
Statistical analysis of main determinant's role in the value formation of residential property assets in Ukraine

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Abstract: The objective of this study is to investigate the influence of both qualitative and quantitative factors on real estate valuation within the Ukrainian residential market. Leveraging a comprehensive dataset from the Ukrainian real estate market, encompassing essential property characteristics and historical pricing data, specific indicators were identified to discern primary determinants impacting residential property values. Through the development of multivariate regression models, this research ranks qualitative indicators to facilitate their integration into the analysis. Regression analysis conducted over data spanning from 2021 to 2023 reveals significant factors affecting housing prices across different segments, including apartments, land plots, and households. Notable determinants include area, building type, renovation quality, layout, heating system, and natural gas availability for apartments; area, distance to the nearest city, soil type, location, natural surroundings, and land use for land plots; and property type, location, and area for households. This study contributes to the understanding of real estate valuation dynamics by employing regression analysis to scrutinize the influence of various factors on property prices. Utilizing data sourced from the continually updated information and analytical database of the Ukrainian real estate market, this research offers valuable insights into the drivers shaping property valuation trends in the region. Notably, the inclusion of individual factor sets comprehensively describing housing price formation, along with the utilization of factor analysis approaches across all three segments of the secondary real estate market in Ukraine, underscores the novelty and significance of this study.

Keywords: Real estate market, factor analysis, regression analysis, apartment cost, qualitative factors, quantitative factors, pricing, apartments, land plots, households.

1. Introduction

The real estate market, as a dynamic and evolving system, undergoes continual transformations influenced by a multitude of factors. For instance, the pricing dynamics of apartments are intricately tied to numerous variables such as size, location, proximity to urban centers, spatial layout, structural condition, and amenities availability, among others. Factor analysis serves as a fundamental tool for processing and interpreting vast datasets within the real estate sector. This methodological approach facilitates the systematic examination and modelling of the diverse factors influencing the target indicators, thereby enabling a comprehensive analysis of the residential real estate market.

Without the systematic collection and organization of market data coupled with rigorous analysis, understanding the impact of individual factors on apartment prices becomes an arduous task. Particularly in the contemporary real estate landscape, characterized by a myriad of variables categorized into quantitative and qualitative dimensions, discerning the influence of each factor poses significant challenges. Unlike quantitative variables, which are relatively straightforward to assess, qualitative variables necessitate the creation of rating scales and coefficients to apply mathematical methodologies effectively.

Moreover, the assessment of real estate value considers multiple factors, both individually and collectively, which may yield divergent outcomes. Factor analysis not only aids in determining the relative importance of each factor but also elucidates their interdependencies and collective influence on the ultimate determinant – housing prices.

Given the intricate nature of the real estate market, categorizing properties into distinct groups is imperative. This study adopts a pragmatic approach by classifying real estate assets into three overarching categories: apartments, land plots, and households. Such classification facilitates a nuanced analysis tailored to the unique attributes of each property type.

The insights derived from this comprehensive analysis hold practical significance for enhancing the precision of real estate valuation methodologies employed by industry experts. Furthermore, they provide a robust foundation for advancing further inquiries into the nuanced dynamics of the real estate market in Ukraine.

2. Object and subject of research

The object of this research is the residential real estate market in Ukraine, focusing on properties such as apartments, land plots, and households. The subject encompasses the various qualitative and quantitative factors influencing the valuation of these properties within the Ukrainian real estate landscape.

3. Target of research

This article aims to explore the impact of qualitative and quantitative factors on real estate valuation using data from the information and analytical database of the residential real estate market in Ukraine. It contributes to the understanding of real estate valuation by utilizing regression analysis to analyse the influence of various factors on property prices. By leveraging data from the constantly updated information and analytical database of the Ukrainian real estate market, this research provides valuable insights into the factors driving property valuation dynamics in the region. Individual sets of factors that comprehensively describe the formation of housing price are taken into account, as well as the utilization of factor analysis approaches across all three blocks of the secondary real estate market in Ukraine.

4. Literature analysis

As it has been already mentioned, understanding the value of real estate involves considering numerous factors, both qualitative and quantitative. Scholars have extensively explored these factors, paying special attention to qualitative aspects.

Extensive research has been devoted to investigating qualitative determinants of real estate valuation, as evidenced by the comprehensive work of Buriskiene, Rudzkiene, and Venckauskaite (2011). Notably, scholars have examined factors such as location, building age, construction type (including wall composition), number of floors and rooms, and total area. The pivotal role of location and neighbourhood quality has been underscored by Nachmen (2007) and further reinforced by Mbachu and Lenono (2012).

Moreover, the impact of heating systems on apartment prices has been scrutinized, with notable contributions from Williams, Ventolo, and Williams (2005) elucidating various heating options. Psunder and Ferlan (2009) have delved into the nuanced exploration of heating systems and their influence on property values.

Ersoz, Ersoz, and Soydan (2018) conducted a rigorous analysis of diverse factors using classification and regression trees (CART) and CHAID algorithms based on data from real estate agents in the Karabük province (Turkey). Frew and Wilson (2002) investigated the influence of road infrastructure on rental prices, particularly focusing on its impact on housing costs through hedonic regression analysis. Similarly, Choy, Mak, and Ho (2007) employed this analytical approach to study the effect of floor level on apartment prices in skyscrapers.

In addition to the aforementioned studies, the work by Kirichuk Y. O., Lando Ye. O. and Believa K. K. (2023) focuses on modelling the real estate market specifically for the purpose of determining property values for taxation. It introduces a mass appraisal model aimed at uncovering the relationships between various factors influencing property prices and their assessed values. Article by Grechanyk, N., Kondur O., and Maizel S. (2008) presents a methodology for analysing the real estate market in Ivano-Frankivsk to identify its trends and investment viability in this sector.

These studies collectively contribute to our understanding of the multifaceted determinants of real estate valuation, shedding light on the intricate interplay between various factors influencing property prices.

While scholarly literature extensively covers the determinants of housing prices, research findings remain inconclusive and lacking in comprehensiveness. Despite a standard list of primary factors affecting housing prices, their influence can vary based on geographical location and temporal dynamics. Furthermore, a notable gap exists in research focusing on the interplay between qualitative and quantitative factors in determining residential property values. While existing studies may extensively address either qualitative or quantitative aspects individually, there appears to be a deficiency in comprehensive analyses that elucidate the interaction and collective impact of these factors on property prices within the Ukrainian real estate market.

Therefore, work focuses on the study of internal real estate factors, in particular their influence on the key characteristic - the price of an apartment, taking into account certain price forming factors. Moreover, using a comprehensive analytical approach this study aims to provide a detailed understanding of the complex interrelationships that shape the real estate market in Ukraine. Through a rigorous empirical analysis and theoretical framework, it seeks to contribute new insights into the fundamental determinants of real estate valuation dynamics, thereby enriching the existing theoretical and practical knowledge on the topic.

5. Research methods

This article serves as a logical extension of prior authors research outlined in the paper titled "Deterministic and Probabilistic Analysis of Ukrainian Residential Property Market Evolution in Turbulent 2019-2022 Years," where comprehensive data collection and processing methodologies,

pertinent to the current study, were delineated (Yakubovsky *et al.*, 2024). The initial electronic information and analytical database was created by the consulting-engineering Group “VERITEX®” specialists by scanning and aggregating information flows and their subsequent in-depth processing using mathematical and statistical methods, including geospatial, cluster and factor analysis.

Since the data is collected across all 24 regions of Ukraine for all real estate objects available on the market, the entire database was divided into segments:

- Unit of apartments (primary and secondary markets)
- Unit of land plots (also divided by designation)
- Unit of households (residential real estate and land plots on which it is located).

Thus, for each unit of the real estate market, we identified the factors that have the greatest impact on the final value and built linear and nonlinear regression models using econometric programs MathLab and Eviews.

It's worth noting that under normal conditions, the influence of different factors on real estate value is simultaneous. In other words, the price of apartments is influenced not by each factor separately, but by several factors in combination. As constructing models to consider all factors is quite complex, it is proposed to group them into sets of 3-4 and examine the corresponding dependencies of the apartment value on:

- Location, building type, layout, and area of the apartment;
- Building type, heating, wall type, and gas availability;

This set of factors is primarily due to the fact that the database contains sufficient information on these factors. Some indicators are repeated in separate models, which makes it possible to compare how their impact will change in different combinations. For example, whether the building type will have a greater impact in a model that considers the presence of an elevator and floor or in a model where additional factors include heating availability, wall type, and gas availability. The models take into account both quantitative (location, area, floor) and qualitative factors (layout, building type, wall type, etc.), which allows us to consider what affects the cost of an apartment as closely as possible.

In analyzing the pricing dynamics of apartments, several key factors are taken into consideration:

- Elevator: Found predominantly in multi-story and modern buildings, elevators necessitate additional maintenance resources. Their presence enhances residents' comfort, often correlating with higher apartment prices.
- Building Type: Ukraine features diverse construction types, varying in materials, layouts, wall height, room count, and heating systems. Apartments within structurally superior buildings, boasting qualities like thermal and sound insulation and durability, tend to command higher prices.
- Floor: Generally, apartments on lower floors are less expensive than those on higher ones. Top-floor units often fetch higher prices due to superior views.
- Location: Proximity to essential amenities such as highways, shops, and pharmacies significantly influences an apartment's desirability and value, particularly in relation to business centers.
- Layout: The arrangement of rooms, bathrooms, and kitchens profoundly impacts overall comfort and, consequently, apartment value.
- Area: Apartment size is a primary determinant of price, with larger units typically commanding higher prices.
- Heating: The heating system type affects utility costs and contributes to overall comfort, consequently influencing an apartment's value.
- Wall Type: The quality of wall materials influences comfort, including heat retention, noise insulation, and overall building durability. Apartments with superior wall materials generally command higher prices.
- Furniture: The presence of high-quality furniture positively correlates with apartment value, serving as an indicator of comfort and housing status.

- **Apartment Condition:** Apartments in better condition with superior renovations naturally command higher prices, reflecting the owner's investment in upkeep and enhancements.

When examining the factors influencing land plot and house prices, a unique set of criteria emerges. While certain factors, like location and accessibility, may overlap with those affecting apartment prices, others are specific to this market segment.

Geographic location stands out as one of the pivotal factors influencing the value of land plots and real estate. In central urban areas, there exists a higher price dynamic owing to the presence of developed infrastructure, convenient transportation access, proximity to stores, educational and medical facilities, as well as a variety of entertainment and cultural offerings. However, the higher population density in these areas may result in increased noise and pollution levels, affecting both demand and property prices.

Conversely, peripheral districts, characterized by lower population density and less developed infrastructure, attract those seeking tranquillity and lower housing or land costs. Lower prices in these regions can be a significant consideration when contemplating real estate investments.

The purpose of the property also plays a substantial role in determining its price. Residential properties, driven by high demand and a range of options, generally command higher prices compared to commercial real estate, where prices hinge on the potential profitability of the business venture and associated investment risks.

The size of the property constitutes another crucial factor. Larger properties may be more expensive due to increased space and potential utility but entail higher maintenance costs. Conversely, smaller properties may be more financially accessible but may not always satisfy the space requirements of individuals seeking more room.

The property's location, soil type, landscape, and intended use further influence its value. Even within the same district, diverse property characteristics can impact its price. For instance, cottage communities offer a cozy and developed environment but come at higher costs compared to other locations. Fertile soil and picturesque landscapes tend to enhance the attractiveness and value of land plots. Finally, the property's intended use, be it residential or commercial, is also factored into its price determination.

As we have previously mentioned, the area of real estate significantly affects the value of the unit indicator (square meter, hectare, etc.). However, the assertion that the unit indicator value will be higher for properties with smaller areas compared to those with larger areas holds true only under the condition that the functional (intended) purpose of the compared properties is identical (Maximov S. J., 2017). Therefore, the discrepancy in the area of functionally identical analogous objects compared to the area of the assessed object within the framework of the comparative methodological approach is neutralized by the following ratio:

$$C_o = C_a * K, \tag{1}$$

Where:

C_o – the adjusted value of the unit indicator of the assessed object,

C_a – the price of the unit indicator of the analogous object,

K – the calculated scaling adjustment coefficient.

In turn, the absolute value of the aforementioned calculated scaling adjustment coefficient (K) can be determined using the following two rules, each of which is used depending on the specific relationship between the total areas of the assessed object and the immediate analogous object:

1. In the case where the total area of the assessed object (S_o) is greater than the total area of the analogous object (S_a), i.e., ($S_o < S_a$), it is advisable to use the following formula:

$$K = \left(\frac{S_a}{S_o} \right)^{\frac{0.1 * S_o}{(S_a + S_o)}}, \tag{2}$$

where 0.1 is the empirical coefficient of "price damping".

2. In the case where the total area of the assessed object (S_o) is less than the total area of the analogous object (S_a), i.e., ($S_a > S_o$), it is advisable to use the following formula:

$$K = \left(\frac{S_a}{S_o}\right)^{\frac{0.1 \cdot S_a}{(S_a + S_o)}}, \quad (3)$$

It is worth noting that the dependencies (2) and (3) provided above are purely empirical, as they were derived through the generalization of the results of static market research on real estate transactions in Ukraine. However, the aforementioned scaling adjustments have become practically recognized in recent years.

At the same time, many appraisers in their practical activities use a more simplified expression for determining the absolute value of the calculated scaling adjustment coefficient (K):

$$K = \left(\frac{S_a}{S_o}\right)^{0.1}, \quad (4)$$

which also reflects the magnitude of the necessary adjustment.

6. Research results

In the current landscape of the Ukrainian real estate market, investigating the determinants shaping the valuation of residential assets holds significant importance. Utilizing statistical methods to analyze the role of key factors in this process yields objective insights and elucidates the dynamics of real estate prices. Within this context, exploring the variation in housing prices across different geographic locations within Ukraine is particularly pertinent. To facilitate comparative assessments of real estate markets across regions, as well as to ascertain their stability and price fluctuations, we can leverage data on apartment price distributions (Fig. 1).

In December 2023, the average apartment prices in Kyiv, Odesa, Kharkiv, Dnipro, and Lviv's secondary markets were \$1936, \$1123, \$913, \$1021, and \$1540 per square meter, respectively. This data highlights notable disparities in both average price levels across regions and the extent of their price volatility.

The average cost per square meter varies significantly among Ukraine's regional centers. Kyiv, Lviv, Uzhhorod, and Odesa exhibit the highest apartment prices, while Mykolaiv, Zaporizhzhia, Sumy, and Kherson feature the lowest. Moreover, the coefficient of variation, indicating price volatility, varies significantly across regions. Kyiv, Kharkiv, and Dnipro experience the largest price fluctuations, whereas Khmelnytskyi, Ternopil, and Lutsk demonstrate more stable pricing dynamics.

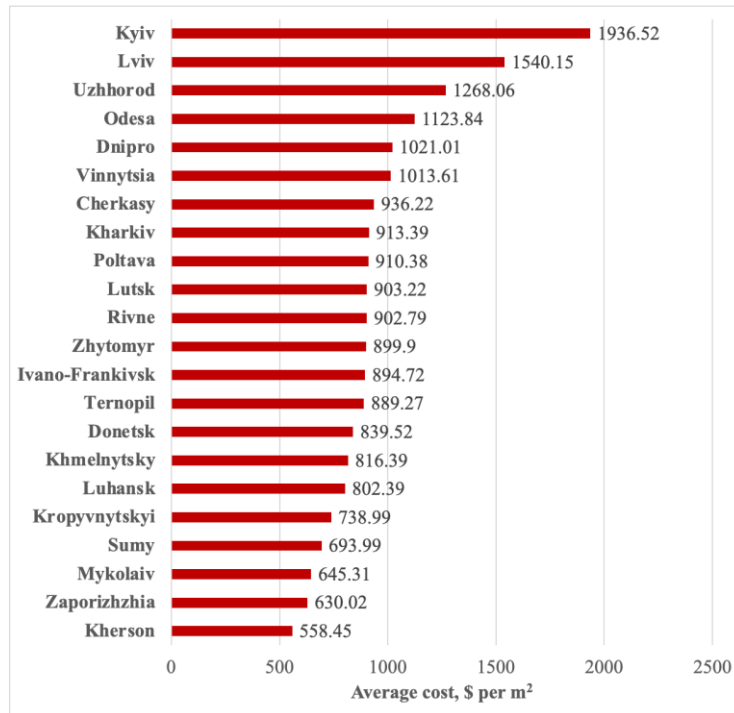


Figure 1. Costs of 1 sq. m. of apartments in secondary market in regional centres of Ukraine as of December 2023.

Source(s): Author's own creation

However, obtaining solely average cost indicators for each city isn't sufficient, considering the geographical zoning and variation in cost indicators within urban areas. Additionally, it's crucial to acknowledge Ukraine's current full-scale war, making distance from the front line a significant price-setting factor.

Establishing the relationship between cost per square meter and total apartment area is important. Analysis reveals that for one-, two-, and multiple-room apartments, the average cost per square meter remains relatively stable up to an approximate total area of 65-70 square meters. Beyond this threshold, a notable increase in cost per square meter is observed. The dependence of average price on apartment area is depicted in ranges (Fig. 2 (a)).

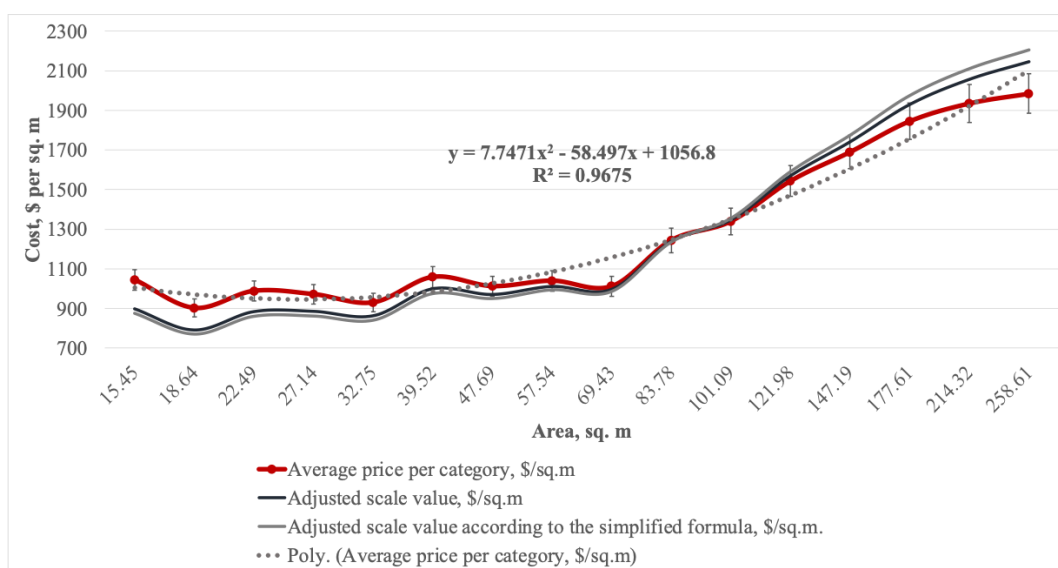


Figure 2 (a). Dependence of the average price on the area of apartments in Ukraine in December 2023.

Source(s): Author's own creation

A sample encompassing the entire territory of Ukraine was utilized. The acquired values were fitted using a second-degree polynomial dependency, with adjustments made for scale utilizing formulas mentioned in the previous part. In both scenarios, similar results were obtained: as apartment area increases, so does its cost, albeit with deviations from actual values observed when correction factors are applied. Attention should be drawn to the fact that the scaled-adjusted cost of apartments differs from the actual cost depending on their size. For apartments with an area of up to 70 square meters, the adjusted cost is lower than the actual cost, while for apartments ranging from 70 to 120 square meters, it coincides with the actual cost. Apartments with an area exceeding 120 square meters have an adjusted cost that exceeds the actual cost. It is noteworthy that the result obtained using the simplified formula in this range is higher than when using the full formula.

It is important to note that the dependence approximated by a second-degree polynomial is not entirely adequate, as for apartments with an area greater than 200 square meters, the cost described by such a law continues to rise. In reality, it tends to stabilize. Therefore, in subsequent stages, attempts were made to find a more suitable model to describe this relationship.

The figure 2 (b) shows two models representing the dependency of apartment prices on their area. The first model is a polynomial function, while the second consists of two distinct dependencies. The initial segment of the second model corresponds to linear, while the subsequent segment is described by a power dependency.

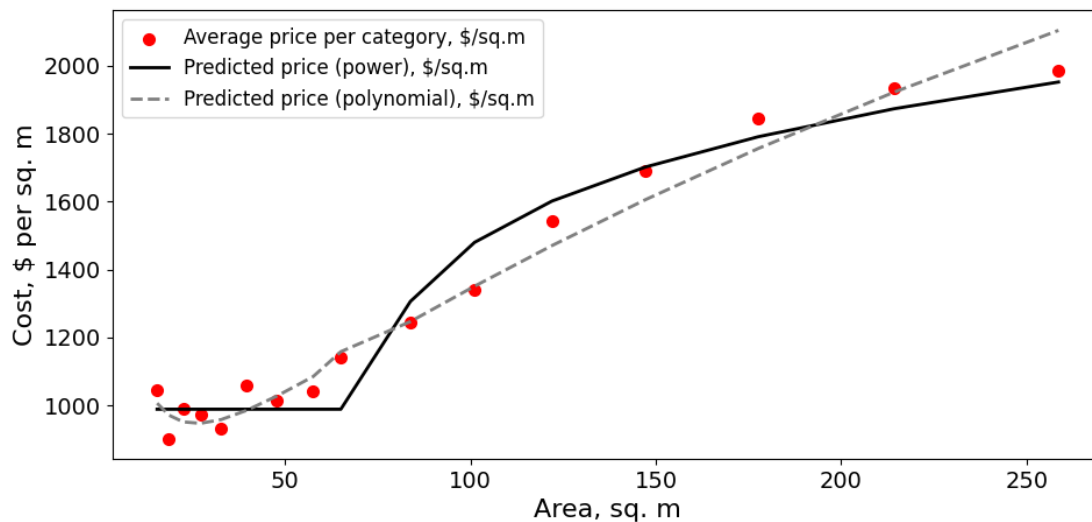


Figure 2 (b). Dependence of the average price on the area of apartments in Ukraine in December 2023.

Source(s): Author's own creation

Table 1. Results of modelling the impact of area on the price of apartments

Goodness of Fit	
	Value
SSE	5.42E+04
R-square	0.9375
DFE	6
Adj R-sq	0.9271
RMSE	95.031

Source(s): Author's own creation

The calculations have revealed a consistent mean price of apartments, measuring up to 70 m², at \$988.44 per square meter. Accordingly, power dependence of the first degree is observed for larger

apartments, a phenomenon corroborated by the constructed regression analysis (Figure 2 (b), Table 1). The coefficient of determination stands at 0.9375, indicating a favourable model quality.

Given the above trends, to simplify the calculations and further reflect the impact of scale changes, the total cost of an apartment bigger than 70 m², taking into account its size (S_i), can be given by the formula:

$$V_i = f(S_i) = a * (S_i - 70)^c, \tag{5}$$

Where:

- V_i – the cost of an apartment more than 70 m²;
- S_r – the area of the apartment under research (more than 70 m²);
- a – the scaling factor;
- c – the exponent or power term.

In the context of the power dependence model with the formula (5), the coefficient a determines the overall magnitude of the relationship between the independent and dependent variables. In this case, $a = 872.912$, indicating the strength of the relationship between the size of the apartment (S_i) and its cost. Coefficient c determines the nature of the relationship between the independent and dependent variables. According to the calculations, $c = 0.1536$, what means the degree to which the cost of the apartment varies as a power of its size relative to a base value of 70 square meters. Together, a and c specify how the cost of the apartment (V_i) changes with respect to changes in its area (S_i) according to the power law relationship described by the formula. Further analysis delves into the impact of floor level (Fig. 3) and type of renovation (Table 2) on the cost per square meter of residential properties in the secondary market, considering distinctions between new and old building stock as well as location. It is assumed that the dynamics of local economic processes differ between major cities and the rest of Ukraine.

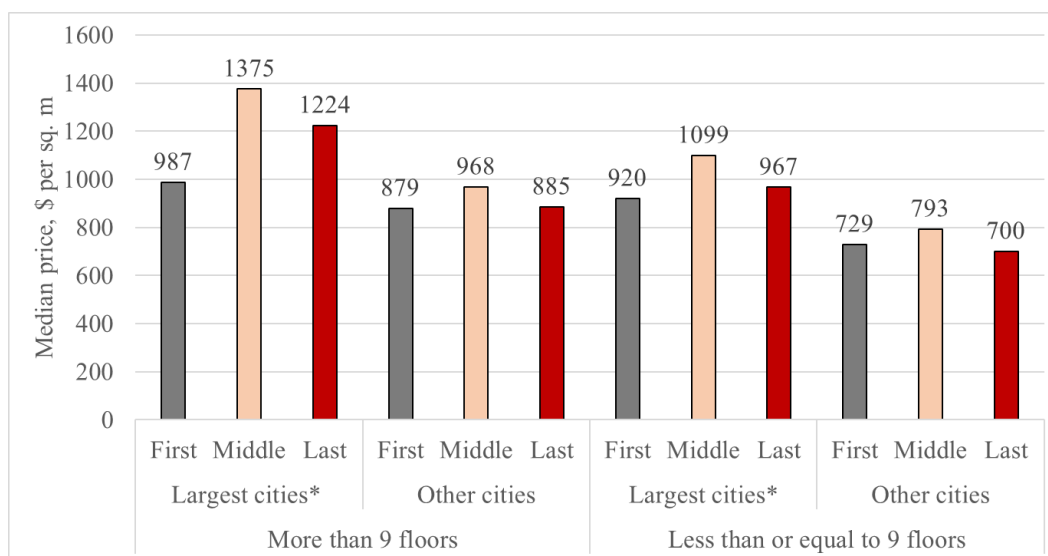


Figure 3. Dependence of the median cost of 1 sq. m. of area on the number of storeys of the building, location and floor of the apartment.

* Largest cities include Kyiv, Dnipro, Lviv, Odesa, Kharkiv.

Source(s): Author's own creation

Based on the findings, the influence of apartment floor level on its value is indeed significant, contingent upon various factors such as location and building stock type. Analysis indicates that top-floor apartments in newly constructed buildings command higher prices due to the allure of panoramic views. Conversely, top-floor units in older buildings experience decreased demand, leading to lower values.

However, it's essential to acknowledge the current context of increased missile attack threats and the active phase of a full-scale war. Consequently, there is a prevailing preference for apartments on lower or middle floors, overlooking view characteristics. Consequently, across Ukraine, top-floor apartments are approximately 10% cheaper.

Regarding the impact of renovation class on housing prices, it's observed that the price difference between habitable condition and cosmetic repair is negligible in major cities, irrespective of building stock type. Conversely, the presence of euro renovation or elite-level housing condition significantly elevates property value.

In new buildings, regardless of location, the price disparity between apartments in good living condition and those with cosmetic repairs is minimal, ranging from 1-2%. This is attributed to standard repairs in new buildings, necessitating no additional expenses. In contrast, for apartments in older buildings, the price difference between those in good living condition and those with cosmetic repairs is more pronounced, ranging from 20-30%. This disparity is due to the potentially costly repairs required in older buildings, including window and door replacements, wiring upgrades, and other refurbishments.

As previously elucidated, location stands out as a pivotal factor influencing real estate prices. Apartments situated in central regions typically command higher prices compared to those on the periphery, attributed to the presence of a more developed infrastructure. Similarly, the elevated prices of apartments in new buildings stem from modern design, superior materials and amenities, and enhanced comfort levels.

These factors are interconnected, with location often influencing building type. In densely populated urban areas, development tends to be more active, resulting in a higher prevalence of new constructions. Building type can also impact apartment layout, as older buildings typically feature less convenient layouts compared to newer counterparts. Furthermore, apartment layout can affect its size, with units boasting user-friendly layouts generally offering larger living spaces.

To delve deeper into this interplay, a multiple regression model was constructed based on five independent variables: location, building type, layout, apartment size, and market availability. It's worth noting that the data underwent outlier removal and smoothing procedures during the initial stages. Additionally, qualitative indicators were ranked and converted into scores to enhance the analysis's robustness.

Table 2 and Figure 4 represent the results of the modelling, from which we can see that the model is quite qualitative and adequate, all variables are significant. This is confirmed by the value of the R-squared coefficient of determination, which is 0.561. This means that 56.1% of the variation in apartment prices can be explained by the variables included in the model. The p-statistic values do not exceed the critical value for the 95% confidence level.

Table 2. Results of modelling the impact of building type, layout, and area on apartment price

Number of observations		40568		
Root Mean Square Error		323		
R-squared		0.561		
Adjusted R-squared		0.561		
F-statistics vs. constant model		-1.04e+04		
p-value		0		
Parameter	Value	Standard Error	t Statistic	P-Value
Intercept	-1077.2068	10.5407	-102.1946	0
Beta{area1}	10.4362	0.11853	88.0443	0
Beta{building_type1}	49.8151	0.87659	56.8281	0
Beta{planning1}	112.7781	1.7828	63.2595	0
Beta{state1}	29.6218	0.68924	-42.9777	0
Beta{sum1}	80.8253	1.9825	40.7702	0

Source(s): Author's own creation

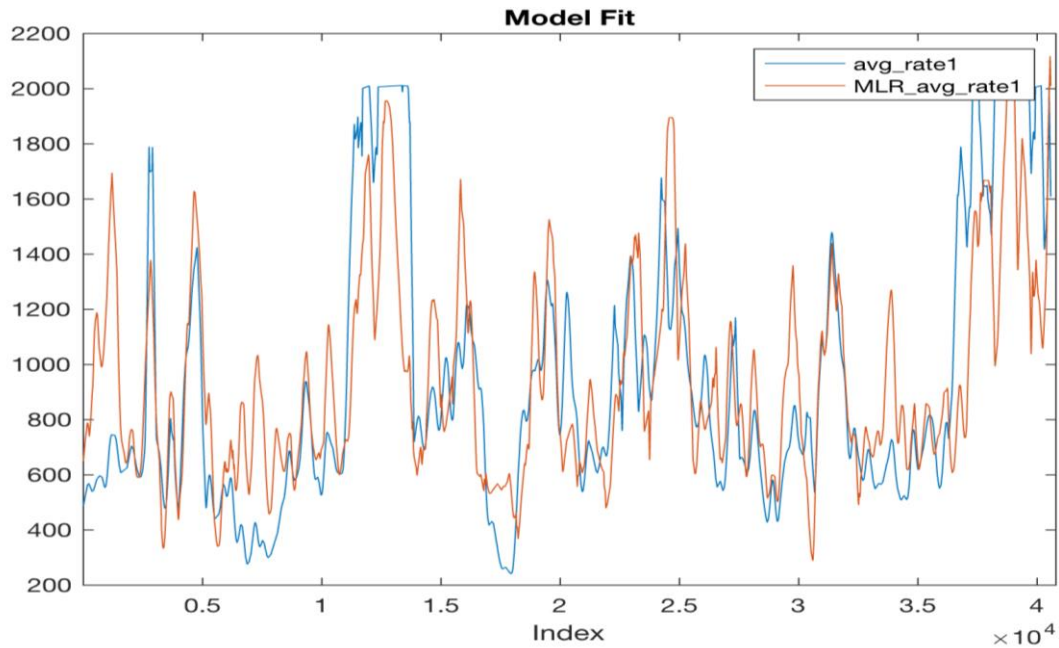


Figure 4. Model of the average price dependence on the type of house, layout, and apartment area.
 Source(s): Author's own creation

Indeed, the price of an apartment is influenced by the aforementioned factors, and the hypotheses regarding the influence of individual variables on apartment prices are corroborated by the analysis. For example, the positive coefficient for β_{area1} (10.44) suggests that an increase in apartment size correlates with a higher average price. Similarly, positive coefficients for location, building type, layout, and sample size indicate direct relationships with price, implying that apartments in central areas, new buildings with desirable layouts, and those in high demand will command higher prices.

Now, we'll shift our focus to another set of determining factors, including gas availability, house type, wall materials, and heating systems. We'll commence by examining each factor individually. Additionally, we've conducted separate analyses to assess the impact of each factor, as outlined in tables 3-4.

Table 3. Impact of heating type on the average cost of an apartment

Heating	Average price, \$/m ²	Absolute difference from the baseline*, \$/m ²	Relative difference from the baseline*, %
Centralized heating	1793.79	427.79	31.32
Combined heating	1241.25	-124.75	-9.13
Individual heating	1103.73	-262.27	-19.20
No heating	790.59	-575.41	-42.12

* The average price of an apartment from 2021-2023 is taken as a baseline, taking into account the availability of data on the presence of gas, type of building, walls, and heating (\$1366).

Source(s): Author's own creation

Table 4. Impact of wall type on the average apartment price

Type of walls	Average price, \$/m ²	Absolute difference from the baseline*, \$/m ²	Relative difference from the baseline*, %
Prefabricated monolithic	2081.53	715.53	52.38
Monolithic brick	1722.86	356.86	26.12
Reinforced concrete	1688.62	322.62	23.62
Monolithic reinforced concrete	1621.92	255.92	18.73
Monolithic frame	1550.22	184.22	13.49
Ceramic block	1473.45	107.45	7.87
Brick block	1454.75	88.75	6.50
Gas block	1383.98	17.98	1.32
Frame block	1289.59	-76.41	-5.59
Expanded clay concrete	1278.03	-87.97	-6.44
Monolithic block	1263.28	-102.72	-7.52
Silicate brick	1225.30	-140.7	-10.30
Ceramic brick	1214.47	-151.53	-11.09
Frame and stone	1189.21	-176.79	-12.94
Monolithic	1183.52	-182.48	-13.36
Aerated concrete	1150.91	-215.09	-15.75
Foam block	1089.52	-276.48	-20.24
Reinforced 3D panel	1065.48	-300.52	-22.00
Shell rock	947.74	-418.26	-30.62
Polystyrene concrete	878.38	-487.62	-35.70
Panel	849.49	-516.51	-37.81
Block and brick	844.52	-521.48	-38.18
Inkerman stone	726.36	-639.64	-46.83
Facing brick	718.71	-647.29	-47.39
SIP	712.02	-653.98	-47.88
Wood and brick	685.93	-680.07	-49.79
Precast concrete	581.66	-784.34	-57.42
Rubble stone	540.48	-825.52	-60.43

* The average price of an apartment from 2021-2023 is taken as a baseline, taking into account the availability of data on the presence of gas, type of building, walls, and heating (\$1366).

Source(s): Author's own creation

The analysis reveals that apartments equipped with gas amenities exhibit a lower average price (\$1085.79 per square meter) compared to those without gas (\$1906.52 per square meter). This trend is attributed to the evolving preferences of buyers, who increasingly favor electric stoves, boilers, and heating systems, indicating a diminishing necessity for gas in apartments.

Examining apartment prices based on house type reveals that apartments in pre-revolutionary buildings command the highest average price (\$1648.94 per square meter), followed by those in newly constructed residential buildings post-2001 (\$1499.33 per square meter). Conversely, apartments in "Khrushchyovkas" (Soviet-era low-cost housing) (\$807.87 per square meter), "Cheshkas" (Soviet-era low-cost housing with specific layouts) (\$771.09 per square meter), and dormitories (\$691.93 per square meter) exhibit the lowest average prices. This discrepancy is logical, as the latter categories generally offer lower quality and consequently provide lesser comfort to residents.

The primary determinant of apartment costs is the type of heating system. Apartments equipped with centralized heating exhibit the highest average price (\$1793.79 per square meter), followed by those with combined heating (\$1241.25 per square meter), and individual heating (\$1103.73 per square meter). Unsurprisingly, apartments lacking heating facilities are the most affordable option (\$790.57 per square meter).

Another crucial aspect concerns the wall material. Apartments featuring monolithic walls, including variants like monolithic-brick (\$1722.86 per square meter) and monolithic-frame (\$1550.22 per square meter), command the highest average prices. Conversely, apartments with brick (\$1454.75 per square meter), aerated concrete (\$1150.91 per square meter), or foam block (\$1089.52 per square meter) walls are priced lower. The lowest prices are observed for apartments constructed with materials such as SIP, wood, brick, prefabricated reinforced concrete, and aerated concrete blocks. This discrepancy can be attributed to their inferior quality and suboptimal characteristics, such as inadequate heat retention and shorter service life.

Considering all four factors, it's evident that apartments in elite buildings (e.g., pre-revolutionary and Soviet-era communal apartments) become more expensive with improvements in wall quality and, consequently, the type of heating system. Notably, apartments with centralized heating tend to command higher average prices, even if the wall material is not of premium quality, underscoring the significance of this factor in the overall price dependency. This trend is observed across apartments with and without gas supply.

An intriguing observation is that in apartments with gas heating, this amenity is absent in modern buildings (housing stock post-1991), yet these apartments are not the most affordable. Surprisingly, the least expensive options are dwellings from the Soviet era equipped with individual heating.

In contrast, for apartments lacking gas heating, there are groups without any heating in all categories of buildings. Here, the most economical options are found in Soviet-era buildings and economy-class housing (guesthouses, dormitories) with no or individual heating.

Summarizing tables were also created for apartments with gas Fig. 5-6 and for those without Fig. 7-8.

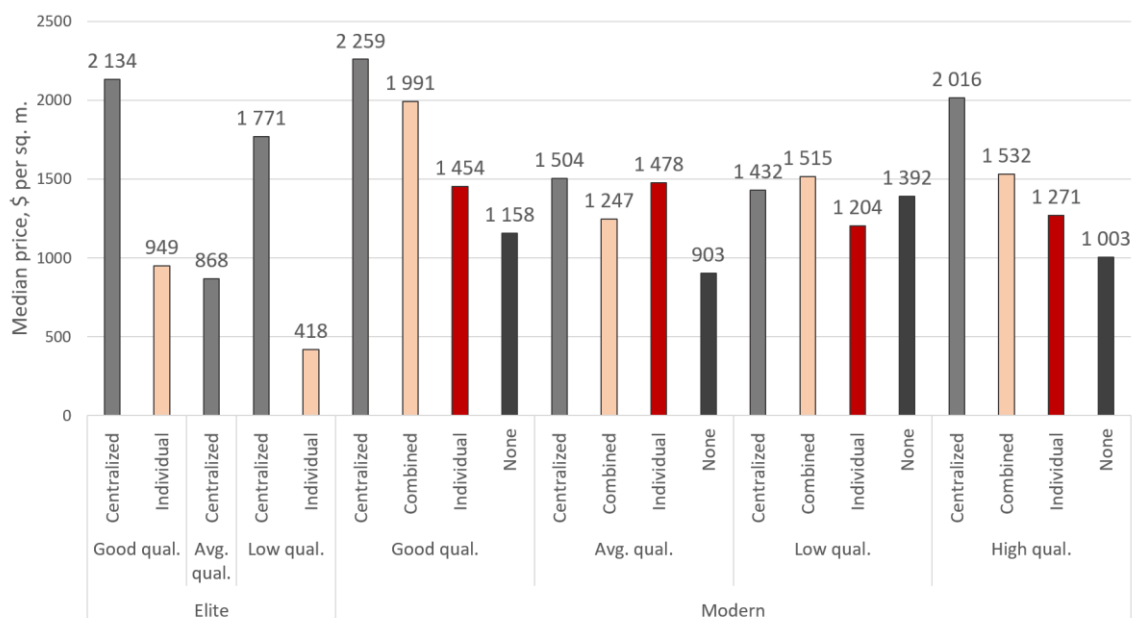


Figure 5. Impact of building type, walls, and heating on the average cost of an apartment in elite and modern buildings (gas supply).

Source(s): Author's own creation

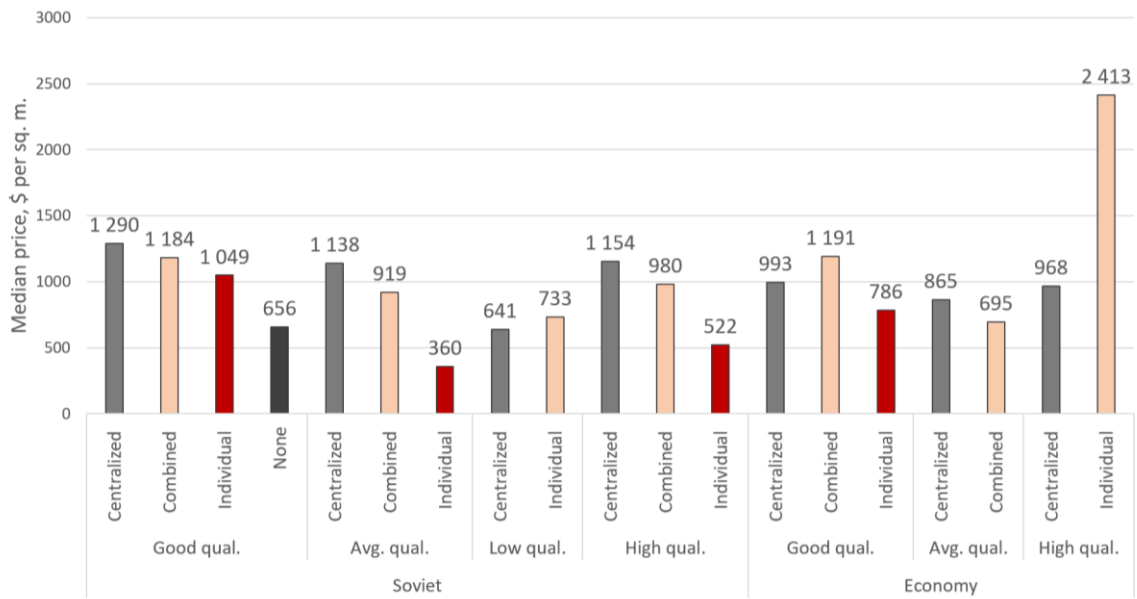


Figure 6. Impact of building type, walls, and heating on the average cost of an apartment in soviet and economy buildings (gas supply).

Source(s): Author's own creation

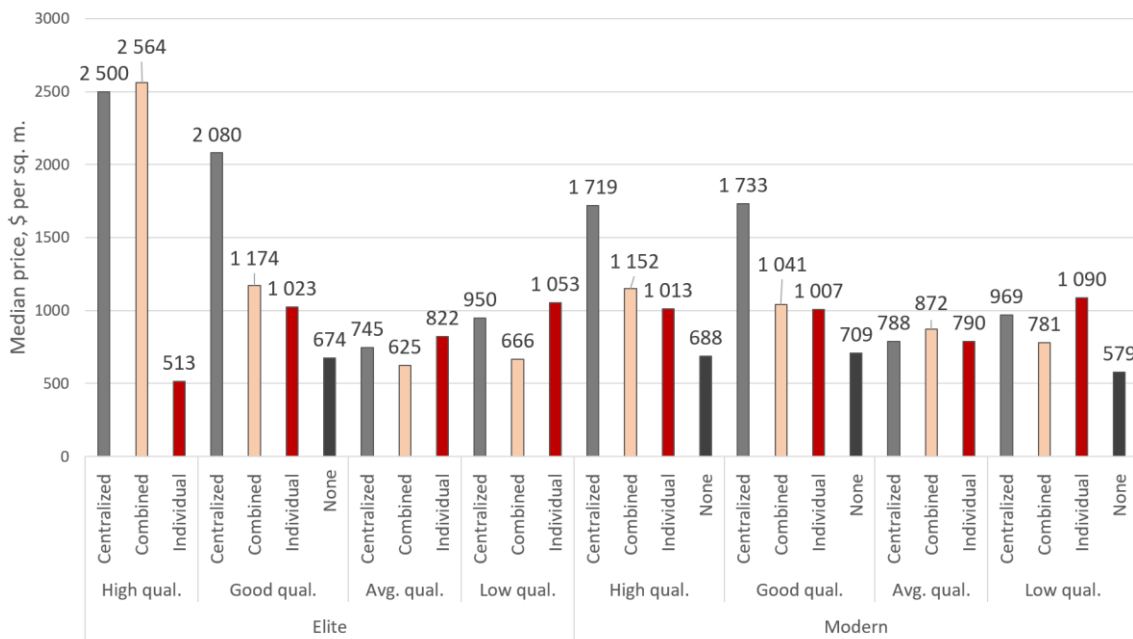


Figure 7. Impact of building type, walls, and heating on the average cost of an apartment in elite and modern buildings (no gas).

Source(s): Author's own creation

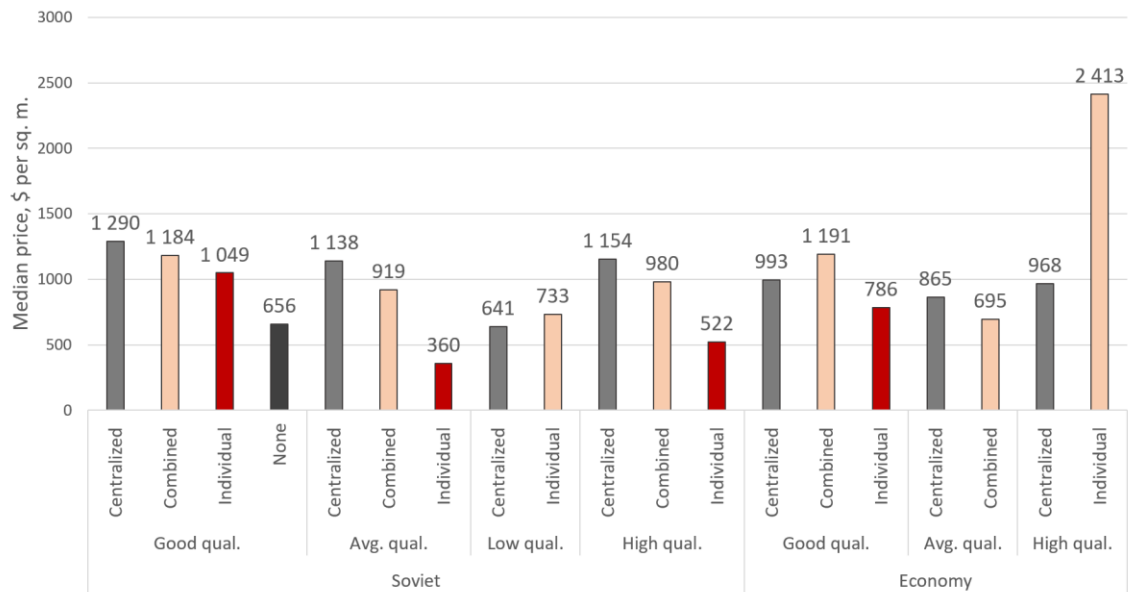


Figure 8. Impact of building type, walls, and heating on the average cost of an apartment in soviet and economy buildings (gas supply).

Source(s): Author's own creation

Different trends emerge in apartments with and without gas. In apartments with gas, the price is more influenced by the type of building, whereas in apartments without gas, the type of walls plays a more significant role. Apartments with superior heating systems tend to command higher prices, and it's noteworthy that the relationship between apartment price and heating type is more linear in apartments with gas. Despite the improvement in heating system quality leading to higher prices, the average price of such apartments does not surpass that of apartments without gas.

To validate these hypotheses, we constructed a linear regression model, the results of which are depicted in Figure 9. Prior to this, qualitative indicators were ranked. Based on the obtained data, the model demonstrates quality (Adjusted R-squared = 0.85) and adequacy (the probability value of the Fisher statistic is very low and close to zero), indicating that all assumptions hold true. Each variable (building type, heating, gas, and wall type) is significant, as evidenced by the probability values associated with each factor at any level of significance (Prob. < 0.5 and 0.01, respectively).

The model reveals that, accounting for all indicators and their characteristics, the most influential factor in apartment cost is the type of building (regression coefficient of 4754.505), followed by heating type (regression coefficient of 1970.581), gas availability (regression coefficient of -373.06), and lastly, wall type (regression coefficient of 166.3685). Additionally, the relationship between apartment prices and building type, heating, and wall materials is direct (indicated by positive regression coefficients), while the presence of gas exhibits an inverse relationship (negative regression coefficient), thus confirming previous findings.

Dependent Variable: RATE
 Method: ARMA Maximum Likelihood (OPG - BHHH)
 Date: 12/10/23 Time: 14:16
 Sample: 1 19643
 Included observations: 19643
 Convergence not achieved after 500 iterations
 Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
BUILDING_TYPE	4754.505	131.6370	36.11829	0.0000
HEATING^2	1970.581	16.58428	118.8222	0.0000
GAS	-373.0638	73.71776	-5.060705	0.0000
WALL_TYPE	166.3685	2.262165	73.54393	0.0000
C	-6465.011	161.6930	-39.98325	0.0000
AR(1)	0.665216	0.000574	1159.048	0.0000
AR(2)	0.256296	0.000683	375.0856	0.0000
SIGMASQ	166697.2	129.8368	1283.898	0.0000

R-squared	0.850565	Mean dependent var	1365.285
Adjusted R-squared	0.850512	S.D. dependent var	1056.206
S.E. of regression	408.3689	Akaike info criterion	14.86271
Sum squared resid	3.27E+09	Schwarz criterion	14.86593
Log likelihood	-145966.2	Hannan-Quinn criter.	14.86377
F-statistic	15965.68	Durbin-Watson stat	2.066187
Prob(F-statistic)	0.000000		

Inverted AR Roots	.94	-.27
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Figure 9. Results of modelling the impact of house type, heating, walls, and gas availability on the cost of an apartment.

Source(s): Author's own creation

Understanding regional variations in land values sheds light on the complex dynamics of the real estate market in Ukraine. The value of land plots in Ukraine varies significantly across different regions, reflecting diverse economic and geographical factors. Residential lands in the Kyiv, Vinnytsia, and Odesa regions are highly valued, while the lowest land values are observed in the Kropyvnytskyi, Chernihiv, and Poltava regions. Additionally, agricultural lands in the Kyiv, Lviv, Odesa, and Ivano-Frankivsk regions command the highest prices.

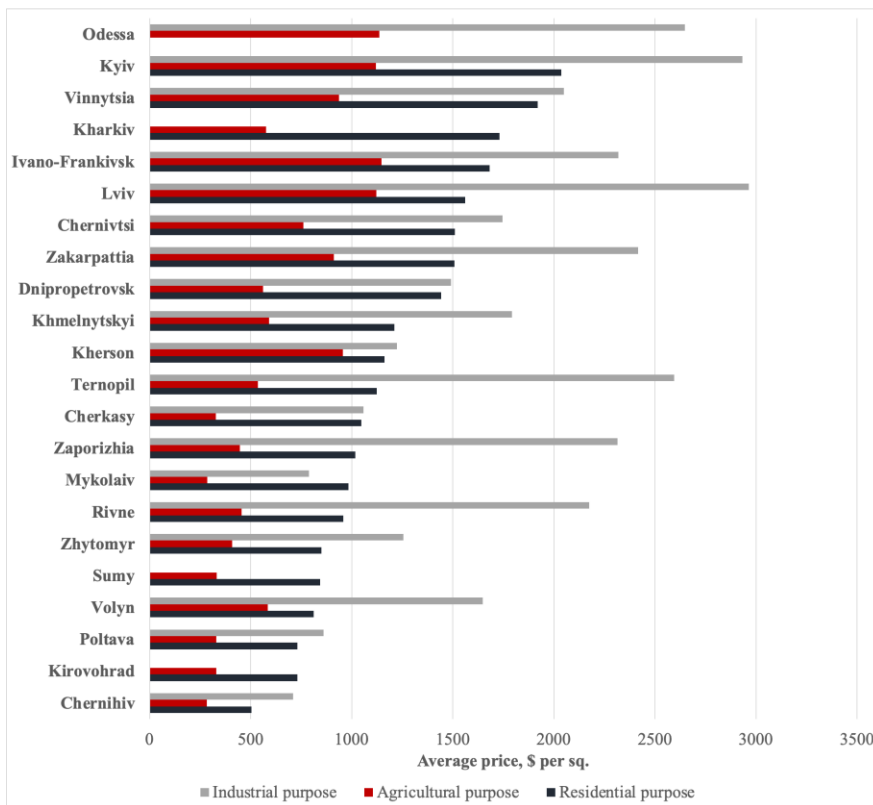


Figure 10. Parameters of land value per 100 square meters in regions of Ukraine as of December 2023 for lands designated for residential, agricultural, and industrial purposes.

Source(s): Author's own creation

The dispersion of land value varies by region. For instance, in the Kyiv region, the average value of 100 square meter of residential land is \$2036.18, with a median value of \$1920 and a coefficient of variation of 1.07. This suggests that the value of 100 square meter of residential land in the Kyiv region can range from as high as \$4000 to as low as \$1000.

The relationship between the value of 100 square meter of land and the total area of the plot is depicted in Figure 11. A sample covering the entire territory of Ukraine was utilized. The obtained values were fitted to a power dependency model, with adjustments made for scale using same formulas as in apartment block.

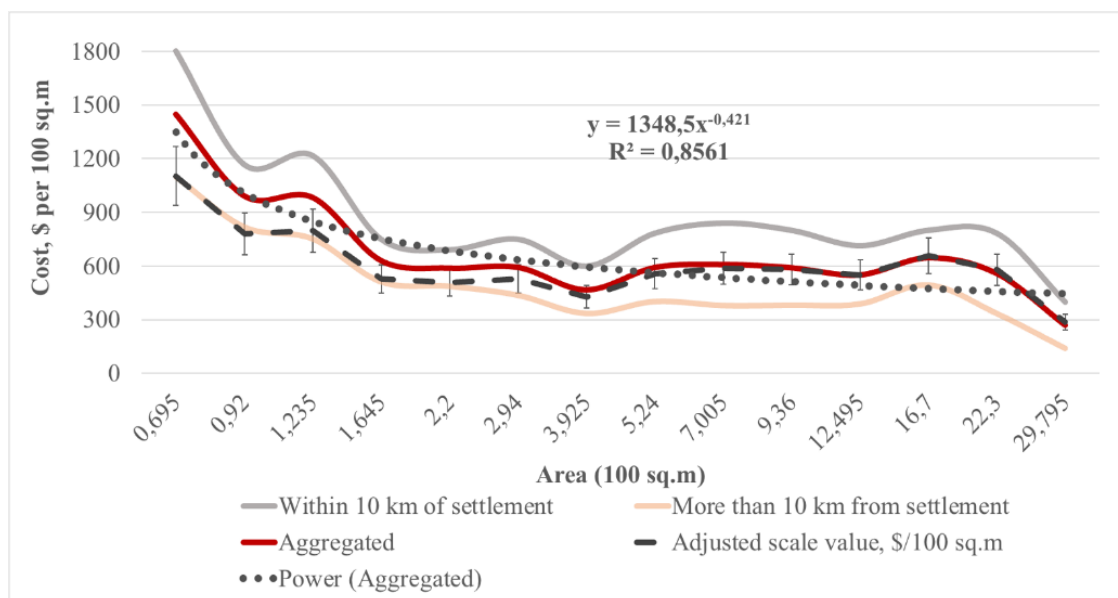


Figure 11. Dependence of land plot value per 100 sq. m. on area.

Source(s): Author's own creation

In both cases, similar trends are observed: with an increase in the area of the plot, its value decreases. However, introducing a correction coefficient reveals noticeable nuances. For plots with an area of up to 500 square meters, there is a significant excess of the actual value over the adjusted one, which gradually diminishes and becomes practically absent for plots with areas exceeding 500 square meters. In other words, as the area increases, the scale effect almost disappears.

The general trend (Fig. 11) shows that for plots with areas up to 100 square meters, there is a significant decrease in price with increasing area. For plots of 100 to 500 square meters, the value decreases more smoothly, and already for plots whose area exceeds 500 square meters, this decrease is very small, and a stabilization of the price at the level of \$400-500 per 100 square meters is observed.

The provided information offers a generalized overview of the existing land market, outlining fundamental aspects and general characteristics of land plots for various purposes. However, beyond this broad overview, the information available within the land market database enables a deeper analysis of the pivotal factors influencing pricing. Quantitative analysis of these influential factors facilitates their direct integration into valuation calculations and allows for precise adjustments when comparing analogues and appraisal objects.

The value of 100 square meters of residential land for plots exceeding 2500 square meters is notably lower than that for plots up to 2500 square meters. This relationship can be attributed to the prevalence of larger plots in rural or underdeveloped areas, where demand is typically lower.

Moreover, it is important to highlight the higher demand in Ukraine for plots up to 2500 square meters. Currently, there is a clear trend indicating that as the plot size increases, the value per square meter of land decreases, likely due to a lack of financially capable buyers.

The land market database facilitates an analysis of influential factors shaping land values. To conduct a comprehensive assessment of the land plot market in Ukraine, it is essential to determine the median price per square meter based on factors such as soil type, location, natural surroundings, and land use method (Tables 5 and 6).

Table 5. Parameters of land value per 100 sq. m as of December 2023, depending on the soil type

Soil	Average cost, \$/100 sq. m	Amount of offers	Coefficient of variation, %	Median cost, \$/100 sq. m	Lower bound of 95% confidence interval	Upper bound of 95% confidence interval
Chernozem	2494	2317	1.01	1071.43	84.11	13648.66
Clayey	2243.31	229	0.81	1321.26	154.14	11325.23
Sandy	3064.83	169	1.02	1875	144.27	24367.6
Stony	4349.26	544	1.04	2100.78	157.13	28086.23

Source(s): Author's own creation

Table 6. Parameters of land value per 100 sq. m as of December 2023, depending on the natural surroundings

Natural surroundings	Average cost, \$/100 sq. m	Amount of offers	Coefficient of variation, %	Median cost, \$/100 sq. m	Lower bound of 95% confidence interval	Upper bound of 95% confidence interval
River	1388.29	12129	1.15	562.5	34.83	9085.53
Forest	1364.61	15764	1.14	571.43	35.74	9135.65
Reservoir	1534.2	1683	1.16	599.97	36.19	9945.81
Hills	1361.43	4424	1.19	616.06	35.36	10732.95
Lake	1555.58	9525	1.13	644.2	41.14	10086.54
Mountains	1376.86	2895	1.25	722.22	37.94	13749.51
Islands	2693.86	366	1.33	1000	46.53	21492.74
Park	2957.68	3649	1.36	1017	45.35	22808.23
Sea	5067.82	676	1.45	2142.86	84.74	54184.87

Source(s): Author's own creation

Indeed, the data shows that Sandy soil exhibits the highest average cost among the soil types listed, while Stony soil has the highest variability in prices. Chernozem and Clayey soils, on the contrary, demonstrate relatively lower average costs and less variability in prices. Similarly, while seafront and island properties command the highest average costs among natural surroundings, there is substantial variability in land prices across different environments. Understanding the relationship between soil types, natural surroundings, and land cost can provide valuable insights, but it's crucial to consider the complex interplay of various factors for a comprehensive evaluation of specific land parcels.

It is apparent that the pricing of residential properties exhibits considerable variation across different regions within Ukraine. Notably, the Kyiv, Odesa, and Zakarpattia regions stand out for having the highest property prices. Furthermore, even within the same region, significant disparities in pricing exist. For instance, in the Ivano-Frankivsk region, the average price per square meter for

properties located within 10 kilometers of settlements is \$561.29, contrasting with \$335.19 for those beyond 10 kilometers.

In addition to this overarching observation, the wealth of data within the real estate market database enables a meticulous analysis of the primary factors influencing pricing dynamics. To conduct a comprehensive examination of the residential property market in Ukraine, it becomes imperative to ascertain the median price per square meter contingent upon the specific type of residential property and its geographical location (Fig. 12).

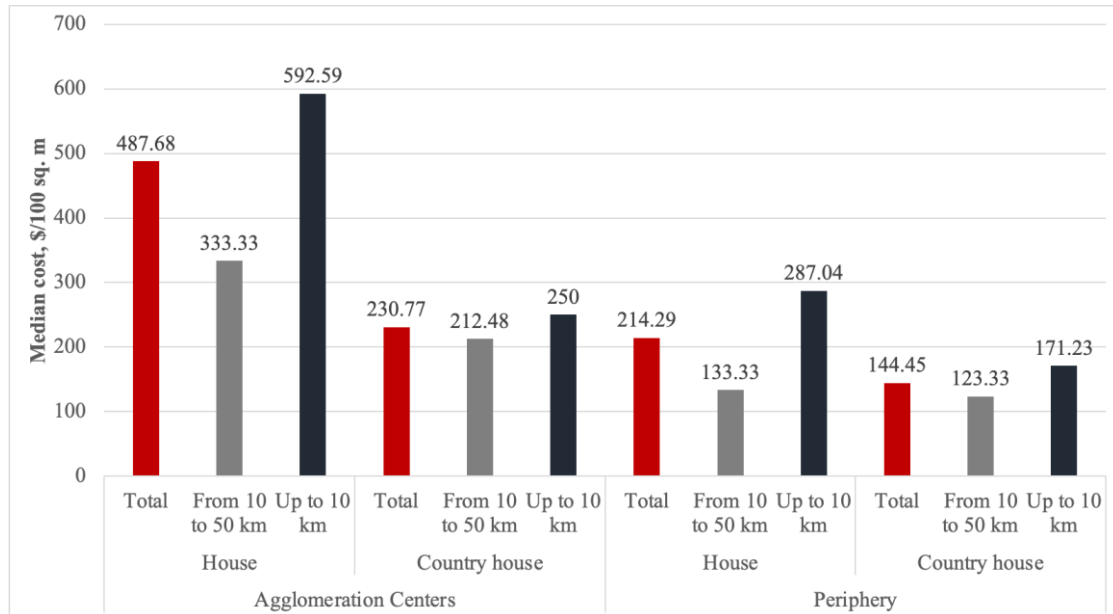


Figure 12. Dependency of the median value on the category of the households.

Source(s): Author's own creation

Figure 13 illustrates the relationship between the cost per square meter of residential properties and their total area. The derived quantitative equation offers a means to accurately approximate these empirical dependencies, facilitating direct adjustments when evaluating the value of current market offerings against appraisal objects and analogues.

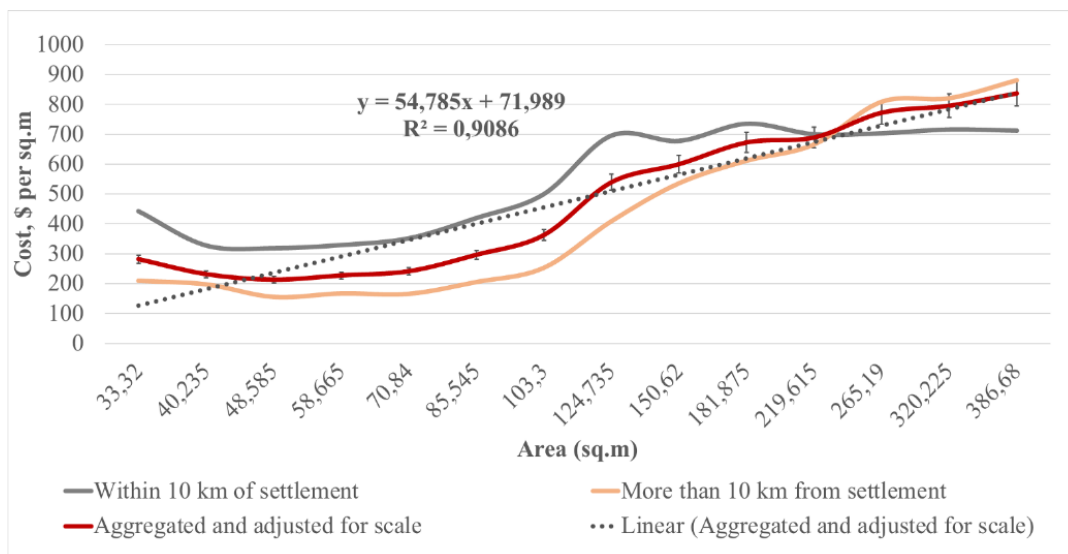


Figure 13. Dependency of the cost per square meter of households on their total area.

Source(s): Author's own creation

The analysis of residential property values reveals a discernible correlation between the cost per square meter and the total area of the property. Larger houses tend to command higher prices per square meter, attributed to their increased room count, expanded living spaces, and larger land plots. Notably, the cost per square meter remains relatively stable for properties up to 100 square meters, hovering around \$250. However, beyond this threshold, a more pronounced increase in cost per square meter is observed as the property's area expands.

Figure 13 depicts this relationship, incorporating scaling adjustments for clarity. The depicted trend aligns with previously established linear dependencies, reaffirming that as the property's area increases, so does its cost per square meter. This relationship underscores the significance of property size in determining its market value, with larger properties experiencing a more significant surge in price per square meter once exceeding the 100-square-meter mark.

This dependency varies somewhat across different regions of Ukraine. For example, in central agglomerations, the cost per square meter of residential properties is higher than in other regions with less developed infrastructure.

7. Prospects for further research development

Prospects for further research development encompass a multifaceted approach aimed at advancing our comprehension of the intricate dynamics governing the Ukrainian real estate market. This includes longitudinal investigations to delineate temporal shifts in the salience of qualitative and quantitative determinants on property valuation, spatial analyses to discern regional idiosyncrasies in price dynamics, and comparative inquiries with disparate global contexts to glean nuanced insights into market behaviors. Additionally, the adoption of sophisticated modeling methodologies, such as machine learning and spatial econometrics, promises heightened prognostic precision. Integration of sentiment indicators into analytical frameworks offers a nuanced appraisal of market psychology, while scrutinizing regulatory perturbations affords clarity on their impact vis-à-vis property valuations. Furthermore, a concerted focus on enhancing data integrity and coverage serves as a cornerstone for ensuring the robustness and applicability of ensuing analyses. These scholarly endeavors collectively endeavor to furnish a comprehensive understanding of the Ukrainian real estate milieu, thereby furnishing policymakers and stakeholders with actionable intelligence requisite for fostering sustainable market dynamics.

8. Conclusions

Based on the conducted research, it can be concluded that the cost of housing in Ukraine is a complex phenomenon, determined by the diversity of quantitative and qualitative factors.

It is essential to conduct a detailed examination of the distinct factors that shape the pricing dynamics of apartments, land plots, and houses individually. For apartments, critical factors include their location within a city, access to amenities, floor level, and total area, all of which significantly influence their market value. Furthermore, the quality of construction, availability of utilities, and security features also contribute substantially to the variability in pricing.

When evaluating land plots, key determinants of value encompass geographical location, soil quality, natural surroundings, and access to infrastructure. Additionally, factors such as the size of the plot, its designated use, and adherence to zoning regulations exert notable effects on pricing trends, with proximity to urban centers often resulting in higher valuation.

In the context of houses, pivotal considerations revolve around the inclusion of amenities such as gardens, garages, and supplementary structures significantly enhances the property's appeal and value. Location remains a critical factor, with proximity to educational institutions, transportation nodes, and commercial hubs influencing pricing dynamics in the housing market.

Moreover, our analysis highlights the variability of these factors' effects across regions, time periods, and other circumstances. For example, we observed an increase in demand for housing in

safer areas during armed conflicts, resulting in higher prices for such properties. Therefore, considering these nuances is essential for accurately gauging and predicting real estate market dynamics in Ukraine.

In conclusion, our findings underscore the multifaceted nature of property valuation, where geographical location, property characteristics, infrastructure, and market dynamics all play pivotal roles. By employing quantitative analysis techniques and statistical modelling, stakeholders can gain deeper insights into the factors shaping property values, enabling informed decision-making for investment, development, and valuation purposes. As the Ukrainian real estate market continues to evolve, staying attuned to these factors will be indispensable for navigating challenges and capitalizing on opportunities in this dynamic sector.

9. Acknowledgements

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