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REAL ESTATE VALUATION AS A TOOL IN BUSINESS RISK MANAGEMENT IN CONDITIONS OF ECONOMIC INSTABILITY

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ABSTRACT: The study aims to analyse the relationship between macroeconomic indicators, real estate market dynamics, and the level of NPLs within the Ukrainian banking system in the period 2006–2023, while proposing a comprehensive methodological approach to determining the collateral value of real estate. The research methodology is based on regression and correlation analysis, the results of which indicate that 92.6% of the variance in real estate prices is explained by nominal GDP dynamics and the exchange rate, whereas the NPL ratio is 91.1% dependent on both its inherent persistence and the macroeconomic factors incorporated into the model. The primary methods of expert monetary valuation of real estate – income capitalisation, sales comparison, and the cost approach – are considered. The findings suggest that the integrated application of these three primary valuation methods enhances the accuracy of property appraisals. The originality of the research lies in its holistic analysis of the interplay between macroeconomic factors, real estate pricing, and NPL levels within the Ukrainian banking system. The developed models, characterised by high explanatory power, can serve as tools for forecasting real estate price trends and shifts in credit risk within the banking sector.

KEYWORDS: real estate valuation, valuation approaches, non-performing loans, real estate market

Introduction

In the contemporary global economic landscape, the financial stability of the banking sector has become a matter of critical importance. For Ukraine, this issue is paramount, given the financial system's acute sensitivity to macroeconomic shocks, currency volatility, and structural shifts in the national economy. The situation in Ukraine is further aggravated by protracted political instability and security threats that significantly undermine economic performance. Geopolitical tensions, the destruction of economic infrastructure, disruptions to production and supply chains, and curtailed investment activity pose additional risks to the domestic financial sector. Consequently, the banking system operates under heightened uncertainty, which may lead to credit quality erosion and a rising share of non-performing loans.

The real estate market plays a pivotal role in shaping credit risk due to its intrinsic link to bank lending. Fluctuations in property prices, shifts in demand, and general market instability can profoundly impact the quality of bank loan portfolios. During periods of economic turbulence or financial crises, declining property values are often correlated with an increase in NPLs, thereby intensifying systemic risks within the financial sector.

In this context, rigorous research into the nexus between credit risk and real estate market dynamics in Ukraine is of vital importance. Analysing these dependencies facilitates a deeper understanding of financial market mechanisms under conditions of extreme uncertainty and supports the development of more robust collateral valuation tools – a cornerstone of banking risk management. Precise real estate appraisal as credit collateral has thus emerged as a key component of risk mitigation strategies in the banking sector. Real estate valuation as collateral is one of the principal aspects influencing the reduction of risks associated with credit relations (Augustyniak et al., 2018). It involves determining the market value of property that can be used as security for obtaining credit resources. Such valuation provides information about the value of a real estate asset, allows assessment of the efficiency of its use, and identifies related costs and income, thereby facilitating effective managerial decision-making.

The purpose of this article is to analyse the factors influencing real estate price levels and to substantiate methodological approaches to the valuation of real estate as collateral, with the aim of improving the accuracy and objectivity of such valuations and enhancing the reliability of mortgage lending as a means of minimising credit risk for financial institutions.

The following research hypotheses were adopted for testing in this article:

H1: Macroeconomic indicators, particularly GDP and the exchange rate, exert a statistically significant influence on real estate price dynamics in Ukraine.

H2: The non-performing loan ratio in the Ukrainian banking system is heavily contingent upon its historical levels and fluctuations in the real estate market.

H3: Macroeconomic factors, such as the exchange rate, credit growth dynamics, and the level of economic development, significantly impact credit risk exposure and the overall stability of the Ukrainian banking system.

H4: The application of statistical metrics (standard deviation and coefficient of variation) substantially improves the reliability of property valuation outcomes.

The relevance of this study is underscored by the necessity for a more profound comprehension of the interactions between macroeconomic variables, the real estate market, and credit risk levels within the Ukrainian banking system amidst heightened economic and political volatility. Statistical and econometric analysis identify the key drivers of NPL formation and assess the role of the real estate market in maintaining the financial stability of the banking sector.

An overview of the literature

In the current economic climate, the Ukrainian banking sector faces multifaceted challenges, with non-performing loan (NPL) risk playing a central role. The NPL ratio serves as a critical indicator of loan portfolio quality, reflecting borrowers' capacity to meet financial obligations. Elevated NPL levels erode bank profitability and constrain the provision of new credit, thereby hindering national economic growth (Bank for International Settlements, 2025; Braun et al., 2024).

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A primary determinant of NPL levels is the quality of the underlying collateral. Real estate market participants and financial institutions traditionally rely on property as the principal form of loan security (Campello et al., 2022). This is because real estate is generally a substantial asset with relatively stable value, capable of being liquidated to mitigate losses in the event of borrower default (Ryan et al., 2022). Consequently, the precise determination of market value directly influences the efficacy of credit risk management in the banking sector (Shevchuk & Shevchuk, 2022; Benmelech et al., 2024). Evidence suggests that substandard property valuation can lead to flawed risk assessments, inadequate loan loss provisioning, and the development of opaque credit portfolios (Karanikolas et al., 2025). Property appraisal is increasingly viewed as a critical component of business risk management, particularly during periods of economic instability.

The definition of real estate is provided in the Ukrainian National Standard No. 1 "General Principles of Property and Property Rights Valuation", approved by the Resolution of the Cabinet of Ministers of Ukraine No. 1440 of 10 September 2003. Real estate is defined as a land plot without improvements or a land plot with improvements inseparably connected to it, buildings, structures, their parts, as well as other property classified as real estate under applicable legislation.

During credit operations secured by property, the lender seeks to minimise the risk of financial loss. If the borrower fails to meet debt obligations, the lender is interested in realising the collateral. This, however, is only possible with liquid assets, i.e., property that is in demand on the market and can easily find buyers. In order to determine both the liquidity and the current market value of such an asset, a valuation is conducted. The amount established as the value of the property should correspond to the credit sum that the bank can safely extend to the borrower.

Real estate valuation is a systematic process of determining the value of a specific asset or its part for various purposes – purchase, sale, donation, inheritance, and many others (Gabrielli & French, 2020). Such valuation always represents a specific value as of a particular date and is documented in a detailed report outlining all calculations performed. The report also specifies the valuation methods applied in each case.

It should be noted that when traditional approaches to real estate valuation are applied, valuers increasingly encounter complex challenges, e.g. limited datasets (Toprakli, 2024; Tajani et al., 2019). The difficulties associated with valuation are further compounded by the growing expectations of investors regarding the quality of the valuation process, who demand results that are more accurate, transparent, and objective (DeLisle & Grissom, 2011; Wyman et al., 2011). In their research, Augustyniak et al. analysed a number of factors underscoring the necessity of reliable valuation. In most cases, the repayment of loan obligations for both commercial and residential properties is secured by the income generated by such real estate. Given the high level of financial leverage, the long-term nature of loan repayment, and the substantial fluctuations in real estate prices, which serve as collateral for financial obligations, significant risks arise for banks and other financial institutions (Augustyniak et al., 2018; Jajuga & Jajuga, 2006). The inherent subjectivity in the valuation process may introduce discrepancies and potentially undermine the reliability of valuation outcomes, particularly in the context of mass appraisal, such as for taxation purposes (Renigier-Biłozor et al., 2022; Wofford et al., 2010).

Contemporary research highlights that traditional valuation models, while fundamental, often fail to account for the complex market dynamics and financial interdependencies characteristic of modern real estate markets (Kucharska-Stasiak, 2025; De Toro et al., 2020). Investor-oriented valuation approaches integrate market signals, asset characteristics, and financial factors into a unified decision-making system, underscoring the necessity for adaptive models in risk management (Kucharska-Stasiak, 2025). Studies on real estate market cyclicality point to the importance of integrated valuation models for determining the highest and best use of assets and for sustainable risk management (D'Amato & Coskun, 2022). To enhance appraisal accuracy, methods incorporating multi-criteria analysis (MCA) are proposed, enabling more effective forecasting of market prices and risks (Kim et al., 2020; Guarini et al., 2020).

Recent studies demonstrate a growing trend towards the use of data-driven methodologies and AI, which make it possible to incorporate diverse information sources – such as economic indicators, property characteristics, and investor behavioural factors – into the valuation process (El Bied et al., 2024). Large volumes of data provide increased transparency, reduce information asymmetry, and facilitate improved financial risk management (Martin & Nagel, 2022). Consequently, AI-based

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models and multimodal approaches demonstrate superior predictive accuracy and can be utilised for risk management under conditions of economic uncertainty (Karanikolas et al., 2025; Miljkovic et al., 2023,;Angrick et al., 2022).

There is a clear necessity to establish robust valuation models that account for both microeconomic and macro-financial factors to ensure precise business risk assessment (Danila, 2024). Real estate price dynamics also significantly influence investment risk (Yiu & Murray, 2024). Furthermore, research highlights the importance of cultural and local factors in property valuation; urban innovations and even cultural or artistic interventions can substantially affect property prices and investment attractiveness (Wang et al., 2023; Cheng et al., 2023). Methodological advancements involving multi-criteria analysis enable increased valuation accuracy, allowing for a more detailed assessment of asset-use efficiency, sustainable urban development, and other factors influencing value (De Toro et al., 2020; Kim et al., 2020; Guarini et al., 2020).

Research shows that economic challenges, including exchange rate fluctuations and a decline in purchasing power, contribute to an increase in both the level of non-performing loans and a decrease in the market value of collateralised property, particularly residential and commercial property (Mohan et al., 2019; Bondarenko et al., 2020). This implies that an unstable economic environment can exert simultaneous pressure on bank credit portfolios and the real estate market, thereby exacerbating credit risk.

Conditions of economic instability, financial crises, and political upheaval significantly complicate the property valuation process in Ukraine. In such environments, real estate markets are characterised by high volatility, low liquidity, and heightened levels of uncertainty. Following the global financial crisis, the COVID-19 pandemic, and the escalation of geopolitical risks in the 2020s, the role of property valuation within Ukraine's risk management framework has expanded considerably. Real estate remains one of the most vital forms of collateral in bank lending; therefore, fluctuations in its value can directly impact the stability of the banking sector. Under these circumstances, banks are compelled to place particular emphasis on the accuracy of collateral appraisals, the regular updating of asset values, and the employment of more sophisticated risk analysis methods.

Despite a significant body of international research dedicated to real estate valuation and its role in bank lending, a research gap exists regarding the functioning of this mechanism in countries with high levels of political and economic instability, such as Ukraine. Most contemporary studies focus on developed financial markets (the USA, EU countries, and China), where real estate markets are characterised by high liquidity and transparency. Conversely, the specificities of property valuation in transition economies remain significantly less explored. Consequently, comprehensive studies analysing the use of real estate valuation as a business risk management tool in bank lending under conditions of armed conflict and macroeconomic instability – defining features of the modern Ukrainian economy – are highly pertinent.

Research methods

In the course of the research conducted on real estate appraisal, three approaches have been distinguished: the cost approach, the income approach, and the sales comparison approach.

The income approach encompasses a group of methods that determine the property value based on future economic income streams, discounted by an expected discount rate. The income-based valuation methods include the investment method and the profits method. The investment method is based on rental income, whereas the profits method is used when the income is derived from business operations. Figure 1 presents the algorithm for the valuation of an income-producing property using the income approach (discounted cash flow approach).

The sales comparison approach to real estate includes a group of valuation methods that determine value by comparing the subject property with other similar properties. This approach is based on transaction prices obtained under market conditions, adjusting these prices for differences in attributes – factors influencing the price (e.g., location, condition, size) – and accounting for price changes over time. The adjusted price for each of the comparables is determined according to the algorithm presented in Fig. 2.

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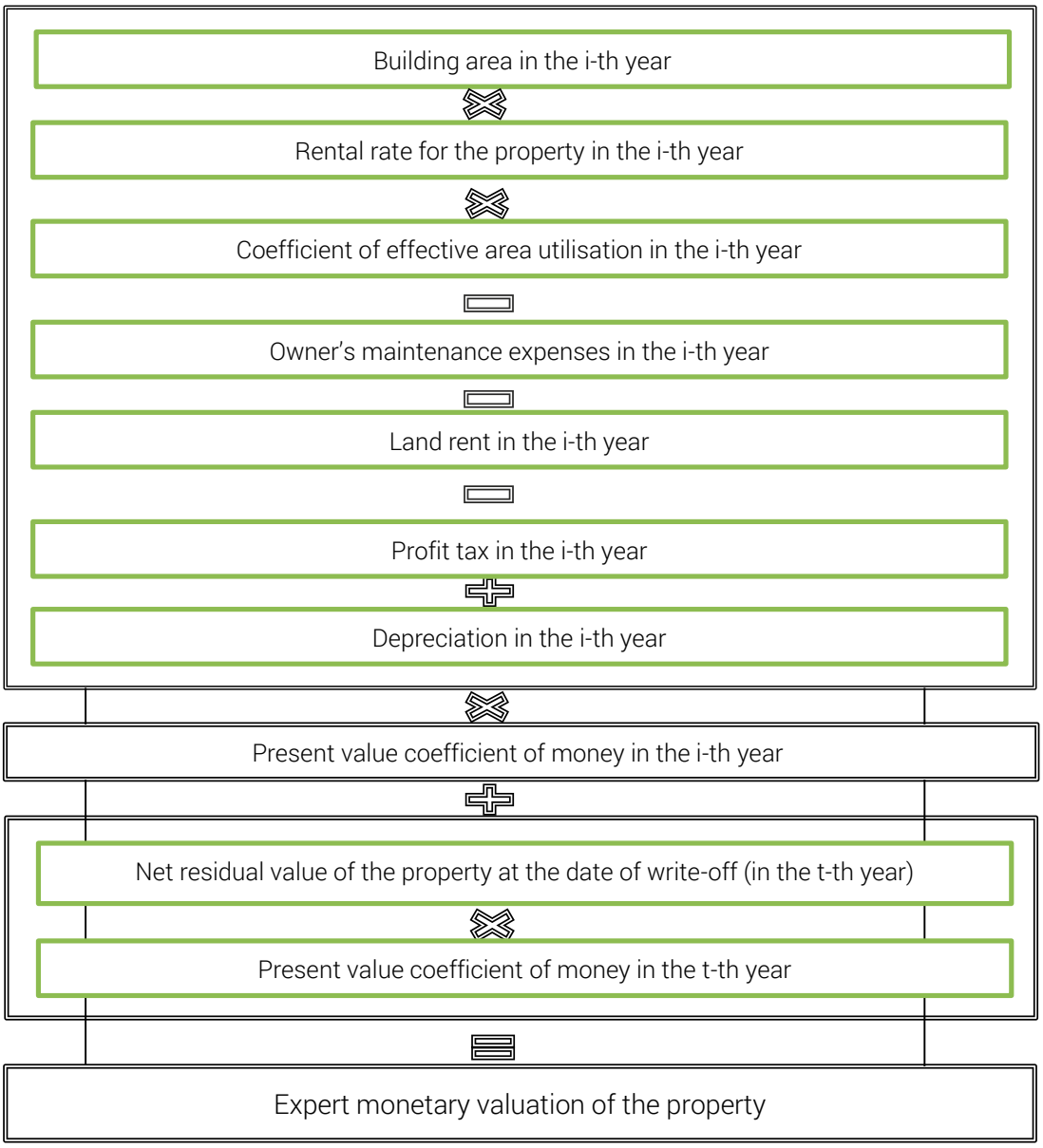


Figure 1. Real estate valuation algorithm using the income approach

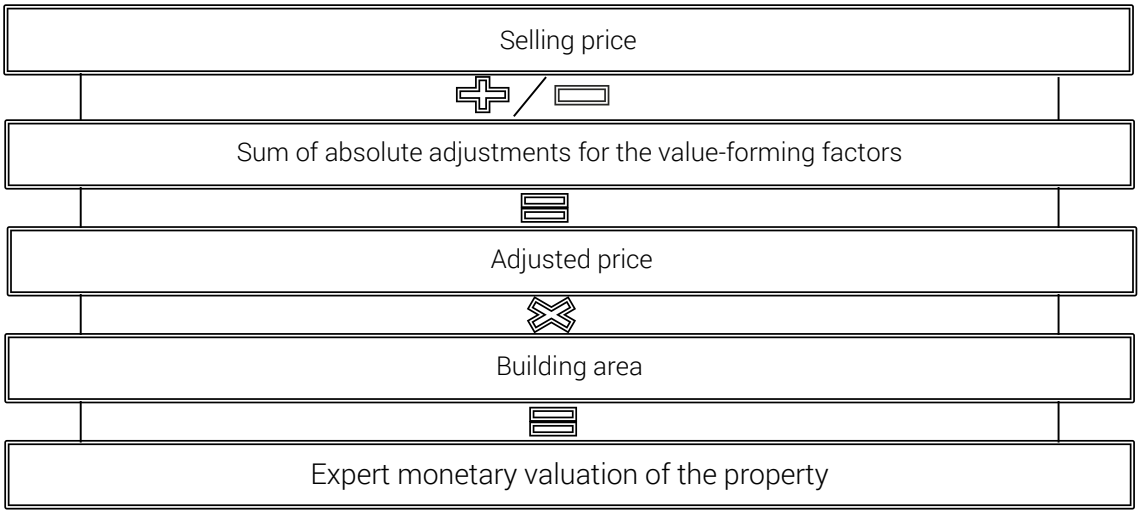


Figure 2. Real estate valuation algorithm using the comparative approach

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The cost approach includes a group of methods that determine the value of an asset based on its replacement or reproduction cost, less depreciation, assuming that a buyer would not pay more than the cost of constructing a similar asset in its current condition. It involves the separate determination of the land value and the construction/reproduction cost of the appraised property (Figure 3).

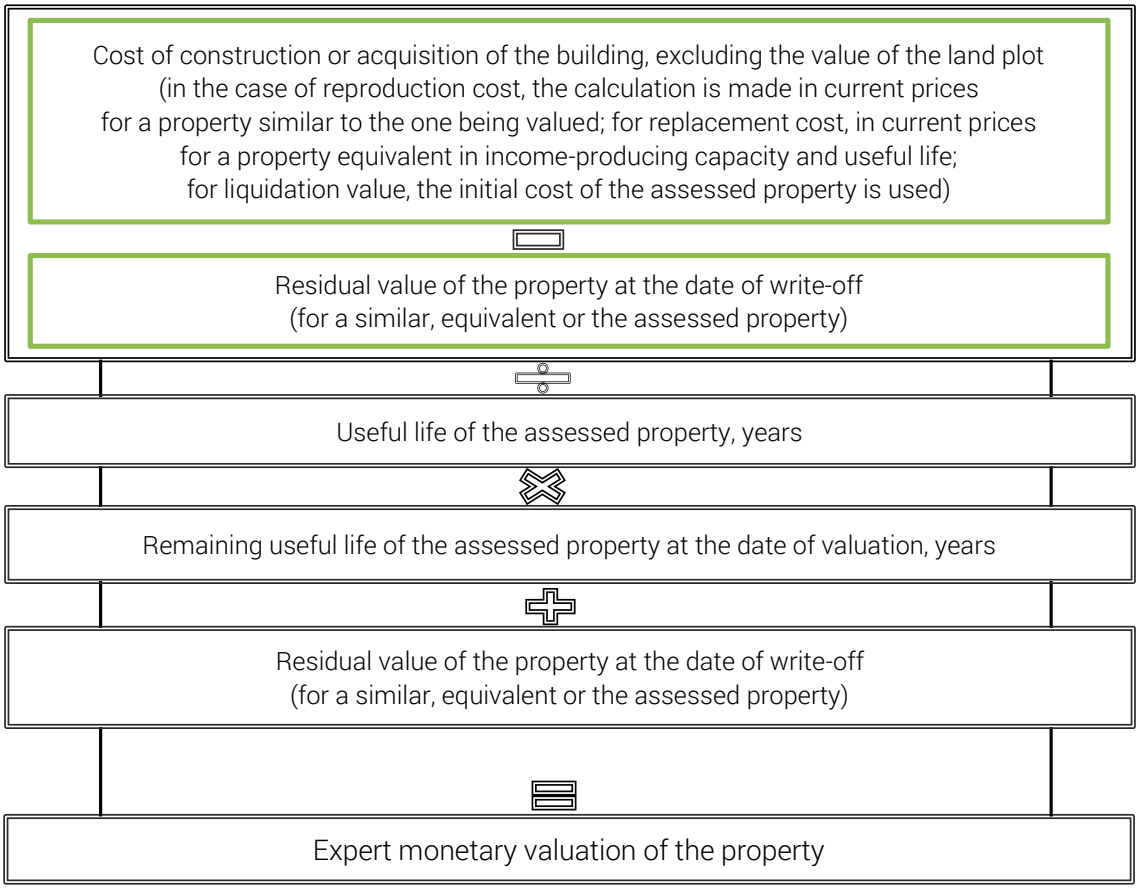


Figure 3. Real estate valuation algorithm using the cost approach

One of the primary disadvantages of cost-based methods is the assumption that the value of a property is identical to the sum of the costs incurred, which may not reflect reality.

A detailed description of the real estate valuation methods used in this paper is presented in the next section to ensure a better understanding of the valuation process and a transparent presentation of the research results.

Results of the research

Macroeconomic Conditions
General Economic Situation in Ukraine

An analysis of the factors influencing real estate prices shows that fluctuations in per capita income, consumer expenditure, and the structure of the economy have a significant impact on property prices, including residential housing (Miller et al., 2011; Simo-Kengne et al., 2013; Almeida, 2025).

In assessing the state of the economy, a system of macroeconomic indicators is employed, among which gross domestic product (GDP) holds a central position. Through analysis of GDP, it is possible to evaluate production and consumption outcomes, economic growth dynamics, labour productivity, and to form a general understanding of the nation's level of prosperity (Klividenko, 2016).

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As economic development is defined as a long-term process, it is appropriate to consider the indicator of growth rate, namely, the rate of increase in GDP volume.

From 2006 to the present, Ukraine has experienced two major economic crises and is currently facing a third. As illustrated in Figures 4a and 4b, Ukraine's nominal GDP in national currency has demonstrated a generally upward trend over the past two decades, with the exception of 2022, which can be explained by the ongoing military actions on the territory of Ukraine. The highest GDP growth rate was recorded in 2021, both in national currency and in US dollars.

A rather different picture emerges when analysing the dynamics of nominal GDP expressed in US dollars. As a consequence of the global financial crisis that began in 2007, Ukraine experienced significant negative changes in its economy as early as 2009, which were immediately reflected in a substantial decline in nominal GDP in USD terms (largely due to a sharp depreciation of the national currency against the dollar). The second economic crisis occurred in 2014–2015, triggered by the onset of military conflict in eastern Ukraine. During this period, the hryvnia weakened more than threefold: from 8 UAH/USD at the beginning of 2014 to 23.8 UAH/USD at the beginning of 2016. As a result, GDP expressed in USD decreased by 28% in 2014 and by 31% in 2015, respectively (see Figures 4a and 4b).

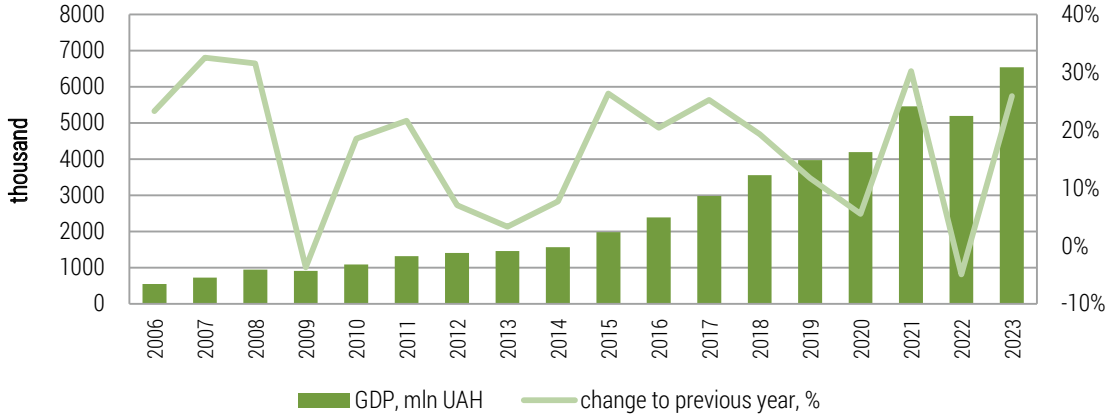


Figure 4a. Nominal GDP in Ukraine, mln UAH

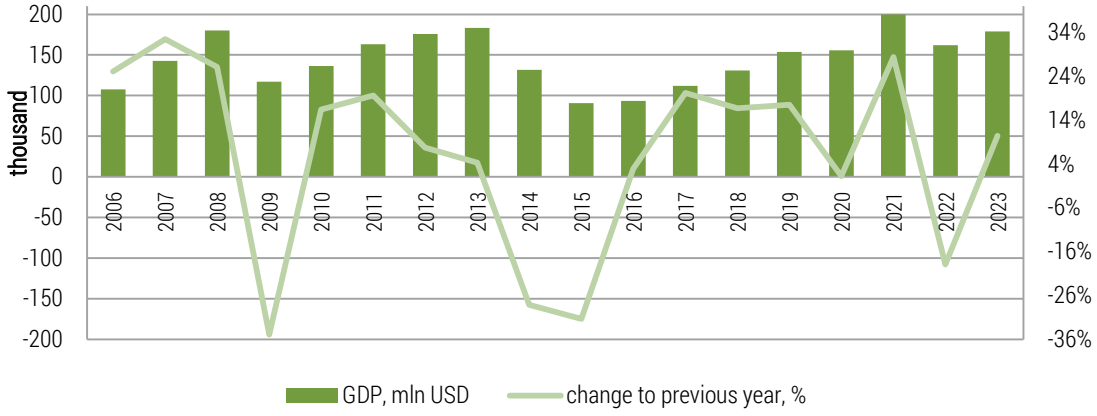


Figure 4b. Nominal GDP in Ukraine, mln USD

Source: authors' work based on www.minfin.com.ua [2025].

The transformations that have taken place in the Ukrainian economy over the past two decades have had a profound impact on the banking system as well as on developments in the real estate markets.

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Non-performing mortgage loans

The problem of non-performing loans (NPLs) during periods of financial crisis is common to many countries across the world (Khairi et al., 2021; Alnabulsi et al., 2022). As shown in Figures 5a, 5b, 5c, and 5d, since 2008, as a result of the adverse effects of the global financial crisis, many EU member states have suffered from high levels of non-performing loans, which in some cases reached 10%, 20%, or even over 30% of the total credit portfolio of a given country.

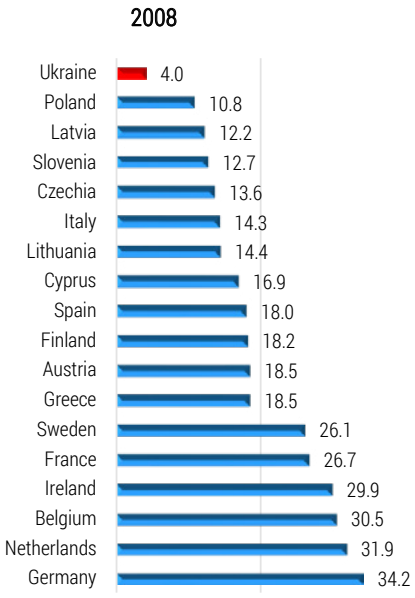


Figure 5a. Gross non-performing loans, domestic and foreign entities, % of gross loans (European Union and Ukraine) in 2008

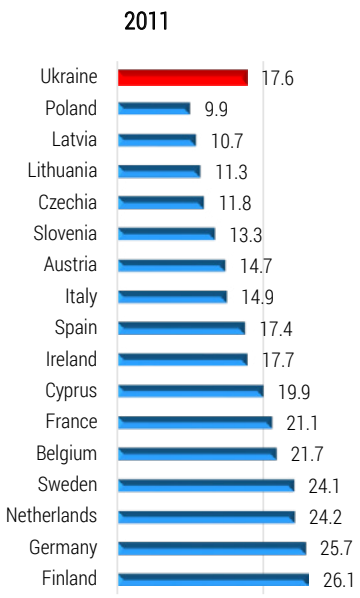


Figure 5b. Gross non-performing loans, domestic and foreign entities, % of gross loans (European Union and Ukraine) in 2011

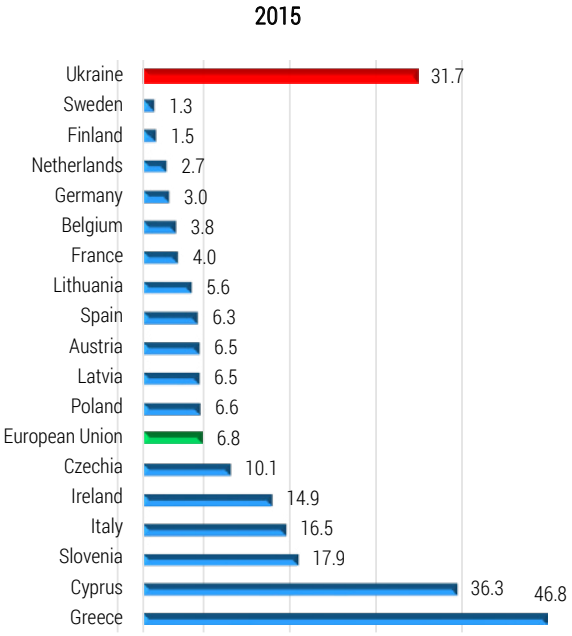


Figure 5c. Gross non-performing loans, domestic and foreign entities, % of gross loans (European Union and Ukraine) in 2015

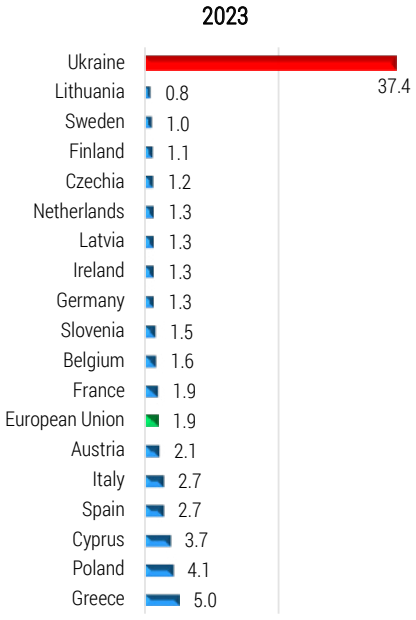


Figure 5d. Gross non-performing loans, domestic and foreign entities, % of gross loans (European Union and Ukraine) in 2023

Source: authors' work based on www. ec.europa.eu [2025].

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In certain instances, such as in 2015, this indicator exceeded 36% in Cyprus and almost reached 47% in Greece. Unfortunately, Ukraine recorded one of the highest NPL ratios in Europe, which peaked at 55% in 2018. Such an exceptionally high level of NPLs had a profoundly negative impact on the efficiency and development of the banking system, significantly contributing to the contraction of lending activity.

It should be noted that a number of factors within the Ukrainian banking system further aggravated the situation. Among the key factors negatively affecting cooperation between banks and borrowers were the following:

- the absence of adequate legal protection for creditors' rights, which at times made debt recovery virtually impossible;
- excessively risky lending practices by banks, often accompanied by low standards in assessing borrowers' creditworthiness, aimed at short-term profit maximisation; and
- the highly hazardous and uncommon practice, by international standards, of lending to related parties (mainly former bank owners).

In Ukraine, the cessation of loan servicing by borrowers who were, in one way or another, affiliated with banks led to the liquidation of many financial institutions, excessive expenditures on refinancing, and other negative consequences.

The outbreak of military hostilities in Ukraine reversed the previously stable downward trend in the share of non-performing loans, which had been gradually declining from 55% to 27% between 2018 and early 2022. According to the National Bank of Ukraine, as of 1 January 2023, the share of NPLs in the banking sector had risen to 38%. As already noted, a major reason for this increase lies in the ongoing military actions on Ukrainian territory, which have triggered a new wave of borrower defaults. According to NBU data, as of October 2023, "war-related" non-performing business loans accounted for more than 30% of their total volume.

The presence of a significant share of non-performing loans compels banks to increase their reserve provisions, which in turn proportionally reduces the amount of funds available for further lending and worsens the financial performance of banking institutions. A substantial rise in NPL volumes is an extremely adverse phenomenon for banks, as it directly affects liquidity, undermines credit ratings, and erodes customer trust, which together can result in further insolvency and the institution's exit from the market (Bayar, 2019). Timely assessment of credit risk and the implementation of prudent restructuring measures, where necessary, are key to ensuring the continued resilience of banks (Salas et al., 2024; Nwafor et al., 2023). Of particular importance in reducing credit risk is the existence of sufficient collateral backing the loan obligation, in most cases, real estate of various types, which serves as a guarantee for the bank that the borrower will repay the loan and fulfil all associated financial commitments.

Characteristics of Real Estate Markets

Real estate markets play a crucial role in the global economy, attracting an increasing number of investors seeking opportunities for capital allocation with minimal risk – a goal that poses growing challenges under current economic conditions (Renigier-Biłozor et al., 2022; Maier & Herath, 2009; Siemińska & Krajewska, 2017). The spatial and temporal distribution of land prices plays a key role in urban development and reconstruction processes (Hu et al., 2012). Research on real estate markets demonstrates that property prices depend on social, demographic, and territorial factors (Tu et al., 2007; Orford, 2000; Watkins, 2008; Clerc, 2019). A strong correlation has been established between these factors and real estate prices (Jones & Leishman, 2006).

The history of the real estate market in Ukraine dates back to the early 1990s, when the privatisation of state-owned flats first became possible. Initially, property prices were relatively low; however, from 1997 onwards, a significant upward trend was observed.

Within a year, under the influence of the 1998 economic crisis, housing prices in Kyiv expressed in US dollars fell by half, despite the fact that prices in hryvnias remained almost unchanged, which was caused by the sharp depreciation of the Ukrainian currency from 1.9 to 3.4 UAH per USD.

In the early 2000s, housing prices returned to pre-crisis levels. The subsequent period, from 2003 to 2008, was marked by dynamic growth in the real estate market. The average price of flats increased more than fivefold – from 560 USD/m^2 to 3,050 USD/m^2, or from 3,000 UAH/m^2 to 15,430 UAH/m^2. As illustrated in Figures 6a and 6b, during this period, the exchange rate of the hryvnia

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against the US dollar remained stable at around 5 UAH per USD, owing to monetary policies implemented by the National Bank of Ukraine.

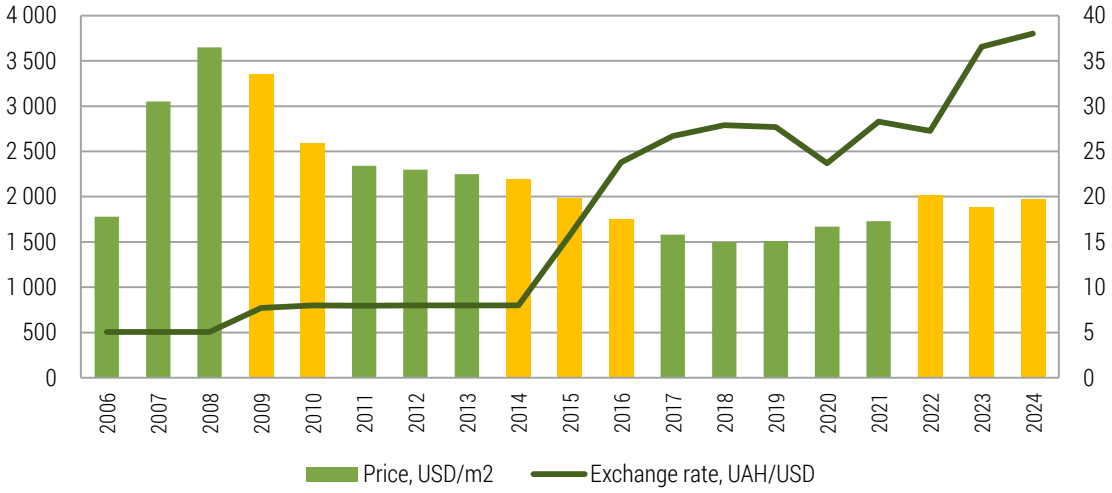


Figure 6a. Housing price dynamics and exchange rate dynamics (UAH/USD), USD/m^2

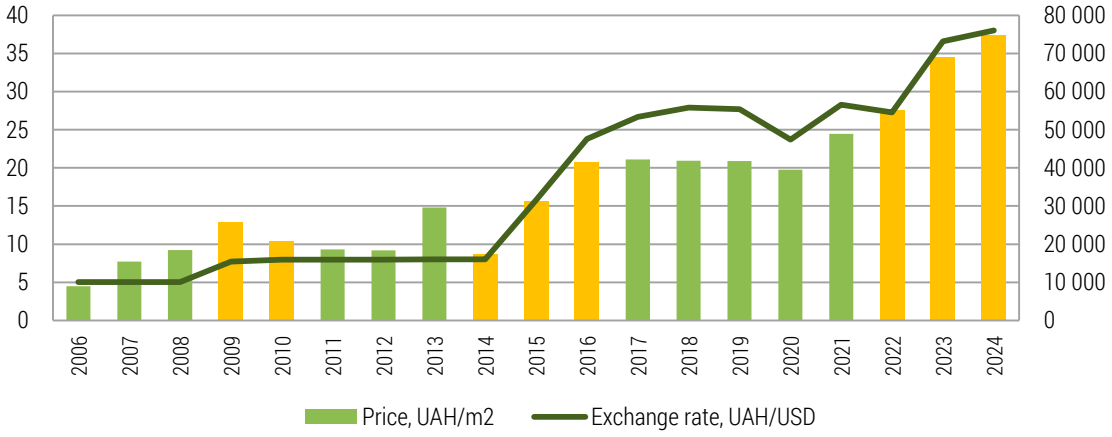


Figure 6b. Housing price dynamics and exchange rate dynamics (UAH/USD), UAH/m^2

Source: authors' work based on www. mof.gov.ua and www.ukrstat.gov.ua [2025].

Despite the onset of the global financial crisis in 2007, housing prices in Ukraine continued to rise by inertia until the end of 2008, reaching approximately 3,650 USD/m^2. This increase was particularly noticeable for Ukrainian households, given the sharp devaluation of the national currency, which lost around 53% of its value during 2008 (the exchange rate changing from 5.05 to 7.7 UAH per USD).

In 2009–2010, Ukraine fully experienced the consequences of the global financial crisis. As shown in Figure 6a, housing prices in USD dropped sharply. Until 2013, prices continued to decline, though at a slower pace. From December 2014, when the country entered a domestic economic crisis amid political upheavals and the Russian occupation of eastern Ukraine, until 2018, real estate prices in US dollars continued to fall, while those expressed in hryvnias rose.

The end of 2021 and the beginning of 2022 proved to be among the most challenging periods for Ukraine's real estate market. The threat of a full-scale invasion, the ensuing military conflict with Russia, and the mass displacement of the population to safer regions of the country had a profound impact on the development of the sector. From 2015 onwards, demand for housing and land plots for construction has been increasing annually. In 2021, Ukrainians purchased more than 631,000 properties (residential units and land plots designated for residential development); however, in 2022, this figure declined threefold. Since 2020, real estate prices expressed in UAH have risen by almost 36%, reaching 74.9 thous. UAH/m^2 by the end of 2023 (Figure 6b).

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An analysis of real estate markets in EU countries also reveals considerable fluctuations in price levels during the period 2006–2015 (Figure 7). Recent studies have shown how the 2008 financial crisis in Europe deepened socio-economic disparities at both local and regional levels (Pérez, 2010; Kauskale et al., 2022).

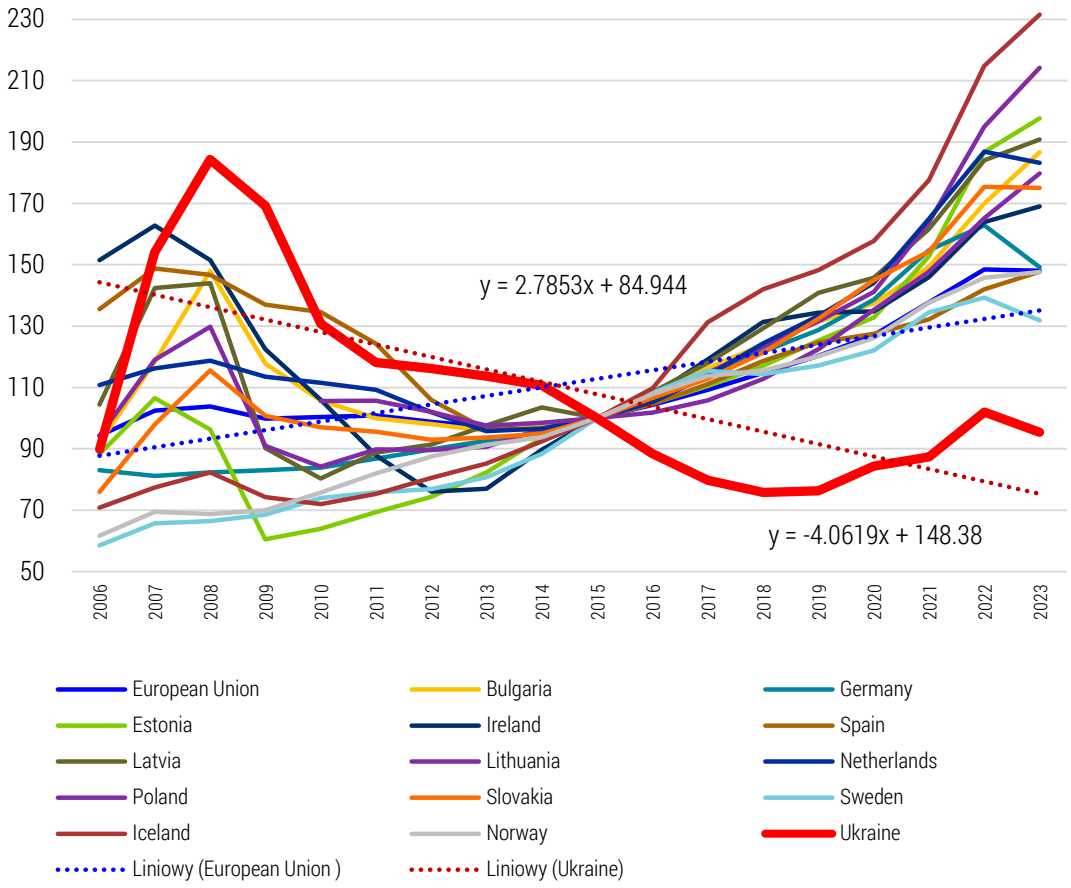


Figure 7. Housing price index (2015 = 100) in EU countries, %

Source: authors' work based on www. ec.europa.eu [2025].

From 2016 onwards, the situation began to change, and over the next six years, property prices showed an upward trend in most EU countries. However, from 2022, renewed price volatility could be observed in the real estate market (Wang, 2022). In some countries, such as Iceland, Lithuania, Bulgaria, Poland, and Estonia, prices continued to rise, while in others, such as the Netherlands, Germany, and Sweden, a noticeable decline was recorded.

When comparing real estate markets in EU countries and in Ukraine, it should be noted that the Ukrainian market remains among the most unstable. Given the ongoing military hostilities, it is difficult to predict when conditions will become more predictable and when real estate can once again be regarded as a reliable form of collateral for securing financial obligations, including loans.

One of the key factors in reducing credit risk is an objective and well-founded valuation of the borrower's real estate that may serve as collateral for loan obligations (Abidoye & Chan, 2018; Johnson et al., 2023). Therefore, the following section of this study presents an assessment of real estate using various valuation methods. This enables a clearer understanding of the valuation process and provides a more objective determination of the value of mortgaged property as security for loan obligations, thereby contributing to the minimisation of credit risk.

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Evaluating the impact of economic factors on property prices and the share of non-performing loans in the banking system

The study covers the period from 2003 to 2023, as it encompasses the pivotal economic and political challenges that have shaped the Ukrainian economy and its banking sector – most notably the global financial crisis, the economic volatility of 2014–2015, structural reforms within the banking system, and the consequences of the 2022 invasion. This timeframe facilitates a comprehensive assessment of the dynamics of the investigated indicators across diverse macroeconomic conditions.

The regression models employ lagged values for the independent variables, as their influence on the dependent variable typically manifests with a temporal delay. Utilising lags allows for a more accurate representation of the causal links between economic indicators while accounting for the inherent persistence of economic processes.

The impact of macroeconomic factors on property prices in Ukraine

To evaluate the influence of economic variables on property prices in Ukraine, a multiple regression and correlation analysis was performed (Table 1). The dependent variable was the natural logarithmic transformation of property prices in UAH per m^2, ln(Price), while the independent variables included Ukraine's nominal GDP, ln(Nominal GDP_{t-1}), and the UAH/USD exchange rate, ln(Exchange $rate_{t-1}$).

Table 1. Impact of macroeconomic factors on property prices in Ukraine: regression analysis results

	Standardised coefficient (b*)	Std. error of b*	Unstandardised coefficient (b)	Std. error of b	t(18)	p-value
Constant			−4.99123	1.488684	−3.35278	0.003543
ln (Nominal GDP $_{t-1}$)	1.309367	0.151435	1.14301	0.132195	8.64639	0.000000
ln (Exchange rate $_{t-1}$)	−0.399363	0.151435	−0.47544	0.180284	−2.63719	0.016736

Regression summary for the dependent variable: ln(Price):

- Multiple correlation coefficient (R): 0.9624.
- Coefficient of determination (R^2): 0.9262.
- Adjusted R^2: 0.9180.
- F-statistic (F(2.18)) = 112.95, p < 0.00001.
- Standard error of estimate: 0.24204.

The research resulted in the construction of a multifactor regression equation describing the dependence of property prices on macroeconomic indicators:

$$\ln(Price_t) = -4.99123 + 1.14301 \ln(Nominal\ GDP_{t-1}) - 0.47544 \ln(Exchange\ rate_{t-1}) + \varepsilon \quad (1)$$

where ε represents the random error term.

The regression model demonstrated high explanatory power (R^2=0.926, adjusted R^2=0.918), indicating that approximately 92% of the variance in property prices is explained by the included economic factors. The model's F-test (F(2,18)=112.95, p<0.001) confirmed its statistical significance. The standard error of the estimate (0.242) indicates satisfactory predictive accuracy.

The regression coefficients revealed a significant impact from the economic variables: Ukraine's nominal GDP had a positive effect (b=1.309, t=8.65, p<0.001), meaning a 1% increase in GDP is associated with a price rise of approximately 1.31%. The UAH/USD exchange rate showed a negative effect (b=–0.399, t=–2.64, p=0.017), reflecting a tendency for prices to decrease as the Hryvnia weakens. Correlation analysis supported the findings of the regression analysis, with a very strong positive correlation (0.947) between property prices and nominal GDP. The correlation with the exchange rate (0.787) is also significant, though slightly weaker than that of GDP. All reported correlation coefficients are statistically significant at p<0.05.

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The negative coefficient for the exchange rate variable (b= –0.399) does not contradict the general upward trend in property prices. The discrepancy between the correlation and regression results arises because correlation reflects a simple bivariate relationship, whereas the regression model isolates the impact of each variable whilst holding other factors constant. In this case, the correlation analysis reveals a positive correlation between the Hryvnia exchange rate and property prices (0.787), which suggests that both property prices and the exchange rate rose simultaneously during periods of general economic growth. However, in the regression model, the impact of the exchange rate is assessed alongside that of nominal GDP, which has a very strong positive influence and a high correlation with property prices (0.947). Consequently, the shared variance between these variables is redistributed, resulting in a sign change. Thus, the negative coefficient does not imply a direct contradiction with the data but represents the net effect of the exchange rate once other macroeconomic factors, specifically GDP, are controlled for.

Impact of real estate market dynamics on non-performing loans in Ukrainian banks

A multiple regression analysis was conducted to evaluate the factors influencing the level of non-performing loans, ln(NPL), in the banking system (Table 2). The model included two explanatory variables: the lagged NPL value, $\ln(NPL_{t-1})$, and the lagged property price, $\ln(Price_{t-1})$. Notably, the LTV indicator, which is used in banking practice to assess the ratio between the loan amount and the value of collateral, was not included in the model. This is because aggregated data for this indicator for the analysed period are absent from the open statistics of the Central Bank of Ukraine, and the corresponding information is formed primarily at the level of individual commercial banks and is not widely available. Furthermore, the correlation and regression analysis did not include a broader range of macroeconomic factors, such as inflation or lending rates. This limitation was a deliberate methodological decision related to the need to avoid multicollinearity between variables, which could lead to a distortion of regression coefficient estimates and a reduction in the model's statistical reliability.

Table 2. Impact of real estate market changes on the NPL level in Ukraine: results of regression analysis

	Standardised coefficient (b*)	Std. error of b*	Unstandardised coefficient (b)	Std. error of b	t(18)	p-value
Constant			-3.96554	0.986850	–4.01838	0.000806
ln (NPL GDP $_{t-1}$)	0.573598	0.102598	0.57896	0.103558	5.59071	0.000026
ln (Price $_{t-1}$)	0.462835	0.102598	0.52205	0.115726	4.51113	0.000270

Regression summary for the dependent variable ln(NPL):

- Multiple correlation coefficient (R): 0.94473.
- Coefficient of determination (R^2): 0.89252.
- Adjusted R^2: 0.88058.
- F-statistic (F(2.18)) = 74.738, p < 0.000001.
- Standard error of estimate: 0.32946.

As a result of the conducted research, a multifactor regression equation was constructed (formula 2):

$$\ln(NPL_t) = -3.96554 + 0.57896 \ln(NPL_{t-1}) + 0.52205 \ln(Price_{t-1}) + \varepsilon. \quad (2)$$

The results of the regression analysis indicate the high explanatory power and statistical significance of the model, as approximately 89 % of the variation in the level of non-performing loans is explained by the included independent variables. Analysis of the regression coefficients shows that both independent variables have a positive and statistically significant impact on the level of non-performing loans. The lagged value $\ln(NPL_{t-1})$ at b=0.579 and p<0.001 indicates the presence of inertia in the dynamics of non-performing loans: their high level in the previous period contributes to the maintenance of an increased level in the next period. The variable $\ln(Price_{t-1})$ also demonstrates a positive impact (b=0.522; p<0.001), which may reflect the relationship between real estate market

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dynamics and banking lending risks. Rising property prices often trigger lending expansion and mortgage market growth. During such upswings, Ukrainian banks may relax underwriting standards for borrowers seeking more expensive properties, leading to higher debt burdens and increased future default risks. Moreover, „asset bubbles" can result in overvalued collateral. In the event of an economic downturn or price correction, collateral values may plummet, hindering loan recovery. Finally, structural issues in Ukraine – such as related-party lending and protracted collateral foreclosure procedures – mean that even rising property values do not always effectively mitigate credit risk.

These findings are corroborated by correlation analysis. The correlation between ln(NPL) and its la**gge**d value is 0.878, and with lagged prices, it **is** 0.840, indicating very strong positive relationships.

The impact of macroeconomic factors on the level of non-performing loans in the Ukrainian banking sector

This study employs an econometric framework to evaluate the factors driving the dynamics of non-performing loans (NPLs) within the Ukrainian banking system (Table 3). A multiple linear regression model was developed to quantify the relationship between NPL levels and a suite of key macroeconomic and financial indicators. The dependent variable is defined as ln(NPL), while the vector of explanatory variables includes the lagged value of non-performing loans ($\ln(NPL_{t-1})$), the rate of credit growth ($\ln(\text{Credit growth}_{t-1})$), the exchange rate ($\ln(\text{Exchange rate}_{t-1})$), and income levels ($\ln(\text{GDP per capita}_{t-1})$).

Table 3. Impact of macroeconomic factors on NPL levels in Ukraine: regression analysis results

	Standardised coefficient (b*)	Std. error of b*	Unstandardised coefficient (b)	Std. error of b	t(18)	p-value
Constant			−18.3812	5.743893	−3.20014	0.005576
ln (NPL_{t-1})	1.313071	0.280248	1.3254	0.282870	4.68540	0.000248
ln (Credit growth $_{t-1}$)	0.479166	0.213886	2.4922	1.112471	2.24028	0.039618
ln (Exchange rate $_{t-1}$)	−0.672288	0.264111	−0.8664	0.340386	−2.54548	0.021600
ln (GDP per capita $_{t-1}$)	0.772931	0.212148	0.7458	0.204694	3.64336	0.002189

Regression summary for the dependent variable ln(NPL):

- Multiple correlation coefficient (R): 0.954707.
- Coefficient of determination (R^2): 0.9114654.
- Adjusted R^2: 0.889332.
- F-statistic (F(2.18)) = 41.180, p < 0.000001.
- Standard error of estimate: 0.31715.

The following multifactor regression equation was derived from the empirical analysis (Formula 3):

$$\ln(NPL_t) = -18.3812 + 1.3254 \cdot \ln(NPL_{t-1}) + 2.4922 \cdot \ln(\text{Credit growth}_{t-1}) - 0.8664 \cdot \ln(\text{Exchange rate}_{t-1}) + 0.7458 \cdot \ln(\text{GDP per capita}_{t-1}) + \varepsilon. \quad (3)$$

The regression results indicate robust explanatory power (R2=0.911) and overall statistical significance for the model (F(2.18)=41.180, p<0.000001).

The coefficients reveal that a 1% increase in the level of NPLs in the preceding period is associated with a 1.33% increase in their current level. This suggests significant inertia in NPL dynamics; essentially, high concentrations of impaired assets in previous periods exert persistent upward pressure on current NPL ratios. Furthermore, a 1% acceleration in credit growth corresponds to a 2.49% increase in NPL levels. This finding implies that rapid credit expansion may compromise underwriting standards or increase credit risk exposure, leading to a higher proportion of NPLs during phases of aggressive lending. At the same time, a 1% increase in the exchange rate (denoting a devaluation of the national currency) is associated with a 0.87% decrease in the NPL level. This likely reflects com-

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plex macroeconomic transmission channels through which exchange rate fluctuations interface with the banking sector and systemic financial stability. Additionally, a 1% increase in GDP per capita correlates with a 0.75% rise in the NPL share, whilst holding other factors constant. This suggests a non-linear relationship where the general level of economic development influences the dynamics of institutional credit risk.

In summary, the correlation and regression analyses are mutually reinforcing, demonstrating that NPL dynamics in the Ukrainian banking system are heavily contingent upon both internal indicator inertia and broader macroeconomic variables – most notably credit expansion, exchange rate volatility, and the trajectory of economic development. The model's high explanatory capacity confirms its utility for the systematic analysis and forecasting of credit risk within the sector.

Real estate valuation

Income-producing properties and their separate parts (such as offices, workshops, etc.) are valued using the income capitalisation approach, the sales comparison approach, and the cost approach (Kruchok, 2012). Their application is demonstrated using a warehouse property, the characteristics of which are presented in Table 4.

Table 4. Characteristics of the Warehouse Building

Indicator	Value
Internal dimensions, m Length Width Height	 120 12 4
Area, m2	1,440
Usable area coefficient	0.92
Main construction materials	foundation – reinforced concrete blocks; floor – cement; walls and roof – steel structures, aluminium sheet
Technical condition	good
Infrastructure	special feature – railway access track
Useful life, years	25
Years in use	10
Initial cost, thous. USD	269.1
Net residual value at the time of write-off, thous. USD	5.0
Type of depreciation	uniform
Land plot area under the building, m2	2,240
Owner's maintenance costs (excluding land rent and taxes), thous. USD	17
Taxes, % of profit	20

Source: authors' work based on Kruchok [2012].

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Valuation of the Warehouse Building using the Income Capitalisation Approach

An analysis of the warehouse rental market in the city district where the assessed property is located showed that the average annual rent for similar buildings amounts to 41.1 USD/m^2, while the rent for land plots beneath them (if such a property is situated on leased land) equals 1.46 USD/m^2.

The expert monetary valuation of an income-producing property using the income capitalisation approach (discounted cash flow approach) may be determined as follows. If the owner of the building and the owner of the land plot on which it stands are different persons, such a valuation is calculated according to formula (4):

$$MV = \sum_{i=1}^{t}(A_i \times RR_i \times EC_i - Ex_i - LR_i - T_i + D_i) \times PVC_i + RV_t \times PVC_t, \quad (4)$$

MV – expert monetary valuation of the property, USD;
A_i– building area in the i-th year, m^2;
EC_i– coefficient of effective area utilisation in the i-th year;
RR_i– rental rate for the property in the i-th year, USD/m^2;
Ex_i – owner's maintenance expenses in the i-th year, USD;
LR_i – land rent in the i-th year, USD;
T_i – profit tax in the i-th year, USD;
D_i– depreciation in the i-th year, USD;
PVC_i– present value coefficient of money in the i-th year;
RV_t – net residual value of the property at the date of write-off (in the t-th year), USD;
PVC_t – present value coefficient of money in the t-th year.

If it is expected that the future annual cash flows will be equal in amount (with the discount rate accounting for the change in the value of money over time), formula (4) simplifies and takes the form of formula (5):

$$MV = \sum_{i=1}^{t}(A_i \times RR_i \times EC_i - Ex_i - LR_i - T_i + D_i) \times PVC_a + RV_t \times PVC_t, \quad (5)$$

where PVC_a is the present value annuity coefficient.

It should be noted that in this case, determining the appropriate discount rate is of crucial importance. Evidently, such a rate should reflect the expected level of inflation and provide a return exceeding this level, taking into account the risks inherent to this type of business activity. In the Ukrainian context, the discount rate is formulated individually for each subject asset, predicated upon prevailing market conditions, required rates of return, and the specific risk premium. The discount rate utilised in real estate valuation remains inherently dynamic, sensitive to systemic market risks and shifting investor expectations; historically, these rates have ranged from a moderate 8–12% during periods of relative stability to considerably higher thresholds (15–22%) throughout crisis phases.

The valuation calculated using formula (5) for the warehouse property described in Table 1 is as follows (discount rate = 10%):

$$MV = (1{,}440\ m^2 \times 0.92 \times 41.1 USD/m^2 - 17{,}225 USD - 3{,}276 USD - 6{,}787.6 USD + 10{,}562.5 USD) \times 7.605 + 5{,}000 USD \times 0.239 = 288{,}079.8 USD.$$

If the owner of the warehouse building were simultaneously the owner of the land plot on which the building stands (the expert monetary valuation of the corresponding plot amounts to 32,760 USD, formulas (4) and (5) would take the form of formulas (6) and (7):

$$MV = \sum_{i=1}^{t} \begin{matrix}(A_i \times RR_i \times EC_i - Ex_i - T_i + D_i) \times \\ PVC_i + (RV_t + LV) \times PVC_t\end{matrix}, \quad (6)$$

where LV – value (expert monetary valuation) of the land plot, USD.

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$$MV = \sum_{i=1}^{t} \frac{(A_i \times RR_i \times EC_i - Ex_i - T_i + D_i) \times PVC_a + (RV_t + LV) \times PVC_t}{}, \quad (7)$$

The calculations according to formula (4) yield the following result:

$$MV = \left(1{,}440\text{m}^2 \times 0.92 \times \frac{41.1\text{USD}}{\text{m}^2} - 17{,}225\text{USD} - 7{,}442.9\text{USD} + 10{,}562.5\text{USD}\right) \times 7.605 + (5{,}000\text{USD} + 32{,}76\text{USD}) \times 0.239 = 315{,}839.8\text{USD}.$$

Thus, the expert monetary valuation of the warehouse building together with the land plot is 27,760 USD higher than without taking the land value into account. However, the land plot value, as is known, equals 32,760 USD. The difference of 4,999.9 USD is explained by the following factor. If the owner of the warehouse were also the owner of the land plot, they would not pay land rent, but their annual taxes would increase from 6,788 USD to 7,443 USD, i.e. by 655 USD. The present value of the annuity of these additional tax payments accounts for the stated difference (655 USD ×7.605 = 4,982 USD). Minor discrepancies between the two calculation methods are due to rounding.

The income capitalisation approach is the principal method for valuing income-producing properties (Baum et al., 2005). However, to avoid significant errors in expert monetary valuation, it is advisable, where possible, to apply an auxiliary method in parallel. In the case of income-producing properties, such an auxiliary method may be the sales comparison approach.

Valuation of the Warehouse Building by the Sales Comparison Approach

Table 5 presents the calculation of the most probable selling price of the warehouse building by means of the sales comparison approach for similar properties (excluding the value of the land plots beneath them). When adjusting the actual selling prices, the following value-forming factors were taken into account (Kruchok, 2012):

- the location of the property,
- the remaining period of its useful life,
- infrastructure (including the presence of a railway siding),
- the date of sale.

The adjusted price for each of the comparable properties (in this case, five warehouse buildings) is determined according to formula (8):

$$P_a = P_s \pm \sum_{i=1}^{n} A_{ai}, \quad (8)$$

where: P_a – adjusted price, USD/m^2;
P_s – selling price, USD/m^2;
A_{ai} – absolute adjustment for the i-th value-forming factor, USD/m^2.

The most probable selling price for the property being valued is determined as the median average of the adjusted selling prices of the comparable properties, excluding the lowest and highest values. (If conditions allow, the most probable selling price may also be determined as the modal average.)

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Table 5. Calculation of the Warehouse Building Price by the Sales Comparison Approach

Indicator	Building being valued	Comparable buildings				
		No. 1	No. 2	No. 3	No. 4	No. 5
Usable area, m^2	1,440	1,500	1,240	1,450	1,600	1,200
Selling price, USD	–	365,000	396,250	255,625	333,750	218,750
Price per 1 m^2, USD	–	243.3	319.6	176.3	208.6	182.3
Location:						
Relative adjustment, %	–	-10	-10	0	0	5
Absolute adjustment, USD/m	–	-24.3	-32.0	0	0.0	9.1
Remaining useful life, years:	15	20	25	10	15	15
Relative adjustment, %	–	-19	-38	19	0	0
Absolute adjustment, USD/m^2	–	-46.2	-121.4	33.5	0.0	0.0
Infrastructure (including the presence of a railway siding):	present	absent	absent	present	absent	absent
Relative adjustment, %	–	15	15	0	0	0
Absolute adjustment, USD/m^2	–	36.5	47.9	0	0	0
Relative adjustment, %	–	-1	-0.5	-0.5	-1	-1
Absolute adjustment, USD/m^2	–	-2.4	-1.6	-0.9	-2.1	-1.8
Adjusted price, USD/m^2	207.4	206.8	212.5	208.9	206.5	189.6

Source: authors' work based on Kruchok [2012].

In this example, the lowest adjusted selling price corresponds to warehouse building No. 5 (189.6 USD/m^2), while the highest corresponds to building No. 2 (212.5 USD/m^2).

The most probable selling price of the assessed warehouse building, calculated per 1 m^2 (excluding warehouse buildings No. 2 and No. 5), is:

$$P = (206.8 + 208.9 + 206.5) \div 3 = 207.4 \text{ USD/m}^2.$$

The expert monetary valuation of this building, excluding the value of the land plot, therefore amounts to: 207.4 USD/m^2×1,440m^2=298,656 USD. To include the value of the land plot, the obtained valuation of the warehouse building should be increased by the land value (+32,760 USD). However, as shown in the results of the valuation by the income capitalisation approach, corresponding tax adjustments (≈ – 5,000 USD) should be taken into account.

The reliability of the expert monetary valuation obtained using the sales comparison approach depends mainly on three key factors:

- the adequacy of the sample of properties whose selling prices are used in the valuation (there should be at least five, and they must be sufficiently comparable to the property being assessed);
- the appropriateness of the selected key attributes, which act as value-forming factors (e.g. location, functional characteristics, remaining useful life, and sale date); the number of such factors should not exceed five to seven;
- the accuracy of determining the influence of each key attribute (value-forming factor) on the final valuation result.

The extent to which these conditions are satisfied, directly affecting the accuracy of the valuation, can be quantitatively determined by mathematical statistics.

One of the important statistical and mathematical indicators is the standard deviation (σ), which determines the degree of fluctuation of a given economic indicator (for example, price). It is calculated as the square root of the average of the squared deviations of individual observations from their arithmetic mean, according to formula (9):

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$$\sigma = \sqrt{\frac{\sum(X-\bar{X})^2}{n}}, \quad (9)$$

where:
σ – standard deviation; its unit of measurement is the same as that of the studied economic indicator;
X – the value of a variant (individual observation);
$\bar{X}$ – the mean value of all variants (individual observations);
n – the number of variants (individual observations).

The standard deviation of market prices for warehouse buildings in our example is:

$$\sigma = \sqrt{\frac{13\ 737.4}{5}} = 52.4 \text{ USD/m}^2.$$

After adjustments for value-forming factors, it changed to:

$$\sigma = \sqrt{\frac{314.8}{5}} = 7.9 \text{ USD/m}^2.$$

Finally, after excluding extreme values of the adjusted prices, the standard deviation became:

$$\sigma = \sqrt{\frac{3.4}{3}} = 1.1 \text{ USD/m}^2.$$

The significant reduction in the standard deviation of adjusted prices for warehouse buildings compared to the actual market prices indicates that, in this example, the main value-forming factors were adequately accounted for.

The exclusion of the lowest and highest adjusted price values from further calculations is justified by the intention to consider only those sales transactions in which both parties acted competently and without external pressure (the minimum and maximum adjusted prices are questionable in terms of whether one of the parties acted impartially and without compulsion).

It is evident that the elimination of extreme adjusted price values contributed to a further reduction in the standard deviation, and consequently to an increase in the reliability of the valuation obtained.

Similar conclusions can be drawn based on the coefficient of variation, calculated according to $V\sigma$ (formula (10)):

$$V\sigma = \frac{\sigma}{\bar{X}} \text{ x } 100\%. \quad (10)$$

This coefficient is derived from the standard deviation, but unlike it, represents a relative rather than an absolute measure (since it is expressed as a percentage). Therefore, the coefficient of variation is a universal indicator of the volatility of economic parameters under study.

The coefficient of variation of market prices for warehouse buildings is as follows:

$$V\sigma = \frac{52.4}{226} \text{ x } 100\% = 23.2\%.$$

Adjusting the prices resulted in a significant decrease of this coefficient:

$$V\sigma = \frac{7.9}{204.9} \text{ x } 100\% = 3.9\%.$$

For the adjusted prices used in determining the median average, the coefficient of variation is even lower:

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$$V\sigma = \frac{3.4}{207.4} x\ 100\% = 0.5\%.$$

Hence, the median average value, equal to 207.4 USD/m^2, represents the most probable selling price of the assessed property, though not the only possible one. Under the normal probability distribution, the possible selling price is expected to fall within the following ranges: with probability P = 0.683, within the interval $\bar{X}\pm\sigma$ (207.4 USD/m^2 ± 3.4 USD/m^2; with probability P = 0.854, within the interval $\bar{X}\pm2\sigma$ 207.4 USD/m^2 ± 6.8 USD/m^2; with probability P = 0.997, within the interval $\bar{X}\pm3\sigma$ 207.4 USD/m^2 ± 10.2 USD/m^2. Thus, with a probability exceeding 99%, it can be asserted that the possible selling price of the assessed warehouse building (excluding the value of the land plot) will be within the range from 283,968 USD to 313,344 USD.

The statistical and mathematical analysis of the obtained results confirms their high reliability, and therefore, the expert monetary valuation of the warehouse building determined by the sales comparison approach may be considered valid.

Valuation of the Warehouse Building by the Cost Approach

Another method of property valuation is the cost approach. This method is applied in three variations, whereby the valuer determines the reproduction cost, the replacement cost, or the liquidation value of the property (Kruchok, 2012). As mentioned earlier, the application of this approach is limited: it is generally used for the valuation of specialised properties, that is, buildings with a restricted market for sale or lease (Wu et al., 2022). Warehouse buildings are not considered specialised properties, yet the use of the cost approach can be useful if the result is compared with valuations obtained by other methods.

In most cases, the reproduction cost is determined, and only when its determination is impossible is the replacement cost calculated. The materials from which the assessed warehouse building was constructed (reinforced concrete and steel structures, brickwork, slate roofing, etc.) are still produced by industry today, and their current prices are known. Therefore, it is possible to determine the reproduction cost of such buildings.

The value of the property determined under the cost approach may be calculated according to formula (11):

$$V = \frac{C-RV}{LU} \times LU_r + RV, \quad (11)$$

where:

V – value of the property determined by the cost approach (reproduction, replacement or liquidation), USD;

C – cost of construction or acquisition of the building, excluding the value of the land plot (in the case of reproduction cost, the calculation is made in current prices for a property similar to the one being valued; for replacement cost, in current prices for a property equivalent in income-producing capacity and useful life; for liquidation value, the initial cost of the assessed property is used), USD;

RV – residual value of the property at the date of write-off (for a similar, equivalent or the assessed property), USD;

LU – useful life of the assessed property, years;

LU_r – remaining useful life of the assessed property at the date of valuation, years.

Based on the analysis of current prices for buildings similar to the one being valued, the reproduction cost of the assessed warehouse building is as follows:

$$V = \frac{403\ 700-6\ 875}{25} \times 15 + 6\ 875 = 244\ 970(\text{USD}).$$

The balance (liquidation) value of the same building is as follows:

$$V = \frac{269\ 062.6-5\ 000}{25} \times 15 + 5\ 000 = 163\ 437.5(\text{USD}).$$

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A significant discrepancy is observed between the reproduction cost and the balance value. A further verification of the reproduction cost calculation revealed that the initial value of the assessed property requires clarification (a revaluation of the property should be carried out).

Comparison of Valuation Results of the Income-Producing Property Obtained by Different Methods

As a result of the expert monetary valuation of the warehouse building using three methods, the following results were obtained: using the income capitalisation approach – 288,004 USD; the sales comparison approach – 298,656 USD (min = 283,968 USD; max = 313,344 USD; P = 0.997); the cost approach – 244,970 USD.

Attention should be drawn to the closeness of the valuations obtained by the first two methods, as well as the considerable deviation of these valuations from the reproduction cost of the assessed property (Kruchok, 2012). The cost approach can be both useful and, in some cases, necessary, but it should be applied with caution. In this case, the above deviation indicates that the demand for warehouse buildings, and, accordingly, their market prices, significantly exceed construction costs. Such a situation arises in locations where warehouse buildings are intensively used and where there is strong demand for their lease or purchase. Under these conditions, constructing a warehouse building may appear, at first glance, more advantageous than its long-term lease or purchase. However, it is important to bear the following in mind. To construct a warehouse, it is first necessary to lease or purchase a land plot, which requires both financial expenditure and time. Additional time is also needed for construction. Therefore, there are alternative options that may be considered.

The situation would change radically if the assessed building were located in an area with poorer location and infrastructure (not in a large city but, for example, at a small railway station remote from major cities, industrial centres, and large markets), where the useful area utilisation coefficient would not be 0.92 but at most 0.80. In that case, the annual rent for the building would be at least twice as low (not 41.1 USD/m^2, but 20.55 USD/m^2). Even if the rental rate for the land plot on which the building stands were reduced fivefold (from 1.46 USD/m^2 to 0.29 USD/m^2), the expert monetary valuation of the warehouse building under the income capitalisation approach would decrease sharply:

$$\mathrm{MV} = \left(1{,}440\mathrm{m}^2 \times 0.8 \times \frac{20.55\mathrm{USD}}{\mathrm{m}^2} - 17{,}225\mathrm{USD} - 655\mathrm{USD} - 1{,}157.9\mathrm{USD} + 10{,}562.5\mathrm{USD}\right) \times 7.605 + 5{,}000\mathrm{USD} \times 0.239 = 116{,}777.38\mathrm{USD}.$$

In this case, the reproduction cost of the warehouse building remains practically the same as in a large city (163,437.5 USD), which means that constructing new warehouse buildings under such conditions would be unprofitable.

The application of the cost approach provides information necessary for well-grounded decision-making, but in this case, the expert monetary valuation of the building should be determined using the income capitalisation approach and the sales comparison approach. Although the valuations obtained by these methods are very close (approximately 288–300 thous. USD per property), it is still necessary to determine a specific valuation figure. It is advisable to follow the well-known rule: when there is a discrepancy between valuations obtained by different methods, the average value should be adopted if the valuation under the primary method is higher; the lower value should be adopted if the valuation under the primary method is lower. In this case, the primary method is the income capitalisation approach, and the auxiliary method is the sales comparison approach. Therefore, based on the above rule, the valuation of 288,004.3 USD should be taken into account.

When using the property (in this case, the warehouse building) as collateral, it must be taken into consideration that the mortgage value should be at least 10–15% lower than the market value. Accordingly, the maximum mortgage value of the warehouse building amounts to 259,240 USD (288,004.3 x 0.9).

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Valuation of Non-Income-Producing Buildings

The valuation of non-income-producing buildings and/or their separate parts differs from that of income-producing properties in that, in this case, the income capitalisation approach cannot be applied (Kruchok, 2012). Therefore, in the valuation of non-income-producing buildings, the primary method is the sales comparison approach, while the cost approach serves as an auxiliary method. If, for certain reasons, the sales comparison approach cannot be applied, the cost approach becomes the sole valuation method available. Below is presented an expert monetary valuation of a three-room economy-class flat, considered as collateral, carried out according to the method proposed by Kruchok (2003), with modifications enabling a more precise and objective valuation of real estate. This method is based on the comparison of transactional prices for similar properties with the introduction of appropriate adjustments. Table 6 presents the price-forming factors for three-room flats (similar to the property being valued) located in the same residential district of the city.

Table 6. Price-forming Factors (for Three-room Flats on the Secondary Housing Market of Kyiv)

Code	Factor	Significance within the group (coefficient)
1	Environment:	
1.1	noise	0.20
1.2	exhaust gas pollution	0.25
1.3	radiation and chemical pollution	0.55
2	Transport network:	
2.1	pedestrian accessibility to rapid public transport (metro, light rail, etc.)	0.40
2.2	intensity of public transport traffic	0.60
3	Features of the building's location (entrance):	
3.1	geological characteristics of the land plot	0.40
3.2	terrain of the surrounding area	0.05
3.3	pedestrian accessibility of parking	0.20
3.4	availability of commercial and service infrastructure	0.35
4	Building characteristics:	
4.1	possible future service life	0.55
4.2	wall material	0.25
4.3	need for repair	0.20
5	Flat location and layout:	
5.1	floor	0.15
5.2	landscape	0.10
5.3	natural lighting	0.10
5.4	room layout	0.10
5.5	ceiling height	0.15
5.6	kitchen	0.10
5.7	bathroom/toilet	0.10
5.8	balconies/loggias	0.05
5.9	corridor/hall	0.10
5.10	storeroom	0.05

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Code	Factor	Significance within the group (coefficient)
6	Flat fittings and finish:	
6.1	flooring	0.25
6.2	entrance door	0.15
6.3	kitchen and bathroom tiling	0.20
6.4	balcony/loggia fittings	0.10
6.5	sanitary equipment	0.10
6.6	internal doors (excluding entrance)	0.20

Source: authors' work based on Kruchok [2003].

Since a complete analogy between the flats being compared is, as a rule, absent, it is necessary to make relevant adjustments to account for differences in quality. Therefore, before the monetary valuation of the flat, its quality assessment, expressed in points, is performed.

If necessary, the list of factors included in any of the six groups mentioned above may be modified or supplemented. The significance of individual factors within each group may also be adjusted, provided that the sum of the significance coefficients for each separate group equals 1 (such significance values are, as a rule, determined using the expert assessment method). The relative importance of each group of factors is determined in the process of statistical analysis of flat transactions (Kruchok, 2003).

Each of the 28 selected price-forming factors is evaluated using a five-point scale (see Table 4). The assessment of each factor is then weighted by its significance (as indicated in column 1 of Table 6), which makes it possible to determine weighted average scores for the six groups of factors listed in Table 6. The expert monetary valuation of a flat is not carried out if any of the factors 1.3, 3.1, or 7.1 is assessed at two points or less.

Table 7. Factor Rating Scale

Expert Assessment of Factor	Point
Highest	5
Very high	4.5
High	4
Above average	3
Average	3
Below average	2.5
Low	2
Very low	1
Lowest	1
Factor absent	0

Source: authors' work based on Kruchok [2003].

After determining the weighted average scores for each of the six groups of factors using the five-point scale, the flat rating is calculated on a 100-point scale (formula 12):

$$R=3.479P_1 + 3.269P_2 + 3.451P_3 + 3.826P_4 + 3.331P_5 + 2.644P_6, \quad (12)$$

where:
R – rating of the flat on a 100-point scale, points;
P_i – weighted average score of the i-th group of price-forming factors, determined on a five-point scale, points.

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The coefficients assigned to each P_i were determined on the basis of statistical and mathematical analysis of data on the quality of flats of the relevant class (assessed by six groups of factors on a five-point scale) and their transaction prices. A six-factor correlation–regression model of a linear type was developed, in which the significance of each factor (in this case, each group of factors) was determined proportionally to the corresponding value of the multiple determination coefficient, while the maximum possible rating of the evaluated flat did not exceed 100 points.

Table 8 presents the weighted average expert evaluation of the six groups of factors, determined according to the above methodology, for a three-room flat with a total floor area of 65 m^2, located in Kyiv.

Table 8. Expert Evaluation of Price-Forming Factors

Group of factors	Weighted average assessment
Environment	4.00
Transport network	3.00
Features of the building's location (entrance)	4.40
Building characteristics	3.75
Flat location and layout	4.30
Flat fittings and finish	4.00

Source: authors' work based on Kruchok [2012].

Accordingly, the rating of the evaluated flat, determined on a 100-point scale, is as follows:

$$R = 3.479\times4+3.269\times3+3.451\times 4.4+3.826\times3.75+3.331\times4.3+2.644\times4 = 78.154 \approx 78.2 \text{ (points)}.$$

The results of the comparison of sale prices for three-room flats similar to the one being evaluated are presented in Table 9.

The average sale price of the flats amounted to 1,432 USD/m^2. For further calculations, the lowest (No. 6) and the highest (No. 2 and No. 4) prices are excluded.

Thus, the median average value of flat sale prices per rating point is:

$$\acute{P} = (18.802+17.672+18.671)\div3 = 18.382(\text{USD}/m^2/\text{point}).$$

Taking into account that the quality rating of the evaluated flat is 78.2 points, the most probable sale price of the flat is 1,437.47 USD/m^2=78.2×18.382 USD/m^2/point, and the expert monetary valuation of the entire flat is 93,436 USD (1,437.47 USD/m^2×65 m^2).

Table 9. Sale Prices and Ratings of Three-Room Flats

No. of property	Total area, m^2	Selling price, USD	Sale price per m^2, USD	Rating, points	Sale price per m^2 per rating point, USD/m^2/point
1	61.9	81,700	1,319.87	70.2	18.802
2	64.0	117,500	1,835.94	85.7	21.423
3	70.0	104,900	1,498.57	84.8	17.672
4	60.0	79,100	1,318.33	60.1	21.936
5	61.2	85,700	1,400.33	75.0	18.671
6	69.7	84,900	1,218.08	75.0	16.241
7	64.5	92,312	1,431.85	75.1	19.058

The reliability of the obtained valuation is verified through the calculation of the standard deviation (σ) and the coefficient of variation (Vσ).

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The standard deviation of flat sale prices amounts to 199.94 USD/m^2, and the corresponding coefficient of variation is 13.96%.

Taking into account the quality of the flats (their rating), the standard deviation of their sale prices is 3.652 USD/m^2 per one rating point, with a coefficient of variation of 10.00%.

Finally, after excluding the extreme values, the standard deviation amounts to 0.497 USD/m^2 per one rating point, and the corresponding coefficient of variation equals 2.70%.

The reduction in the coefficient of variation from 13.96% to 2.70% indicates that this apartment valuation methodology adequately accounts for the significant price-forming factors, and the results obtained based on its application are reliable.

The possibilities of applying the cost approach to determine the most probable sale prices of flats on the secondary housing market are extremely limited. The secondary market offers flats constructed at different times (before the First World War, between the two World Wars, and in recent years), using various technologies and materials. All these factors significantly complicate the application of the cost approach to their valuation.

Unfinished buildings, as a rule, are appraised using the cost approach. In practice, the following sequence for the valuation of unfinished construction projects using this method is quite common (Table 10).

Table 10. Valuation of an Unfinished Food-Processing Complex, USD

Indicator	Costs incurred in creating the object	Construction readiness, %	Future costs	Accepted for valuation calculations
Design and land allocation	11,015	10	–	11,015
Value of the land plot	21,138	–	–	21,138
Engineering preparation and site improvements	15,794	80	3,159	12,635
Construction				
Stage 1	177,917	10	–	177,917
Stage 2	167,000	38	103,540	63,460
Stage 3	111,638	–	111,638	–
Financial servicing (loan interest)	49,824	–	49,824	–
Management and marketing (consulting and legal services)	24,875	–	13,246	11,629
Local charges	5,950	–	-	5,950
TOTAL	585,150	–	281,406	303,744
Building materials	–	–	–	6,526
Uninstalled equipment	–	–	–	51,313
Accounts receivable	–	–	–	5,400
Accounts payable	–	–	–	6,813
OVERALL TOTAL	–	–	–	360,170

As a result of the conducted study, it has been established that buildings are valued using the same methods as land plots, namely, i.e. the income capitalisation approach, the sales comparison approach, and the cost approach. At the same time, a significant distinction is emphasised between buildings, which have a finite economic life, and land plots, which do not. Consequently, the income capitalisation approach is applied as a method of discounting future cash flows generated by the valuation object over its period of useful economic life.

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Discussion and Conclusions

Valuation of real estate as collateral is a key stage in securing financial obligations, particularly when loans are granted. A well-grounded valuation of real property used as collateral enables banks and other financial institutions to determine the true value of the pledged asset, thereby reducing credit risks and enhancing the financial security of the creditor. Conducting an independent expert valuation ensures objectivity in determining the value of real estate and contributes to transparency in credit relations.

On the basis of the study conducted, the following conclusions can be drawn:

1. The research carried out has shown that fluctuations in macroeconomic indicators, particularly gross domestic product, household incomes and exchange rates, directly influence the formation of property prices in Ukraine. Over the past two decades, the Ukrainian economy has experienced several periods of crisis, accompanied by significant fluctuations in nominal GDP both in the national currency and in USD. The most substantial declines in economic indicators were observed in 2009, 2014–2015 and 2022, resulting from the global financial crisis, military hostilities in the eastern part of the country, and the full-scale invasion, respectively.
2. The analysis of real estate market developments in Ukraine and the member states of the European Union demonstrates that housing prices are shaped by a complex interaction of economic, social, demographic and spatial factors. The spatial and temporal dynamics of property values reflect the overall condition of the economy, currency stability and investor confidence. In Ukraine, the property market over the past three decades has been characterised by considerable volatility and a high degree of dependence on macroeconomic and political processes. Historical fluctuations in the exchange rate, financial crises and periods of military conflict have caused sharp changes in housing prices, both in the national currency and in US dollars. The most significant declines were recorded in 1998, 2008, 2014–2015 and 2022, while periods of stabilisation were accompanied by strong growth in prices and demand. Comparison with EU countries shows that the Ukrainian property market is significantly more vulnerable to external and internal shocks. Whereas most EU countries have shown steady price growth since 2016, the Ukrainian market has remained unstable owing to political uncertainty and reduced investment activity. Objective valuation of real estate is not only a prerequisite for fair market relations but also an essential instrument for minimising credit risk in the banking sector.
3. The results of the regression and correlation analysis confirm that macroeconomic indicators exert a statistically significant influence on real estate price dynamics in Ukraine, with 92.6% of the variance in property prices explained by fluctuations in nominal GDP and the exchange rate. A 1% increase in nominal GDP results in an average property price appreciation of approximately 1.14%, substantiating the robust positive impact of economic growth on the real estate market. Conversely, a 1% increase in the exchange rate (denoting a devaluation of the Hryvnia) is associated with a price contraction of approximately 0.48%. Thus, these findings validate hypothesis H1: that macroeconomic indicators – specifically GDP and the exchange rate – are statistically significant determinants of real estate price trends in Ukraine.

   However, the study is subject to several limitations. First, the current model incorporates only two macroeconomic factors – nominal GDP and the exchange rate – which, while accounting for 92.6% of price variance, omit other potentially relevant drivers. Factors such as demographic shifts, employment levels, residential construction volumes, and commercial banking credit policies were not examined within the scope of this research. Second, the reliance on aggregated macroeconomic data may mask significant regional heterogeneities and idiosyncratic market behaviours across different geographical areas of Ukraine.
4. The problem of non-performing loans (NPLs) is one of the key threats to the stability of banking systems both in Ukraine and worldwide. Analysis of NPL dynamics shows that financial crises significantly increase the share of distressed loans in banks' credit portfolios, reducing their liquidity and their ability to lend to the real sector of the economy. Ukraine is characterised by an exceptionally high level of non-performing loans, which reached 55% in 2018 and remains among the highest in Europe. The main causes of this include shortcomings in the legislative framework governing creditor rights protection, poor standards of assessing borrowers' creditworthiness,

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and the widespread practice of lending to related parties. These factors led to the bankruptcy of numerous banks and substantial financial losses for the state. The outbreak of full-scale invasion in 2022 halted the previously positive trend of decreasing the NPL share, triggering a new wave of borrower defaults and pushing the level of problematic loans to 38% as of early 2023. The increase in the volume of NPLs adversely affects the resilience of the banking sector, reduces lending activity and undermines depositor confidence.

5. The empirical results identify a significant correlation between the trajectory of non-performing loans (NPLs) in the Ukrainian banking system, their lagged values, and fluctuations in the real estate market. The econometric model demonstrates robust explanatory power, with the specified variables accounting for 89.3% of the variance in NPL levels. It was established that a 1% increase in the NPL ratio in the preceding period results in an average 0.58% rise in the current level, confirming the inherent path dependency and inertia of asset quality trends. Simultaneously, a 1% appreciation in real estate prices in the prior period is associated with an approximate 0.52% increase in NPLs. These findings validate hypothesis H2: that NPL levels in the Ukrainian banking sector are substantially influenced by both historical inertia and property market volatility.

   Despite these findings, the study is subject to certain constraints. First, the models utilise aggregate sector-wide data, which may mask significant disparities between individual financial institutions or specific credit segments.
6. Macroeconomic determinants – notably the exchange rate, lending dynamics, the level of economic development, and the level of non-performing loans in the previous period – have a significant impact on the level of NPLs in Ukraine, which is an important indicator of the level of credit risk and the stability of the Ukrainian banking system. The model accounts for 91.1% of the observed variance through the incorporated factors. The results highlight pronounced inertia: a 1% increase in the NPL level in the preceding period results in a 1.33% rise in the current level. Furthermore, a 1% acceleration in credit growth is accompanied by a 2.49% increase in NPLs, suggesting a marked intensification of credit risk during phases of aggressive lending activity. At the same time, the correlation analysis reveals that a 1% devaluation of the national currency (currency depreciation) is associated with a 0.87% reduction in the NPL level. This inverse relationship may be attributed to banks adopting more conservative lending postures during periods of currency volatility, thereby reducing exposure to high-risk segments. Additionally, a natural contraction in demand for foreign-currency-denominated loans typically occurs during such periods, temporarily lowering the NPL share within the total portfolio structure. Furthermore, a 1% increase in GDP per capita is associated with a 0.75% rise in the NPL ratio. This positive correlation can be explained by the fact that economic growth stimulates increased lending, including high-risk loans, which temporarily raises the proportion of NPLs in banks' overall portfolios. In other words, during periods of economic recovery, banks lend more actively, and some of these loans may turn into NPLs, particularly in the high-risk borrower segment. The results of the multiple regression analysis confirm hypothesis H3: macroeconomic factors, in particular the exchange rate, lending dynamics and the level of economic development, have a significant impact on the formation of credit risk and the stability of Ukraine's banking system.

   The limitations of the study are as follows: the model employs a circumscribed set of macroeconomic variables and does not account for political, regulatory, or industry-specific factors that may influence NPL levels. Further, as the study is predicated on historical data, it assumes that past correlations will persist into the future – an assumption that may diminish predictive accuracy during periods of exogenous economic shocks.
8. Effective resolution of the non-performing loan problem requires a comprehensive approach: improvement of legislation, strengthened oversight of high-risk lending, enhanced borrower assessment standards and the development of debt restructuring mechanisms. A crucial component of credit risk mitigation remains the availability of sufficient collateral for loans, primarily in the form of real property, which contributes to improving the financial stability of the banking system.
9. The study of valuation methods for income-producing and non-income-producing buildings has made it possible to identify patterns that ensure sound and reliable results of expert monetary valuation of real property:

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- The income capitalisation approach is the principal method for valuing income-producing assets. Its application makes it possible to account for future cash flows, inflationary processes and the risks associated with the use of the building. The results of the calculations for the warehouse building indicated an expert value of around 288 thous. USD, which aligns with the expected market return.
- The sales comparison approach confirmed the results obtained using the income capitalisation approach. The expert value of the property was determined at approximately 299 thous. USD, differing from the previous result by less than 4%. Statistical and mathematical verification demonstrated the high reliability of the valuation and the adequacy of the price-forming factors taken into consideration. The evaluation of real estate valuation outcomes using the sales comparison approach confirms that the application of statistical metrics, such as standard deviation and the coefficient of variation, significantly enhances appraisal reliability. By accounting for fundamental value-driving factors and excluding outliers within adjusted price sets, the dispersion of indicators is markedly reduced, yielding a more robust valuation. Consequently, hypothesis H4 is substantiated.
- The cost approach produced a significantly lower valuation, approximately 245 thous. USD, which is explained by the fact that market demand for such buildings substantially exceeds the costs of reproducing them. This confirms the limited applicability of this method for market valuation of income-producing buildings and reinforces its role as an auxiliary method or one suitable primarily for specialised structures.

  Comparison of the valuation results obtained using the three methods indicates that the most objective value is that determined using the income capitalisation approach, supported by the findings of the comparative analysis. This is the value that should be adopted as the baseline when determining the market value of the object. However, it must be borne in mind that when determining the mortgage (collateral) value of a warehouse building for lending purposes, a downward adjustment of 10–15%, and in some cases even 20%, should be applied. This approach is necessitated by the requirement to ensure lending security, specifically by mitigating risks associated with declining asset liquidity, market volatility, and the potential costs of collateral disposal in the event of a credit default.

9. For non-income-producing buildings (such as residential flats), the principal method remains the sales comparison approach, preceded by a qualitative assessment using the factor-based scoring system. The developed scoring methodology makes it possible to incorporate the influence of the objective characteristics of the property on its market price and ensures a high degree of reliability in the results. The cost approach has limited applicability for residential property because of the considerable heterogeneity of objects on the secondary market, but it may be effective for valuing unfinished construction or specialised buildings.

Based on the findings of the research, it can be stated that the combined application of the income capitalisation approach, the sales comparison approach, and the cost approach enhances the accuracy, objectivity and reliability of expert monetary valuation of real estate. The most effective is a combined approach, in which the principal method is corroborated by an auxiliary method, while statistical techniques are employed to verify the reliability of the results.

The originality of this study resides in its holistic approach to analysing the nexus between macroeconomic indicators, real estate market dynamics, and NPL levels within the Ukrainian banking sector. By integrating regression and correlation analyses, the research evaluates both the inertial effects of historical NPL levels and the influence of exogenous economic factors on credit risk. Moreover, the study incorporates the unique structural characteristics of the Ukrainian real estate and banking markets, ensuring the findings are highly pertinent to domestic credit appraisal frameworks and financial stability forecasting.

Future research should focus on a multifaceted assessment of credit risk within Ukrainian banks, incorporating variables such as loan portfolio quality, regulatory capital requirements for NPLs, and loan loss provisioning. Additionally, investigations should address the prevalence of related-party lending, the degree of loan portfolio dollarisation, and concentration risks within specific asset segments, alongside a deeper analysis of real estate price determinants. Subsequent studies may also employ spatial econometric modelling and expanded longitudinal datasets to quantify systemic risk in the Ukrainian banking sector. Such an approach will facilitate a deeper understanding of the inter-

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play between real estate market development and financial stability, enabling a comparative statistical analysis between the Ukrainian context and European Union member states to identify diverging credit risk determinants.

The contribution of the authors

Conceptualisation, N.W., M.W., N.D. and O.P.; literature review, M.W., N.W., O.P. and N.D.; methodology, N.W., M.W., O.P. and N.D.; formal analysis, N.W., M.W., N.D. and O.P.; writing, N.W., M.W., O.P. and N.D.; discussion and conclusions, N.W., M.W., N.D. and O.P.

The authors have read and agreed to the published version of the manuscript.

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WYCENA NIERUCHOMOŚCI JAKO NARZĘDZIE ZARZĄDZANIA RYZYKIEM BIZNESOWYM W WARUNKACH NIESTABILNOŚCI GOSPODARCZEJ

STRESZCZENIE: Celem badania jest analiza zależności między wskaźnikami makroekonomicznymi, dynamiką rynku nieruchomości oraz poziomem kredytów zagrożonych w systemie bankowym Ukrainy w latach 2006-2023, a także opracowanie kompleksowego podejścia metodycznego do określania wartości zabezpieczenia nieruchomości. Metodologia badania opiera się na zastosowaniu analizy regresji i korelacji, której wyniki wykazały, że 92,6% zmian cen nieruchomości jest wyjaśniane dynamiką nominalnego PKB oraz kursu walutowego, natomiast poziom NPL w 91,1% zależy zarówno od wewnętrznej inercji tego wskaźnika, jak i od czynników makroekonomicznych uwzględnionych w skonstruowanym modelu. W artykule omówiono główne metody wyceny nieruchomości – metodę kapitalizacji dochodu, metodę porównawczą oraz metodę kosztową. Uzyskane wyniki wskazują, że kompleksowe zastosowanie trzech podstawowych metod wyceny zwiększa dokładność określania wartości nieruchomości. Oryginalność badania polega na kompleksowej analizie zależności między czynnikami makroekonomicznymi, cenami nieruchomości oraz poziomem kredytów zagrożonych w systemie bankowym Ukrainy. Opracowane modele o wysokiej zdolności wyjaśniającej mogą być wykorzystane do prognozowania dynamiki cen nieruchomości, jak również zmian ryzyka kredytowego w sektorze bankowym.

SŁOWA KLUCZOWE: wycena nieruchomości, metody wyceny nieruchomości, kredyt zagrożony, rynek nieruchomości

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