journal of Economy, Management and Social Sciences*, *2*(8), 639–643.

Oregon. (2017). *Appraisal Methods: Basic information and procedures for setting up a mass appraisal program*. Oregon Department of Revenue.

Peraturan Otoritas Jasa Keuangan Republik Indonesia, (2018).

Pagourtzi, E., Assimakopoulos, V., Hatzichristos, T., & French, N. (2003). Real estate appraisal: a review of valuation methods. *Journal of Property Invesment & Finance*, *21*(4), 383–401. doi: 10.1108/14635780310483656

Puspitarini, I., & Devianto, I. R. (2021). Determinants of public asset value for land property: A study in the city of Tangerang, Indonesia. *Planning Malaysia Journal*, *19*(3). doi: 10.21837/pm.v19i17.1000

Reichert, A. K. (2002). Hedonic modeling in real estate appraisal: The case of environmental damages assessment. In *Real Estate Valuation Theory* (pp. 227–284). Springer. doi: 10.1007/978-1-4615-0909-7_11

Rosen, S. (1974). Hedonic prices and implicit markets: Product differentiation in pure competition. *Journal of Political Economy*, *82*(1), 34–55. doi: 10.1086/260169

Shapiro, E., Mackmin, D., & Sams, G. (2019). *Modern methods of valuation* (12th ed.). Taylor & Francis. doi: 10.1201/9781315145419

Şipoş, C., & Crivii, A. (2008). A liniear regression model for real estate appraisal. *3rd Wavo Valuation Congress "Valuation in Diversified and Emerging Economies."*

Šnajberg, O. (2015). Valuation of real estate with easement. *Procedia Economics and Finance*, *25*, 420–427. doi: 10.1016/S2212-5671(15)00753-4

Tabar, M. E., & Sisman, Y. (2019). Creating a real estate appraisal model by fuzzy logic. *2nd International Conference on Agriculture, Technology, Engineering and Sciences (ICATES 2019)*.

Vaz, J. F. (2015). Real estate appraisal and subjectivity. *European Scientific Journal*, *11*(9).

Yang, S., Wang, L., & Bi, Y. (2025). A study on the price spatial differentiation and influencing factors of rural homestay in Suzhou based on the hedonic price model. *Buildings*, *15*(10). doi: 10.3390/buildings15101610

Yazdani, M. (2021). House price determinants and market segmentation in Boulder, Colorado: A hedonic price approach. *General Economics*, *21*(8).