

“International housing finance projects and mortgage-market development in Central Asia with implications for housing affordability”

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INTERNATIONAL HOUSING FINANCE PROJECTS AND MORTGAGE-MARKET DEVELOPMENT IN CENTRAL ASIA WITH IMPLICATIONS FOR HOUSING AFFORDABILITY

Abstract

Housing affordability and mortgage-market development remain important challenges in Central Asia, where long-term housing finance is constrained by differences in financial-system development, borrowing costs, household incomes, and institutional capacity. This study examines the relationship between international housing-finance interventions and mortgage-market development in Kazakhstan, Uzbekistan, and the Kyrgyz Republic over 2020–2025. Using 18 country-year observations, the analysis combines the Mortgage-to-GDP ratio and outstanding mortgage portfolios with two indicators of international financial activity: IFI Finance and IFI Projects. Real interest rates, inflation, and real GDP growth are included as macro-financial controls, while Price-to-Income and Mortgage Burden provide supplementary measures of housing affordability. The empirical analysis employs descriptive statistics, Pearson correlations, pooled OLS regressions with lagged and contemporaneous IFI variables, diagnostic tests, and HC3 heteroskedasticity-consistent inference. The results do not provide stable evidence of a significant association between IFI-supported activity and Mortgage-to-GDP. Lagged IFI Projects are significant only in one specification and lose significance under HC3 estimation, while neither contemporaneous IFI variable is significant. In contrast, real interest rates show more consistent positive associations with mortgage-market depth, while the relationship with real GDP growth requires caution because GDP is the denominator of the dependent variable. Mortgage Burden is associated with Mortgage-to-GDP, whereas evidence for Price-to-Income is weaker. The findings indicate that international housing-finance interventions should be interpreted alongside domestic macro-financial and institutional conditions rather than as independent determinants of mortgage-market development.

Keywords

housing, affordability, mortgages, investments, projects, Central Asia

JEL Classification

G21, R21, R31

INTRODUCTION

Housing affordability and mortgage-market development remain important policy issues in Central Asia. Kazakhstan, Uzbekistan, and the Kyrgyz Republic face sustained housing demand, differences in household incomes and financial-system development, and constraints on housing supply. Residential floor space per capita also varies substantially, reaching 24.5 m² in Kazakhstan, 18.9 m² in Uzbekistan, and 12.7 m² in the Kyrgyz Republic in early 2025. Differences in demographic, income, financial-inclusion, and institutional conditions further shape access to formal housing finance (Bureau of National Statistics of the Republic of Kazakhstan, 2025; Statistics Agency under the President of the Republic of Uzbekistan, 2025; National Statistical Committee of the Kyrgyz Republic, 2025).

The three Central Asian countries are selected as the core study group because they represent distinct mortgage-market and institutional conditions within the region and provide comparable country-year data for 2020–2025. To provide an external benchmark, the supplementary analysis includes Poland, Germany, Spain, Czechia, and Romania. These European countries provide reference points across different levels of mortgage-market depth, lending conditions, housing prices, and affordability outcomes.

Mortgage finance connects household housing access with financial intermediation and economic development. Its expansion depends on borrowing costs, household income, housing prices, and the availability of long-term funding. In emerging economies, limited domestic capacity to provide long-term housing finance creates an additional role for international financial institutions (IFIs), which may provide funding and support financial-market development. In Central Asia, IFI-supported housing-finance projects involve defined financing commitments, implementation periods, and institutional counterparts, making implementation timing and institutional capacity relevant to their potential contribution to mortgage-market development.

Despite growing research on mortgage markets and housing affordability, limited longitudinal evidence examines the relationship between IFI-supported housing-finance activity and mortgage-market development in Central Asia. In particular, the scale and number of IFI-supported projects have received limited empirical attention alongside macro-financial and housing-affordability conditions. The timing of international interventions is also relevant because project-based financing may affect mortgage-market outcomes with a lag.

Against this background, this study examines the relationship between international housing-finance interventions and mortgage-market development in Kazakhstan, Uzbekistan, and the Kyrgyz Republic over 2020–2025. Using 18 country-year observations, the study measures mortgage-market development primarily through the Mortgage-to-GDP ratio, with the outstanding mortgage portfolio as a complementary indicator. IFI Finance and IFI Projects capture the scale and extent of international financial activity, while real interest rates, inflation, and real GDP growth serve as macro-financial controls. Price-to-Income and Mortgage Burden are used as supplementary affordability indicators. The empirical analysis combines descriptive statistics, correlation analysis, multivariate OLS regression, diagnostic tests, and HC3 robustness checks, including both lagged and contemporaneous IFI specifications.

The study makes three contributions. First, it provides longitudinal comparative evidence on IFI-supported housing-finance activity and mortgage-market development in Central Asia. Second, it distinguishes between the financial scale of IFI support and the number of supported projects while accounting for macro-financial conditions. Third, it examines mortgage-market development together with complementary housing-affordability indicators, linking international housing-finance interventions with broader mortgage-market outcomes.

1. LITERATURE REVIEW AND HYPOTHESES

The literature on mortgage-market development increasingly treats housing finance as an interconnected system in which mortgage lending, housing affordability, macroeconomic conditions, financial intermediation, and institutional infrastructure jointly determine market outcomes. Filotto et al. (2018), using evidence from European countries, demonstrate that residential mortgage lend-

ing is closely associated with housing-market conditions and economic growth, while Adelino et al. (2018) emphasize the two-way interaction between housing and mortgage markets and financial stability. Cho (2007) conceptualizes a well-functioning mortgage intermediation system around three complementary dimensions—intermediation efficiency, affordability enhancement, and risk management—arguing that the sequencing of institutional development is particularly important for emerging mortgage markets. Renaud (2008) simi-

larly identifies persistent structural constraints in developing mortgage markets and emphasizes that institutional arrangements, funding mechanisms, and market infrastructure condition the feasible development path of housing finance. These studies establish that mortgage-market development cannot be adequately assessed through lending volumes alone; it depends on the interaction between financial intermediation, affordability, risk management, and institutional capacity.

A substantial strand of the literature focuses specifically on housing affordability and the conditions under which households can access mortgage finance. Squires and Webber (2019) show that changes in housing affordability during and after the global financial crisis varied considerably across regions, suggesting that mortgage rates alone cannot explain affordability outcomes. McCord et al. (2011) demonstrate that the post-crisis affordability problem can shift from house-price affordability toward constraints associated with deposits and mortgage liquidity, illustrating the importance of financing conditions in determining effective access to housing. Szumilo and Vanino (2021) provide causal evidence that improving mortgage affordability through equity-loan support can relax household liquidity constraints and generate broader economic effects. Radzinski (2014), examining subsidized mortgage lending in Poland, likewise demonstrates the role of public intervention in improving access to housing finance, particularly where house prices and household incomes create affordability constraints. Owusu-Manu et al. (2018) extend this perspective to Ghana, identifying economic, financial, property-market, and geographical factors as important determinants of mortgage price affordability. Together, these studies indicate that affordability is a multidimensional outcome shaped by prices, incomes, financing costs, down-payment requirements, and public support mechanisms rather than by mortgage interest rates alone.

Macroeconomic and monetary conditions constitute another central determinant of mortgage-market performance. Yiu (2023) shows that real interest-rate shocks can affect housing prices and affordability, while Everett et al. (2019) find that restrictive monetary-policy shocks reduce mortgage-lending growth and that prudential regu-

lation can influence the transmission of monetary conditions to mortgage markets. Filotto et al. (2018) similarly identify macroeconomic and housing-market variables as important determinants of mortgage development. Yates and Berry (2011) demonstrate that housing and mortgage markets can exhibit significant vulnerability during periods of economic turbulence, with affordability pressures particularly relevant for households with constrained incomes. These findings are complemented by Gete and Reher (2016), who show that loan-to-value policies affect the extensive margins of mortgage credit and involve a trade-off between broader access to homeownership and mortgage-default risk. Thus, the macro-financial environment should be incorporated into empirical assessments of mortgage-market development rather than treated merely as background conditions.

The literature further emphasizes the importance of lending standards and institutional risk management. Nield (2010) discusses the tension between expanding access to low-cost homeownership and maintaining responsible lending and borrowing practices. Benetton et al. (2017) show that differences in mortgage-risk specialization can emerge from regulatory capital frameworks, while Spilbergs (2020) identifies borrower, loan, housing-market, and macroeconomic factors associated with mortgage delinquency. Ozturkkal and Wahlstrøm (2025) further demonstrate the relevance of loan-specific and macroeconomic characteristics for mortgage-default prediction in an emerging-market context. These findings reinforce the importance of considering credit risk when evaluating mortgage-market expansion. At the same time, mortgage collateral and valuation constitute an important component of this institutional framework. Bienert and Brunauer (2007) emphasize the need for risk-sensitive approaches to mortgage lending value and collateral valuation, while López Gómez and Matea (2020) demonstrate that mortgage-appraisal systems differ substantially across countries in terms of methodological standards, certification, reporting, and supervisory arrangements.

Institutional infrastructure is particularly important in emerging mortgage markets, where limited access to long-term funding can constrain

the expansion of mortgage lending. Chiquier et al. (2004) show that emerging housing-finance systems are frequently constrained by credit, liquidity, and interest-rate risks and argue that mortgage securities can provide access to longer-term capital-market funding. However, they emphasize that successful mortgage securitization requires an established primary mortgage market, standardized lending and servicing practices, reliable property appraisal, and an adequate legal and regulatory framework. Hassanein and El-Barkouky (2008), examining Egypt, identify inefficient property registration, high mortgage rates, the absence of a developed secondary market, and limited credit-enhancement instruments as major constraints on mortgage-market development. Their analysis also illustrates how institutional innovations such as liquidity facilities can support the development of housing finance. Ballesteros and Dulay (2013) similarly show that mortgage-backed securitization in an emerging market requires appropriate regulation, underwriting, valuation, credit information, and servicing infrastructure. These findings are consistent with the broader institutional perspective of Cho (2007), Renaud (2008), and Sirenko et al. (2023), who emphasize that mortgage-market development depends on the interaction of funding capacity, regulatory arrangements, market transparency, and government-supported programs.

The European and Central Asian context provides an especially relevant institutional reference for the present study. The World Bank (2013) identifies mortgage portfolio dynamics, mortgage funding, macroprudential supervision, prudent loan-level lending, consumer protection, mortgage securitization, and regional funding arrangements as interconnected components of housing-finance policy in Europe and Central Asia. Ganbarov et al. (2020), focusing on Azerbaijan, further demonstrate how state influence, construction-sector risks, social objectives, and financial conditions interact in the sustainable development of an emerging mortgage market. These findings are complemented by Luque (2020), who demonstrates that bank capitalization and funding costs influence the geographic allocation of residential mortgage lending during financial stress. This institutional perspective is particularly relevant to Kazakhstan, Uzbekistan, and the Kyrgyz Republic, where mortgage-market development

occurs within emerging financial systems and where long-term funding and institutional capacity remain important considerations.

Long-term funding and secondary-market development also connect mortgage-market expansion with broader financial-system development. Chiquier et al. (2004), Hassanein and El-Barkouky (2008), and Ballesteros and Dulay (2013) demonstrate that secondary-market mechanisms can diversify funding sources and potentially increase the availability of long-term housing finance. Fei (2010) examines the application of option-pricing approaches to emerging mortgage and mortgage-backed securities markets, highlighting the importance of mortgage characteristics, borrower risk attitudes, and institutional conditions for risk valuation. Buckley et al. (2003) similarly examine mortgage credit-risk policies from an institutional perspective. These studies suggest that the expansion of mortgage lending is partly dependent on the ability of financial systems to mobilize and manage long-term capital.

Several studies extend the literature toward social, environmental, and alternative dimensions of housing finance. Reuschke and MacLennan (2014) link housing assets and mortgage-related wealth to small-business investment, indicating that housing finance can generate effects beyond residential consumption. Adegoke et al. (2024) emphasize transparency, equitable access, and regulatory oversight in mortgage lending. Basu et al. (2022) examine the relationship between bank ESG disclosures and the geographic distribution of mortgage lending, while Fernández et al. (2025) identify tensions between ESG-finance requirements, social housing, and decarbonization objectives. Hamilton et al. (2016) consider the role of energy performance in mortgage lending, whereas Hanif (2019) and Asadov (2022) examine alternative Islamic mortgage structures and their implications for risk sharing and resilience. These studies broaden the understanding of mortgage-market sustainability, although they are secondary to the macro-financial and institutional determinants examined in the present study.

Recent technological studies provide additional evidence on mortgage-market risk management but are less directly connected to the present empirical framework. Nica et al. (2021), Chang and

Koss (2019), and Meer (2021) demonstrate the potential of machine-learning and digital tools for mortgage valuation, market surveillance, and default prediction. Courchane et al. (2013) similarly examine the relationship between underwriting standards, loan products, and mortgage performance. While these contributions demonstrate the growing importance of data-driven mortgage management, they do not directly address the macro-level relationship between international housing-finance interventions and mortgage-market development.

Overall, the literature establishes that mortgage-market development is shaped by a combination of macroeconomic conditions, interest rates, housing affordability, credit standards, LTV constraints, institutional capacity, and access to long-term funding. Existing studies provide substantial evidence from Europe, North America, and selected emerging markets, while the World Bank (2013) provides a broader policy framework for Europe and Central Asia. However, the literature remains comparatively limited in examining whether the scale and timing of internationally supported housing-finance interventions are systematically associated with mortgage-market development across Central Asian economies. In particular, there is limited longitudinal cross-country evidence linking IFI-supported housing-finance activity with mortgage-market development while simultaneously controlling for real interest rates, inflation, and economic growth. This gap motivates the present study, which examines Kazakhstan, Uzbekistan, and the Kyrgyz Republic over 2020–2025 and evaluates mortgage-market development using the mortgage-to-GDP ratio while treating housing affordability measures as complementary outcomes. The approach therefore connects the institutional literature on housing-finance development with empirical evidence on macro-financial conditions and affordability in Central Asian mortgage markets.

The aim of this study is to examine the relationship between international housing-finance interventions and mortgage-market development in Kazakhstan, Uzbekistan, and the Kyrgyz Republic during 2020–2025, accounting for macro-financial conditions and supplementary housing-affordability indicators.

Based on this literature, the study tests the following hypotheses:

- H1: Greater IFI-supported housing-finance activity is positively associated with mortgage-market development in some Central Asian economies.*
- H2: The positive association between IFI-supported housing-finance activity and mortgage-market development persists after controlling for major macro-financial conditions.*
- H3: Mortgage-market development is significantly associated with housing-affordability conditions, measured by the Price-to-Income Ratio and Mortgage Burden.*

The hypotheses are formulated around observable relationships in the available country-year dataset.

2. RESEARCH METHODOLOGY

This study uses a quantitative comparative design to examine the relationship between international housing-finance interventions and mortgage-market development in Kazakhstan, Uzbekistan, and the Kyrgyz Republic during 2020–2025.

The unit of analysis is the country-year observation, yielding 18 observations. All mortgage-market, IFI, macro-financial, and housing-affordability variables are measured at the national level. The dependent variable is the Mortgage-to-GDP ratio. The main explanatory variables are IFI Finance and IFI Projects. Real interest rates, inflation, and real GDP growth are included as macro-financial controls, while Price-to-Income and Mortgage Burden capture housing-affordability conditions.

Data were compiled from national statistical authorities, central banks, the Asian Development Bank (ADB, 2025), the European Bank for Reconstruction and Development (EBRD, 2025), the International Monetary Fund (IMF, 2026), and publicly available commercial-bank information.

The empirical analysis includes descriptive statistics, Pearson correlation analysis, and multivari-

ate OLS regression. Models 1-4 use one-period lagged IFI variables and progressively introduce macro-financial controls and alternative affordability measures. Model 5 uses contemporaneous IFI variables to assess sensitivity to intervention timing. Model diagnostics include variance inflation factors (VIF), the Breusch-Pagan test, Shapiro-Wilk and Jarque-Bera tests, and the Durbin-Watson statistic. HC3 heteroskedasticity-consistent standard errors are additionally used as a robustness check.

2.1. Measurement of mortgage-market development

Mortgage-market development is measured by the outstanding mortgage portfolio and the mortgage-to-GDP ratio. The latter is the principal dependent variable and captures mortgage-market depth relative to the size of the economy.

The mortgage-to-GDP ratio is calculated as:

$$\frac{\text{Mortgage}}{\text{GDP}_{it}} = \frac{\text{OMP}_{it}}{\text{GDP}_{it}} \cdot 100, \quad (1)$$

where OMP_{it} denotes the outstanding mortgage portfolio, and GDP_{it} represents gross domestic product for country i in year t .

2.2. International financial support and project activity

International financial intervention is represented by two variables: IFI Finance and IFI Projects. IFI Finance measures the total financing amount associated with IFI-supported housing-finance projects. The reference year is the project completion year, deliberately selected because the associated project financing had been fully utilized by project completion. IFI Projects measures the number of IFI-supported housing-finance projects completed in each year. This timing convention avoids assigning the full project-level financing amount to an earlier approval or commitment year, when the financing had not yet been fully realized. Nevertheless, the measure does not represent annual disbursements and therefore should be interpreted as a project-level indicator of the financial scale of completed interventions.

IFI Finance captures the financial scale of international support, whereas IFI Projects captures the number of completed projects. To account for a potential time lag between project completion and mortgage-market outcomes, Models 1-4 use one-period lagged IFI variables ($\text{IFI Finance}_{i,t-1}$ and $\text{IFI Projects}_{i,t-1}$), while Model 5 uses contemporaneous IFI variables to assess sensitivity to intervention timing.

2.3. Macroeconomic and housing-affordability variables

The regression analysis controls for three macro-financial variables: real interest rate, inflation, and real GDP growth, capturing borrowing costs, price dynamics, and economic activity.

Housing affordability is measured by Price-to-Income and Mortgage Burden. Price-to-Income captures housing prices relative to household income, while Mortgage Burden measures the share of household income required to service mortgage debt. The two indicators are included separately rather than combined into a composite index.

2.4. Housing affordability indicators

To complement the longitudinal regression analysis, housing affordability is assessed using the Price-to-Income Ratio (PIR) and Mortgage Burden (MB). These indicators provide supplementary measures of housing affordability and the estimated mortgage-payment burden relative to household income.

2.4.1. Price-to-Income (PIR)

The PIR measures housing price relative to annual household income and indicates the number of annual household incomes required to purchase a residential property. In this study, PIR is calculated by the authors using housing-price and household-income data obtained from Numbeo:

$$\text{PIR}_{it} = \frac{\text{House price}_{it}}{\text{Annual Household Income}_{it}}, \quad (2)$$

where House Price_{it} denotes the residential property price, and $\text{Annual Household Income}_{it}$ represents annual household income for country i in year t .

2.4.2. Mortgage Burden (MB)

The MB measures the estimated mortgage payment relative to household income. In this study, MB is calculated by the authors using mortgage-payment and household-income information obtained from Numbeo:

$$MB_{it} = \frac{\text{Monthly Mortgage Payment}_{it}}{\text{Monthly Household Income}_{it}} \cdot 100, \quad (3)$$

where *Monthly Mortgage Payment_{it}* represents the monthly mortgage payment, and *Monthly Household Income_{it}* represents monthly household income. The monthly mortgage payment is derived from the estimated monthly mortgage payment for a standardized 90 m² dwelling, assuming 100% mortgage financing over a 20-year term. The dwelling price is based on the average price per square meter in the city center and outside the city center. Household disposable income is calculated as 1.5 times the average monthly net salary, consistent with the Numbeo methodology. MB is expressed as a percentage of monthly household disposable income; therefore, values above 100% indicate that the estimated monthly mortgage payment exceeds the standardized household disposable income under the assumed mortgage conditions. This indicator is a standardized national-level affordability estimate rather than a borrower-level debt-to-income (DTI) ratio.

2.5. Econometric specification

The principal dependent variable is the mortgage-to-GDP ratio. The baseline specification is:

$$MGDP_{it} = \alpha + \beta_1 IFIFinance_{i,t-1} + \beta_2 IFIProjects_{i,t-1} + \varepsilon_{it}. \quad (4)$$

This constitutes Model 1.

Model 2 adds the macro-financial controls:

$$MGDP_{it} = \alpha + \beta_1 IFIFinance_{i,t-1} + \beta_2 IFIProjects_{i,t-1} + \beta_3 RIR_{i,t} + \beta_4 INF_{i,t} + \beta_5 GDP_{i,t} + \varepsilon_{it}. \quad (5)$$

Model 3 adds Price-to-Income:

$$MGDP_{it} = \alpha + \beta_1 IFIFinance_{i,t-1} + \beta_2 IFIProjects_{i,t-1} + \beta_3 RIR_{i,t} + \beta_4 INF_{i,t} + \beta_5 GDP_{i,t} + \beta_6 PIR_{i,t} + \varepsilon_{it}. \quad (6)$$

Model 4 instead adds Mortgage Burden:

$$MGDP_{it} = \alpha + \beta_1 IFIFinance_{i,t-1} + \beta_2 IFIProjects_{i,t-1} + \beta_3 RIR_{i,t} + \beta_4 INF_{i,t} + \beta_5 GDP_{i,t} + \beta_6 MB_{i,t} + \varepsilon_{it}. \quad (7)$$

Finally, Model 5 replaces the lagged IFI variables with contemporaneous measures while retaining the same macro-financial controls:

$$MGDP_{it} = \alpha + \beta_1 IFIFinance_{i,t} + \beta_2 IFIProjects_{i,t} + \beta_3 RIR_{i,t} + \beta_4 INF_{i,t} + \beta_5 GDP_{i,t} + \varepsilon_{it}. \quad (8)$$

Models 1-4 use 15 observations because the one-period lag removes the first year of each country series. Model 5 uses the complete 18 observations because contemporaneous IFI variables are used.

2.6. Diagnostic and robustness procedures

Model diagnostics include variance inflation factors (VIF) for multicollinearity, the Breusch-Pagan test for heteroskedasticity, Shapiro-Wilk and Jarque-Bera tests for residual normality, and the Durbin-Watson statistic for first-order serial correlation.

Given the small sample, HC3 heteroskedasticity-consistent standard errors are used as an additional robustness check. Model 5 provides a timing-sensitivity assessment by replacing lagged IFI variables with contemporaneous measures and using all 18 observations.

The estimated coefficients are interpreted as conditional associations rather than causal effects given the limited sample and country-year design. Because the pooled OLS specification does not include country-specific effects, the estimated coefficients may reflect a combination of between-country differences and within-country changes over time.

3. RESULTS

This section presents the empirical findings for Kazakhstan, Uzbekistan, and the Kyrgyz Republic over the 2020–2025 period. The analysis proceeds from descriptive statistics and Pearson correlation analysis to multivariate OLS regression results and diagnostic tests. The final subsection provides supplementary cross-country evidence on mortgage-market conditions, macroeconomic dynamics, residential property prices, and housing affordability across selected Central Asian and European countries.

3.1. Descriptive statistics

Table 1 reports descriptive statistics for the variables used in the analysis. The dataset comprises 18 country-year observations for Kazakhstan, Uzbekistan, and the Kyrgyz Republic over 2020–2025.

The mean Mortgage-to-GDP ratio is 3.704%. IFI Finance has a mean of US\$40.102 million and a median of zero, while IFI Projects has a mean of 0.333 and a median of zero, indicating that IFI-supported housing-finance activity is concentrat-

ed in a limited number of country-year observations. The real interest rate and inflation average 12.667% and 10.222%, respectively, while real GDP growth averages 5.383%. The mean Price-to-Income Ratio is 12.444, and the mean Mortgage Burden is 229.111.

3.2. Pearson correlation analysis

Table 2 presents the Pearson correlation coefficients for the variables included in the empirical analysis. Mortgage/GDP is positively correlated with the real interest rate ($r = 0.761$) and inflation ($r = 0.403$), while its correlations with IFI Finance ($r = 0.251$) and IFI Projects ($r = -0.008$) are relatively weak. Mortgage/GDP is negatively correlated with real GDP growth ($r = -0.581$), Price-to-Income ($r = -0.370$), and Mortgage Burden ($r = -0.175$).

The strongest correlations among the explanatory variables are observed between Price-to-Income and Mortgage Burden ($r = 0.926$), and between the real interest rate and inflation ($r = 0.720$). IFI Finance and IFI Projects are moderately positively correlated ($r = 0.644$). The strong correlation between the two affordability indicators is considered when specifying the regression models.

Table 1. Descriptive statistics

Variable	Mean	Median	Std. Dev.	Min	Max	N
Mortgage/GDP	3.704%	4.177%	0.922%	2.219%	4.594%	18
IFI Finance	40.102	0.000	90.586	0.000	350.800	18
IFI Projects	0.333	0.000	0.485	0.000	1.000	18
Real interest rate	12.667	13.750	3.374	5.000	18.000	18
Inflation	10.222	10.400	2.831	5.000	15.000	18
Real GDP growth	5.383	6.200	4.566	-7.100	11.500	18
Price-to-Income	12.444	14.050	3.327	7.600	15.900	18
Mortgage Burden	229.111	256.550	78.972	114.600	333.000	18

Table 2. Pearson correlation matrix

Variables	IFI Finance	IFI Projects	Mortgage/GDP	Real interest rate	Inflation	Real GDP growth	Price-to-Income	Mortgage Burden
IFI Finance	1.000	0.644	0.251	0.253	0.025	0.011	0.048	0.099
IFI Projects	0.644	1.000	-0.008	0.176	-0.114	-0.047	-0.079	-0.126
Mortgage/GDP	0.251	-0.008	1.000	0.761	0.403	-0.581	-0.370	-0.175
Real interest rate	0.253	0.176	0.761	1.000	0.720	-0.509	-0.275	-0.180
Inflation	0.025	-0.114	0.403	0.720	1.000	-0.317	-0.113	-0.130
Real GDP growth	0.011	-0.047	-0.581	-0.509	-0.317	1.000	0.033	0.277
Price-to-Income	0.048	-0.079	-0.370	-0.275	-0.113	0.033	1.000	0.926
Mortgage Burden	0.099	-0.126	-0.175	-0.180	-0.130	0.277	0.926	1.000

Notes: Pearson correlation coefficients based on 18 observations. Correlation coefficients measure pairwise linear association and do not imply causality.

3.3. Regression results

Table 3 reports five regression specifications with Mortgage/GDP as the dependent variable. Models 1-4 use one-period lagged IFI variables and therefore contain 15 observations, while Model 5 uses contemporaneous IFI variables and the full sample of 18 observations.

Model 1 provides the baseline specification with lagged IFI Finance and IFI Projects. Neither IFI variable is statistically significant, and the model has limited explanatory power ($R^2 = 0.099$; adjusted $R^2 = -0.051$).

Model 2 adds the real interest rate, inflation, and real GDP growth. Model fit improves substantially ($R^2 = 0.798$; adjusted $R^2 = 0.685$). The real interest rate is positively associated with Mortgage/GDP, whereas inflation and real GDP growth are negatively associated with

it. The lagged IFI variables remain statistically insignificant.

Model 3 adds Price-to-Income as an affordability indicator. The model explains 85.0% of the variation in Mortgage/GDP ($R^2 = 0.850$). Price-to-Income is not statistically significant, while the coefficients on the real interest rate, inflation, and real GDP growth remain statistically significant.

Model 4 instead includes Mortgage Burden. The model has $R^2 = 0.915$ and adjusted $R^2 = 0.851$. Lagged IFI Projects is positive and statistically significant, while lagged IFI Finance remains statistically insignificant. Mortgage Burden is also positively associated with Mortgage/GDP, while the real interest rate, inflation, and real GDP growth retain their respective signs and statistical significance.

Model 5 provides a parsimonious contemporaneous specification using the full 18-observation

Table 3. Regression results for mortgage/GDP

Variables	Model 1	Model 2	Model 3	Model 4	Model 5 (timing sensitivity)
IFI Finance (t-1)	0.00000713 (0.00003845)	0.00000307 (0.00002179)	-0.00002284 (0.00002528)	-0.00002734 (0.00001786)	-
IFI Projects (t-1)	0.00610 (0.00858)	0.00294 (0.00519)	0.00925 (0.00607)	0.00981** (0.00413)	-
IFI Finance	-	-	-	-	0.00000582 (0.00002221)
IFI Projects	-	-	-	-	-0.00221 (0.00424)
Real interest rate	-	0.00242** (0.000612)	0.00312*** (0.000697)	0.00271*** (0.000434)	0.00305*** (0.000702)
Inflation	-	-0.00175** (0.000889)	-0.00249** (0.000772)	-0.00207** (0.000485)	-0.00125 (0.000740)
Real GDP growth	-	-0.00215** (0.000877)	-0.00313*** (0.000916)	-0.00304*** (0.000594)	-0.000832** (0.000372)
Price-to-Income	-	-	0.00126 (0.000760)	-	-
Mortgage Burden	-	-	-	0.0000588*** (0.00001773)	-
Constant	0.03637*** (0.002824)	0.03839*** (0.01250)	0.02758* (0.01315)	0.02933** (0.00903)	0.01613** (0.00640)
Observations	15	15	15	15	18
R ²	0.099	0.798	0.850	0.915	0.671
Adjusted R ²	-0.051	0.685	0.737	0.851	0.534
F-statistic	0.663	7.099	7.540	14.311	4.892
Prob > F	0.5332	0.00594***	0.00592***	0.000687***	0.01135

Notes: Standard errors are reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Models 1-4 use one-period lagged IFI variables and 15 observations. Model 5 uses contemporaneous (non-lagged) IFI variables and 18 observations.

sample and excluding the two affordability indicators. The model has $R^2 = 0.671$ and adjusted $R^2 = 0.534$. Neither contemporaneous IFI Finance nor IFI Projects is statistically significant. The real interest rate remains positively associated with Mortgage/GDP, while real GDP growth is negatively associated with it; inflation is not statistically significant in this specification.

Overall, the results do not provide stable evidence of a statistically significant association between IFI-supported housing-finance activity and Mortgage/GDP across specifications. Lagged IFI Finance is insignificant in Models 1-4, while lagged IFI Projects is significant only in Model 4. In the contemporaneous Model 5, both IFI variables are statistically insignificant. The macro-financial controls, particularly the real interest rate, show more consistent associations across specifications. These results should be interpreted as conditional associations rather than causal effects given the small sample and pooled specification.

3.4. Regression diagnostics and robustness checks

Table 4 summarizes the diagnostic results across the five regression specifications. The Breusch-Pagan test indicates heteroskedasticity in Model 1 ($p = 0.0457$), while the null hypothesis of homoskedasticity is not rejected in Models 2-5 ($p > 0.05$). The Durbin-Watson statistics range from 0.627 to 2.193 across the five models.

The Shapiro-Wilk test rejects residual normality in Models 1 and 4 ($p < 0.05$), whereas the Jarque-Bera test indicates non-normal residuals only in Model 4. The VIF results show no severe multicollinearity in the revised specifications, with the highest VIF equal to 3.84 in Model 3 for Price-to-Income.

HC3 heteroskedasticity-consistent inference is reported separately in Table 5. The HC3 results indicate that the statistical significance of some coefficients changes relative to conventional OLS inference, particularly for inflation and real GDP growth. In the contemporaneous Model 5, the real interest rate remains statistically significant at the 1% level, while real GDP growth is significant at the 10% level; neither IFI Finance nor IFI Projects is statistically significant. Given the small sample size, these diagnostic and robustness results support a cautious interpretation of the estimated conditional associations.

3.5. Supplementary cross-country evidence on mortgage markets and housing affordability

To complement the regression analysis, this section provides descriptive cross-country evidence for the three Central Asian study countries and five European benchmark countries: Poland, Germany, Spain, Czechia, and Romania. The benchmark countries were selected to provide a broader range of mortgage-market depth, lending conditions, housing prices, and affordability outcomes for comparison with Central Asian markets.

Table 4. Regression diagnostics and robustness checks

Test / measure	Model 1	Model 2	Model 3	Model 4	Model 5
Variance Inflation Factor (VIF)					
IFI Finance	1.85	1.98	3.19	2.72	1.74
IFI Projects	1.85	2.25	3.70	3.01	1.82
Real interest rate	–	1.47	2.29	1.56	2.40
Inflation	–	1.68	2.50	1.74	1.88
Real GDP growth	–	1.68	2.85	2.11	1.24
Price-to-Income	–	–	3.84	–	–
Mortgage Burden	–	–	–	2.15	–
Breusch–Pagan p-value	0.0457	0.8348	0.9389	0.9357	0.7663
Durbin–Watson	0.627	1.458	1.873	2.193	1.370
Shapiro–Wilk p-value	0.0181	0.9835	0.0924	0.0141	0.2658
Jarque–Bera p-value	0.4071	0.8812	0.0887	0.0077	0.4139
Observations	15	15	15	15	18

Table 5. HC3 robustness check – p-values

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
IFI Finance	0.9106	0.9718	0.7382	0.5772	0.9245
IFI Projects	0.4003	0.7434	0.2857	0.1284	0.6181
Real interest rate	—	0.0016***	0.0004***	< 0.001***	0.0025***
Inflation	—	0.0459**	0.0068***	0.0019***	0.1634
Real GDP growth	—	0.0410**	0.0048***	0.0016***	0.0747*
Price-to-Income	—	—	0.0935*	—	—
Mortgage Burden	—	—	—	0.0077***	—

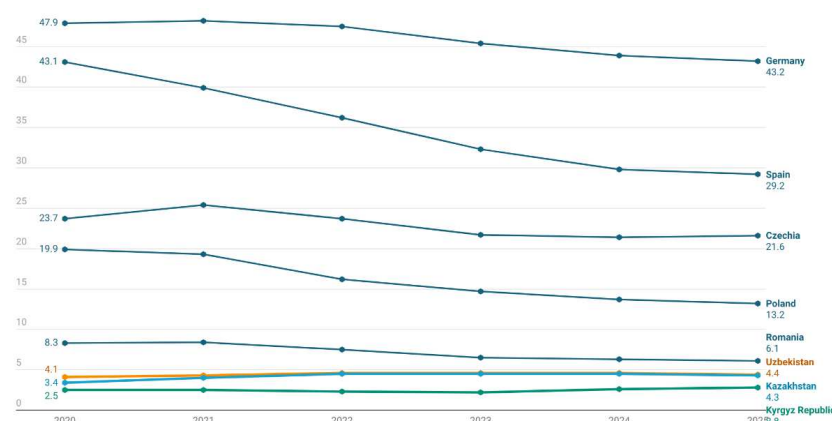
Note: HC3 p-values are based on heteroskedasticity-consistent HC3 standard errors. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Mortgage-market depth is first compared across the selected countries using the mortgage-to-GDP ratio. This indicator provides a standardized measure of the relative scale of mortgage lending across economies with different levels of economic output (Figure1).

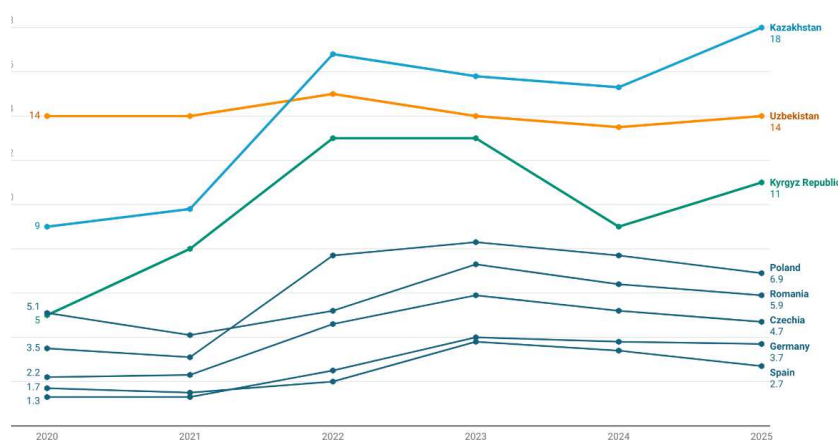
Figure 1 shows substantial differences in mortgage-market depth between the Central Asian and European countries.

Mortgage-market depth is complemented by a comparison of mortgage lending interest rates,

Source: Compiled by the authors based on data from the International Monetary Fund (IMF, 2026) and the central banks of Uzbekistan, Kazakhstan, and the Kyrgyz Republic.

**Figure 1.** Mortgage-to-GDP ratio in selected Central Asian and European countries, 2020–2025 (%)

Source: Compiled by the authors based on data from the International Monetary Fund (IMF, 2026) and the central banks of Uzbekistan, Kazakhstan, and the Kyrgyz Republic.

**Figure 2.** Mortgage lending interest rates in selected Central Asian and European countries, 2020–2025 (%)

Source: Compiled by the authors based on data from the International Monetary Fund (IMF, 2026).

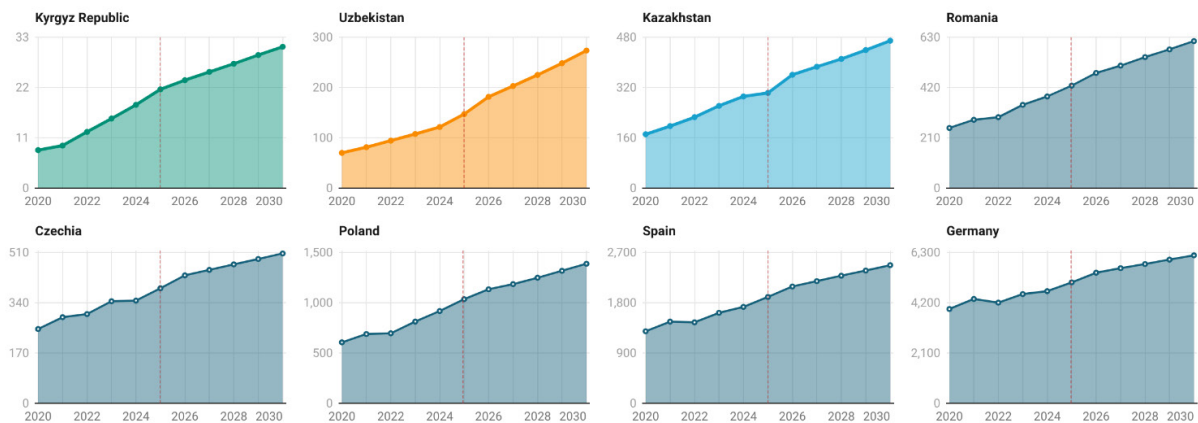


Figure 3. Historical and projected GDP dynamics in selected Central Asian and European countries, 2020–2030 (USD billion)

which provides additional context on borrowing conditions in the selected markets (Figure2).

Figure 2 indicates considerable differences in mortgage lending rates and their dynamics across the selected countries during 2020–2025.

The comparison is further extended to macroeconomic dynamics by examining historical GDP developments and medium-term projections for the selected countries. This provides broader economic context for differences in mortgage-market development (Figure3).

Figure 3 distinguishes historical GDP dynamics through 2025 from projected developments for 2026–2030, highlighting differences in the scale

and expected trajectory of the selected economies.

Residential property prices provide a further dimension for interpreting cross-country differences in housing affordability. Figure 4 compares residential property prices per square meter in the capital cities of the selected countries.

Figure 4 shows substantial differences in residential property prices across the selected capital cities, providing additional context for the affordability indicators presented below.

Finally, housing affordability is examined using the Price-to-Income Ratio and Mortgage Burden calculated according to the methodology described in Section 2.4. The bubble chart provides a

Source: Compiled by the authors based on data from Numbeo (2026).

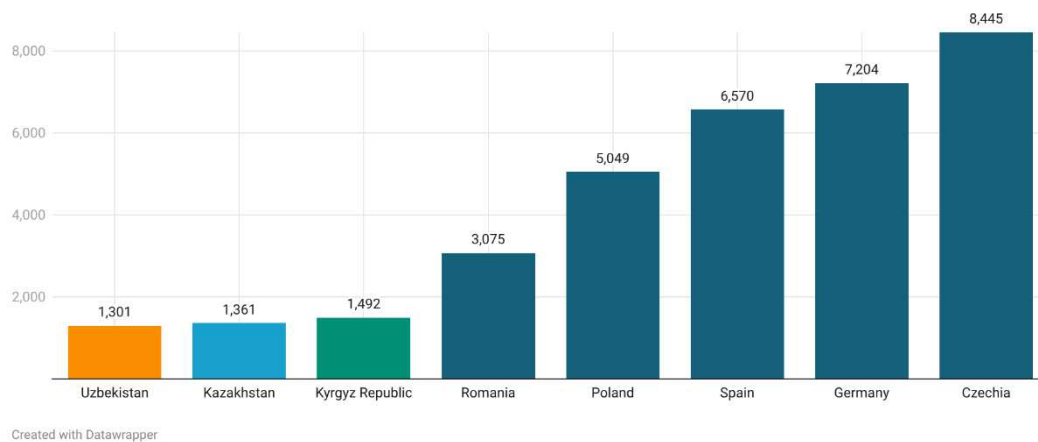
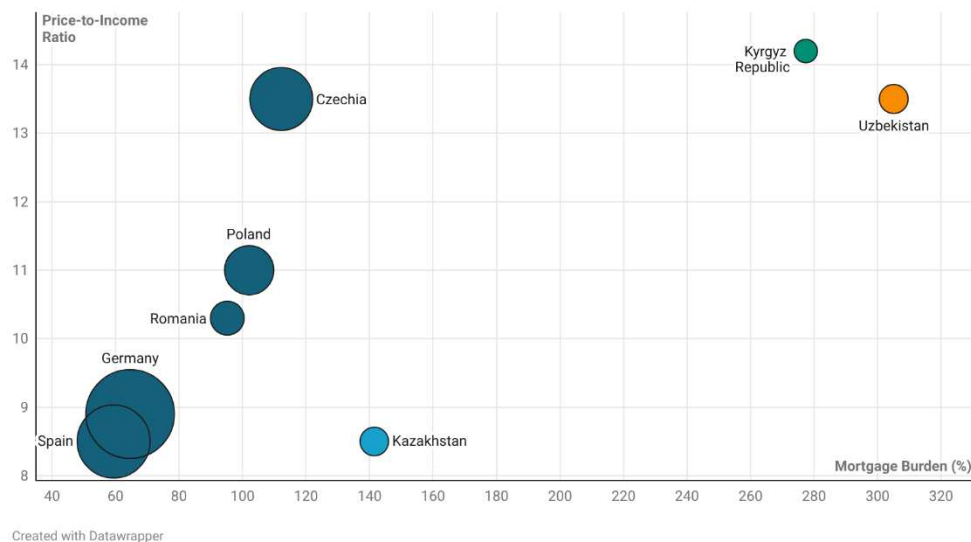


Figure 4. Residential property prices in selected Central Asian and European capital cities, 2025 (USD per square meter)



Note: Price-to-Income and Mortgage Burden are calculated by the authors using Numbeo data and the formulas specified in Equations (2) and (3), respectively. Bubble size represents the Mortgage-to-GDP ratio.

Figure 5. Price-to-income ratio and mortgage burden in selected Central Asian and European countries, 2025

descriptive comparison of these indicators across the selected countries, while bubble size represents mortgage-market depth.

Figure 5 shows substantial cross-country variation in the two housing-affordability indicators. The figure is intended as supplementary descriptive evidence and does not imply a causal relationship between the indicators.

4. DISCUSSION

The findings indicate that mortgage-market development in Central Asia is associated with international financial activity, macro-financial conditions, and housing-affordability factors. However, the relationship between IFI-supported activity and Mortgage/GDP is not stable across specifications. Lagged IFI Finance is statistically insignificant in Models 1–4, while lagged IFI Projects is significant only in Model 4. In the contemporaneous Model 5, neither IFI variable is statistically significant. Overall, H1 receives limited but non-robust support, H2 is not supported, and H3 receives partial support.

The positive association between lagged IFI Projects and Mortgage/GDP in Model 4 does not remain statistically significant under HC3 robust

inference. Therefore, the evidence for H1 is not robust across estimation methods. H2 is not supported because the expected positive association between IFI-supported activity and mortgage-market development is not consistently statistically significant after accounting for macro-financial conditions. These findings do not establish that international financing has no practical effect; rather, they indicate that its relationship with mortgage-market depth cannot be robustly identified using the available sample.

The macro-financial variables show more consistent associations. Real interest rates are positively associated with Mortgage/GDP across Models 2–5, while real GDP growth is negatively associated with the dependent variable. The latter relationship should be interpreted cautiously because GDP is part of the denominator of Mortgage/GDP, meaning that faster GDP growth can mechanically reduce the ratio when mortgage lending grows more slowly. Inflation is significant in Models 2–4 but becomes insignificant in Model 5.

The affordability results indicate that mortgage-market depth and housing affordability are distinct dimensions. Price-to-Income is not statistically significant in Model 3, although its HC3 p-value indicates weak evidence at the 10% level, while Mortgage Burden is positively associated

with Mortgage/GDP and remains significant under HC3 estimation. The high correlation between Price-to-Income and Mortgage Burden ($r = 0.926$) requires cautious interpretation. Overall, H3 receives partial support. The positive association between Mortgage Burden and Mortgage/GDP should not be interpreted as evidence that a higher mortgage burden improves housing affordability.

The robustness analysis and supplementary cross-country comparison support a cautious interpretation of the results. The revised specifications do not indicate severe multicollinearity, with a maximum VIF of 3.84. However, HC3 estimation changes the significance of several coefficients, while neither IFI variable is significant in the contemporaneous specification. The supplementary cross-country evidence also shows substantial dif-

ferences in mortgage-market depth and housing affordability, but these descriptive comparisons do not establish causal relationships.

Given the small sample of 18 country-year observations and the pooled specification, the results should therefore be interpreted as conditional associations rather than causal effects. From a project-management perspective, the findings suggest that the contribution of IFI-supported housing-finance projects may depend not only on financing volume but also on implementation timing, institutional capacity, and integration with domestic financial systems. This interpretation is consistent with Cho (2007) and Renaud (2008), who emphasize that mortgage-market development depends on institutional capacity, funding mechanisms, and market infrastructure, rather than on financing availability alone.

CONCLUSION

This study examined the relationship between international housing-finance interventions and mortgage-market development in Kazakhstan, Uzbekistan, and the Kyrgyz Republic over 2020–2025 using 18 country-year observations. The analysis combined Mortgage/GDP with IFI Finance, IFI Projects, macro-financial variables, and housing-affordability indicators.

The results do not provide stable evidence of a significant relationship between IFI-supported activity and Mortgage/GDP. Lagged IFI Finance is statistically insignificant across Models 1–4, while lagged IFI Projects is significant only in Model 4 and loses significance under HC3 estimation. Neither IFI variable is significant in the contemporaneous Model 5. In contrast, macro-financial variables, particularly the real interest rate, show more consistent associations with mortgage-market depth. The affordability analysis further indicates that Mortgage Burden is associated with Mortgage/GDP, while evidence for Price-to-Income is weaker.

The findings should be interpreted cautiously because of the small sample, pooled country-year specification, and the combination of national mortgage-market indicators with housing-affordability measures. These limitations restrict causal inference and the generalizability of the results. Future research should extend the time and country coverage and incorporate household-level, housing-supply, and institutional variables to enable more robust panel-data analysis.

Overall, the evidence suggests that international housing-finance interventions are not uniformly associated with mortgage-market development. Their relationship with mortgage-market outcomes should be considered alongside domestic macro-financial conditions, institutional capacity, implementation timing, and household affordability.

AUTHOR CONTRIBUTIONS

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