



## ARTÍCULOS

UTOPIA Y PRAXIS LATINOAMERICANA. AÑO: 25, n° EXTRA 12, 2020, pp. 333-345  
REVISTA INTERNACIONAL DE FILOSOFÍA Y TEORÍA SOCIAL  
CESA-FCES-UNIVERSIDAD DEL ZULIA. MARACAIBO-VENEZUELA  
ISSN 1316-5216 / ISSN-e: 2477-9555

### Macroeconomic Determinants of the Mortgage Loan

*Factores macroeconómicos determinantes del préstamo hipotecario*

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Este trabajo está depositado en Zenodo:  
[DOI: https://doi.org/10.5281/zenodo.4280163](https://doi.org/10.5281/zenodo.4280163)

#### ABSTRACT

This research aims to assess the relationship of macroeconomic indicators and those related to the banking sector of the economy. They will be considered with the volume of mortgage loans granted on the example of the Russian economy. It is shown that the increase in the weighted average mortgage rate is correlated with the increase in the volume of mortgage loans; the increase in the average nominal wage contributes to the increase in the volume of mortgage loans. The direct relationship between the volume of mortgage loans and problem mortgage debt can predict the inflating of the "credit" bubble.

**Keywords:** Inflation, interest rate, linear regression model, mortgage loan, unemployment.

#### RESUMEN

Esta investigación tiene como objetivo evaluar la relación de los indicadores macroeconómicos y los relacionados con el sector bancario de la economía. Serán considerados con el volumen de préstamos hipotecarios concedidos en el ejemplo de la economía rusa. Se muestra que el aumento de la tasa hipotecaria promedio ponderada, se correlaciona con el aumento del volumen de préstamos hipotecarios; el aumento del salario nominal medio contribuye al aumento del volumen de préstamos hipotecarios. La relación directa entre el volumen de préstamos hipotecarios y la deuda hipotecaria problemática puede predecir la inflación de la burbuja del "crédito".

**Palabras clave:** Crédito hipotecario, desempleo, inflación, modelo de regresión lineal, tasa de interés.

Recibido: 10-09-2020 Aceptado: 05-11-2020



## INTRODUCTION

The main tool for stimulating the development of the Russian housing market is mortgage lending, which in modern conditions is also developing due to state support in the form of preferential mortgage lending for families with children, residents of the far Eastern Federal district and state programs for subsidizing mortgage loans. The Russian mortgage market has a huge potential that needs to be controlled, preventing the formation of a "mortgage bubble" (Abramkin et al.: 2015, pp.259-263; Bagautdinova et al.: 2017, pp.4908-4912).

According to the Central Bank of Russia data, the share of the Russian mortgage market, despite high growth rates, is relatively small. In the Russian Federation, the share of mortgages in GDP is 6%, and in other countries, it is evaluated as 25%. But, despite this, it is important to develop mortgages in a high-quality segment with risk control, which, in turn, poses a threat to the entire financial market (Jordi: 2008; Lou & Yin: 2014, pp.336–363). In Russia, the mortgage lending market is developing quite rapidly, due to the influence of macroeconomic, political and social factors (Abel & Bernanke: 2010, pp.764). Decreasing oil prices and the purchasing power of the ruble can make significant adjustments to the pace of development of the mortgage lending market in the country (Bulatova et al.: 2019). In modern conditions, the study of socio-economic phenomena of the mortgage level is conducted on the basis of statistical and mathematical methods, which include a wide range of different methods and techniques that allow making the detailed and complete analysis of the primary information about the object under study, presented in a mathematical format.

Issues of mortgage lending are the subject of numerous discussions in the scientific literature. For this study, a key role in empirically confirming the theoretical arguments in favor of the impact of macroeconomic factors on the volume of mortgage loans granted in Russia was played by an article, in which, using data on large mortgage services in the United States, the author argued the following point of view: the impact of unemployment on mortgage default is insignificant, in contrast to common risk factors, such as high leverage of the borrower or low FICO indicators of the borrower. The research results demonstrated in (Gyourko & Tracy: 2014, pp.87–96) were further developed in (Samerkhanova & Kadochnikova: 2015, pp.55-59). Using the example of the development of the Russian economy, it shows the predominant influence of household income on the dynamics of mortgage loans issued. The authors have identified four groups of determinants of mortgage lending: variables of mortgage loans, housing market and mortgage market participants, macroeconomic variables and money market variables. Empirically, the predominant influence of money market characteristics on the weighted average mortgage rate is shown.

The authors (Gabriel & Rosenthal: 2013, pp.42–50) used year-by-year regression models and fixed-effect panel data analysis models to identify the relationship between the agglomeration economy and mortgage lending. The authors showed that urbanization increases liquidity, improves access to information and credit in the 1990s, but after 2000 the effects dissipate, possibly due to changes in consumer sentiment due to the development of secondary markets and information technologies. This view is presented in the article of (Wadud et al.: 2020, p.101132). The authors also do not find any connections between consumer sentiment and the mortgage rate. However, they show a significant positive impact of the unemployment rate and, in general, a negative impact of income per capita on the level of overdue mortgage loans. The authors of another article (Campbell & Cocco: 2015, pp.1495-1554) used a dynamic decision model for household mortgage lending, which includes income from work, house prices, inflation, and interest rate risk. The article (Agarwal & Liu: 2003, pp.75-84) empirically shows the influence of the unemployment rate on consumers' propensity to bankruptcy due to macroeconomic fluctuations. A study (Steinbuks & Elliehausen: 2014, pp.47-72) using the example of US legislation shows that legal restrictions reduce the use and attractiveness of a mortgage loan.

Using the findings obtained in the article of, and in the article of (Shao et al.: 2020, p.102530), the impact of administrative decentralization in China on the financial agglomeration of loans in districts was defined. In

the article of (Diaz-Serrano & Raya: 2014, pp.22–32), a unique set of data on mortgage loans granted in Spain revealed discrimination in terms of higher interest rates for immigrant borrowers.

In the same way as we use a regression model, but we modify it by expanding it through indicators of the banking sector of the economy.

In order to find the most appropriate model for measuring factors of the volume of mortgage loans provided, fairly simple linear models of multiple regression are presented. Ten annual indicators that characterize the banking system and the Russian economy for the period from 2015 to 2020 are used to build models. The usual least squares method is used to evaluate model parameters, and the traditional formal student and Fisher tests are used to verify statistical significance.

The main purpose of the study is to detect and evaluate the value factors of mortgage loans issued in the Russian financial system. The research idea was suggested by the works.

Based on the analysis of the literature, two main research questions were formulated:

1. What macroeconomic indicators are related to the volume of mortgage loans granted?
2. What economy indicators of the banking sector development contribute to changes in the volume of mortgage loans granted?

The following results were obtained. There was no statistically significant correlation between the volume of mortgage loans and the number of credit institutions, unemployment, inflation, gross domestic product, and the average cost per square meter of housing. Intuitively, we found a statistically significant inverse relationship between the volume of mortgage loans and the weighted average mortgage rate and a direct relationship with nominal wages. This corresponds to theoretical representations of (Brooks: 2008, p.674), as well as conclusions obtained by. However, a direct correlation between the volume of mortgage loans and mortgage debt was confirmed, which in the future may predict the inflating of the "credit" bubble.

The paper consists of an introduction, two main sections, and a conclusion. In the first section, we formulate the linear multiple regression models used and describe the indicators used in the Russian banking system and economy based on a review of the literature regarding the selection of economic indicators that affect the volume of mortgage loans granted. The second section presents the results of evaluating models. The conclusion contains conclusions and recommendations for further research in the field of analytical econometric tools determinants of mortgage lending.

## **METHODOLOGY**

Correlation and regression analysis are popular methods for analyzing and predicting the development of socio-economic phenomena that are closely related to mathematically expressed indicators. It is based on the study of several supposedly interrelated phenomena. In other words, it is assumed that there are cause-and-effect relationships when a change in one variable leads to a change in another.

Correlation analysis allows one to identify the presence and closeness of the connections between the studied phenomena, as well as check the presence or absence of collinear factors. The main purpose of correlation analysis is to obtain information about one variable using another. The correlation coefficient shows the tightness of the linear relationship and changes in the range from -1 to 1. Minus one means a complete linear inverse relationship. The unit is a complete linear positive relationship. Zero – no linear correlation. When there is a positive correlation, an increase in one factor leads to an increase in another, and when there is a negative correlation, the growth of one indicator leads to a decrease in the other.

Regression analysis allows identifying the statistical significance of factors and the difference between the correlation coefficient and zero using a formal Student test.

To build a linear model of multiple regression, quarterly statistical data for 5 years from 01.01.2015 to 01.01.2020 were used (Table 1, Table 2).

Variables	Data type	Source	Internet Link
Variables of the economy's banking sector			
Volume of mortgage loans granted – $Y_t$	mln.rub	Bank of Russia	<a href="https://cbr.ru/statistics/bbs/statisticheskiy-byulleten-banka-rossii/">https://cbr.ru/statistics/bbs/statisticheskiy-byulleten-banka-rossii/</a>
Number of credit institutions – $X_{t1}$	units	Bank of Russia	<a href="https://cbr.ru/statistics/bbs/statisticheskiy-byulleten-banka-rossii/">https://cbr.ru/statistics/bbs/statisticheskiy-byulleten-banka-rossii/</a>
The weighted average interest rate on mortgage loans – $X_{t2}$	%	Bank of Russia	<a href="https://cbr.ru/statistics/bbs/statisticheskiy-byulleten-banka-rossii/">https://cbr.ru/statistics/bbs/statisticheskiy-byulleten-banka-rossii/</a>
Weighted average loan term for mortgage loans – $X_{t3}$	month	Bank of Russia	<a href="https://cbr.ru/statistics/bbs/statisticheskiy-byulleten-banka-rossii/">https://cbr.ru/statistics/bbs/statisticheskiy-byulleten-banka-rossii/</a>
The mortgage debt – $X_{t5}$	mln.rub	Bank of Russia	<a href="https://cbr.ru/statistics/bbs/statisticheskiy-byulleten-banka-rossii/">https://cbr.ru/statistics/bbs/statisticheskiy-byulleten-banka-rossii/</a>
Variables-macroeconomic indicators			
Key rate – $X_{t4}$	%	Bank of Russia	<a href="https://cbr.ru/statistics/bbs/statisticheskiy-byulleten-banka-rossii/">https://cbr.ru/statistics/bbs/statisticheskiy-byulleten-banka-rossii/</a>
Average cost of 1 sq. m. in the housing market – $X_{t6}$	rub.	Federal statistics service	<a href="https://www.gks.ru/dbscripts/cbsd/DBInet/cgi">https://www.gks.ru/dbscripts/cbsd/DBInet/cgi</a>
Average monthly nominal salary – $X_{t7}$	rub.	Federal statistics service	<a href="https://www.gks.ru/labor_market_employment_salaries?print=1">https://www.gks.ru/labor_market_employment_salaries?print=1</a>

Unemployment rate – $X_{t8}$	%	Federal statistics service	<a href="http://old.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/wages/labour_force/#">http://old.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/wages/labour_force/#</a>
Inflation rate – $X_{t9}$	%	Inflation level	<a href="https://уровень-инфляции.рф/таблицы-инфляции">https://уровень-инфляции.рф/таблицы-инфляции</a>
Gross domestic product – $X_{t10}$	bln.ru b.	Federal statistics service	<a href="http://old.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/accounts/#">http://old.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/accounts/#</a>

**Table 1.** Data sources

Variables	Mean	Median	Standard Deviation	Variation	Minimum	Maximum
The volume of mortgage loans – $Y_t$	532373,1	512567	214215	4,59E+10	217169	942203
Number of credit organizations – $X_{t1}$	782,5714	943	259,0623	67113,26	442	1049
The weighted average mortgage rate – $X_{t2}$	11,14333	10,5	1,682038	2,829253	8,79	14,5
The weighted average mortgage loan term – $X_{t3}$	192,4633	186,7	15,17571	230,3021	172,5	219,5
The key rate – $X_{t4}$	6,29	4,27	4,715408	22,23507	2,3	16,93
The mortgage debt – $X_{t5}$	9,488095	9	2,590217	6,709226	6,25	17
The average cost of 1 sq. m. in the housing market – $X_{t6}$	23178,39	24165,8	5872,363	34484648	2064,1	30685,9
The average monthly nominal wage – $X_{t7}$	5220205	4848716	1382022	1,91E+12	3423684	7518191
Unemployment rate – $X_{t8}$	55948,81	54637,4	3336,66	11133300	51530,15	63546,2
Inflation rate – $X_{t9}$	40740,95	40103	5993,01	35916172	31566	52383
Gross domestic product – $X_{t10}$	5,109524	5,1	0,430006	0,184905	4,5	5,9

**Table2.** Descriptive statistics of variables

We use the volume of mortgage loans granted in millions of rubles as a dependent variable –  $Y_t$ .

In the econometric literature, the use of time series reference levels to study statistical relationships is discouraged due to the possible false regression (Hamilton: 1994, p.820; Cowpertwai & Metcalfe: 2009, p.262) False regression is a situation when there is no causal connection between the explanatory and dependent variable, but the correlation coefficient between them is close to one in modules, and the equation describing such connection corresponds to the data with high accuracy (Brockwell & Davis: 2016, pp.428; Neusser: 2016, p.42). This situation usually occurs when working with time series, which are characterized by

the presence of a trend, deterministic or random. Such time series are called non-stationary. To avoid false regression in modeling we use absolute increments of time series levels:

$$\Delta Y_t = \beta_0 + \beta_1 \Delta X_{t1} + \beta_2 \Delta X_{t2} + \beta_3 \Delta X_{t3} + \dots + \beta_{10} \Delta X_{t10} + \varepsilon_t, \quad (1)$$

where:  $\beta_0$  – free coefficient,

$\beta_1 \dots \beta_{10}$  – regression coefficient,

$\varepsilon_t$  – random variation (regression error).

To evaluate the model, we use the usual least squares method (Wooldridge: 2013, p.865). Previously, to test the regressors for multicollinearity, we applied the matrix of linear coefficients of pair correlation. Multicollinearity is the presence of a linear connection between the explanatory variables of the model, which distorts estimates of regression parameters. If the modal value of the linear coefficient of paired correlation is greater than 0.7, then such a pair of regressors is considered collinear, and one of the regressors is excluded from the linear model of multiple regression. The final regression model is also freed from statistically insignificant (redundant) regressors.

The adequacy of the regression model is estimated by the coefficient of determination  $R^2$ :

$$R^2 = \frac{\sum (\Delta \hat{Y}_{t,x} - \Delta \bar{Y}_t)^2}{\sum (\Delta Y_t - \Delta \bar{Y}_t)^2} = 1 - \frac{\sum (\Delta Y_t - \Delta \hat{Y}_{t,x})^2}{\sum (\Delta Y_t - \Delta \bar{Y}_t)^2}, \quad (2)$$

where:  $\Delta \hat{Y}_{t,x}$  – the growth value of the dependent variable predicted by the regression equation;

$\Delta \bar{Y}$  – average growth value of the dependent variable;

To predict the volume of mortgage loans granted, based on a linear trend, the forecast values of the absolute growth of each regressor of the final model are determined, then the growth of the dependent variable is determined, which is added to the last known initial level of the time series of the volume of mortgage loans granted.

## RESULTS

The matrix of linear coefficients of pair correlation, constructed from the initial levels of time series, defined the multicollinearity. After switching to absolute increments of variables, the matrix of linear coefficients of pair correlation showed a practical absence of collinear regressors. Among macroeconomic indicators, the largest direct linear relationship between the increase in the volume of mortgage loans granted ( $\Delta Y_t$ ) is observed with an increase in the average monthly nominal wage ( $R_{\Delta Y_t \Delta X_{t17}} = 0.65091$ ), gross domestic product ( $R_{\Delta Y_t \Delta X_{t10}} = 0.53552$ ), and the reverse – with the average price of 1 square meter in the housing market ( $R_{\Delta Y_t \Delta X_{t16}} = -0.41716$ ). Among the indicators of the banking sector of the economy, the greatest inverse linear relationship between the increase in the volume of mortgage loans granted is observed with an increase in the weighted average rate ( $R_{\Delta Y_t \Delta X_{t12}} = -0.47070$ ), the weighted average loan term ( $R_{\Delta Y_t \Delta X_{t13}} = -0.44382$ ),

	$\Delta Y_t$	$\Delta X_{t1}$	$\Delta X_{t2}$	$\Delta X_{t3}$	$\Delta X_{t4}$	$\Delta X_{t5}$	$\Delta X_{t6}$	$\Delta X_{t7}$	$\Delta X_{t8}$	$\Delta X_{t9}$
$\Delta Y_t$	1									
$\Delta X_{t1}$	0,316 63	1,000 00								
$\Delta X_{t2}$	- 0,470 70	- 0,137 12	1,000 00							
$\Delta X_{t3}$	- 0,443 82	- 0,091 65	0,645 04	1,000 00						
$\Delta X_{t4}$	- 0,093 74	0,022 89	0,576 97	0,331 50	1,000 00					
$\Delta X_{t5}$	0,244 10	- 0,116 99	0,295 26	0,497 13	0,436 40	1,000 00				
$\Delta X_{t6}$	- 0,417 16	- 0,223 58	0,182 53	0,022 96	0,371 40	0,039 34	1,000 00			
$\Delta X_{t7}$	0,650 91	0,227 22	- 0,144 78	- 0,191 58	- 0,025 26	0,099 75	- 0,299 97	1,000 00		
$\Delta X_{t8}$	- 0,118 61	- 0,009 76	- 0,001 73	0,003 55	- 0,229 25	- 0,216 96	0,203 63	0,241 88	1,000 00	
$\Delta X_{t9}$	0,037 21	- 0,119 58	0,295 42	0,371 39	0,058 28	0,356 99	- 0,371 45	0,106 78	- 0,264 13	1,000 00
$\Delta X_{t10}$	0,535 52	0,102 51	- 0,176 91	- 0,070 66	- 0,070 52	0,135 62	- 0,357 69	0,513 29	- 0,300 49	0,160 30

**Table 3.** The correlation matrix

There is also a close direct linear connection between the two pairs of regressors: the weighted average rate and the weighted average loan term ( $R_{\Delta X_{t2}\Delta X_{t3}} = 0.64504$ ), as well as the weighted average rate and the key rate ( $R_{\Delta X_{t2}\Delta X_{t4}} = 0.57697$ ). Therefore, we exclude the regressors  $\Delta X_{t3}$  and  $\Delta X_{t4}$  from further analysis. The results of evaluating linear multiple regression models are summarized in Table 4. In the regression model (1), three regressors were statistically significant:  $\Delta X_{t2}$  – increase in the weighted average rate,  $\Delta X_{t5}$  – increase in mortgage debt, and  $\Delta X_{t7}$  – increase in the average monthly nominal wage. In other words, a linear statistical connection with the increase in the volume of mortgage loans granted was confirmed only for the increments of these variables. In model (2), the multiple correlation coefficient takes the value of 0.8174 and indicates a fairly close joint relationship between the growth of the dependent variable  $\Delta Y_t$  (the volume of mortgage loans granted) and the increase in the weighted average mortgage rate ( $\Delta X_{t2}$ ), the increase in debt on mortgage loans granted ( $\Delta X_{t5}$ ), and the increase in the average monthly nominal salary ( $\Delta X_{t7}$ ).

Dependent variable: The volume of mortgage loans in Russian banks		
Regressor	(1)	(2)
Intercept	-127234,5782* (62 741,45)	-147748,3** (55067)
$\Delta X_{t1}$	228,198113 (283,51)	
$\Delta X_{t2}$	-137526,8989** (58 200,34)	-165830,5*** (51863)
$\Delta X_{t5}$	0,493405533* (0,254)	0,4886487** (0,2229)
$\Delta X_{t6}$	-25,7878723 (28,86)	
$\Delta X_{t7}$	19,5850537** (8,66)	22,039482*** (5,9368)
$\Delta X_{t8}$	-77998,84041 (111 011,68)	
$\Delta X_{t9}$	-10277,52566 (18 099,28)	
$\Delta X_{t10}$	1,207958436 (3,49406)	
Standard Error (Se)	91 705,67596	87 960,89057
R <sup>2</sup>	0,752016266	0,668153458
n	20	20

**Table 4.** The results of the regression assessment of the volume of mortgage loans

For model (2), the coefficient of determination  $R^2$  assumed a value equal to 0.6682, which indicates that this model explains 67% of the variation in the volume increase of mortgage loans granted. The remaining 33% of the growth variation may be due to the influence of other factors that are not taken into account in this model. The indicator of 67% indicates that the model (2) has a good predictive ability, the regressors  $\Delta X_{t2}$ ,  $\Delta X_{t5}$ , and  $\Delta X_{t7}$  in this case are interconnected with the dependent variable  $\Delta Y_t$ .

According to the evaluation results, the linear multiple regression model (2) has the following form:

$$\Delta Y_t = -147\,748,331 - 165\,830,53 \cdot \Delta X_{t2} + 0,486 \cdot \Delta X_{t5} + 22,039 \cdot \Delta X_{t7} + \varepsilon_t$$

The signs of coefficients in the regression equation correspond to economic intuition, which is confirmed by the economic interpretation: an increase in the weighted average mortgage rate by 1 percentage point will, all other things being equal, reduce the increase in the volume of mortgage loans granted by an average of 165,830.53 million rubles. An increase in mortgage debt by 1 mln rub will, all other things being equal, lead to an increase in the volume of mortgage loans by an average of 0.486 mln rub. An increase in the average monthly nominal salary by 1 ruble will lead, all other things being equal, to an increase in the volume of mortgage loans granted by an average of 22.039 mln rub.

The forecast of the possible volume of mortgage loans granted, obtained using model (2), is presented in Table 5.



Date	The volume of mortgage loans – $Y_t$	The average weighted mortgage rate – $X_{12}$	The mortgage debt – $X_{15}$	The average monthly nominal wage – $X_{17}$
Forecast of absolute growth of variables				
01.04.2020	44629,91433	-0,12	287837	1449
01.07.2020	46730,39665	-0,10	295724	1487
01.10.2020	48830,87896	-0,09	303698	1527
01.01.2021	50931,36128	-0,07	311671	1566
01.04.2021	53031,8436	-0,06	319472	1604
01.07.2021	55132,32591	-0,04	327359	1643
01.10.2021	57232,80823	-0,02	335332	1682
01.01.2022	59333,29055	-0,01	343306	1721
Time series level forecast				
01.04.2020	713 296	8,67	7 806 054	53 833
01.07.2020	760 026	8,57	8 101 835	55 322
01.10.2020	808 857	8,48	8 405 534	56 849
01.01.2021	859 789	8,41	8 717 150	58 416
01.04.2021	912 820	8,35	9 036 685	60 022
01.07.2021	967 953	8,31	9 364 137	61 667
01.10.2021	1 025 186	8,29	9 699 507	63 350
01.01.2022	1 084 519	8,28	10 042 796	65 73

**Table 5.** The forecast of the volume of mortgage loans

## DISCUSSION

This paper is devoted to the regression analysis of mortgage loans granted volume factors in the Russian economy. We proceeded from empirically proven theoretical arguments in favor of the influence of macroeconomic indicators and indicators of the banking sector of the economy on the volume of mortgage loans granted. The paper uses quarterly Russian statistical data from 2015-2020. For the study, we applied practical recommendations by (Neusser: 2016, p.42) on a methodological approach to analyzing the relationships of non-stationary time series. The approach to modeling mortgage credit regressors presented in the study has a number of advantages due to the ability to assess the contribution of each of the considered model factors to the variation in the volume of mortgage loans provided, and to predict changes in the found dependencies in the future. In particular, it allows one to perform a better selection of predictors of mortgage lending and preserve the possibility of meaningful interpretation of modeling results for making practical decisions in the banking sector of the economy.

Figures 1-4 show the forecast of statistically significant predictors and possible volume of mortgage in 2020-2022.

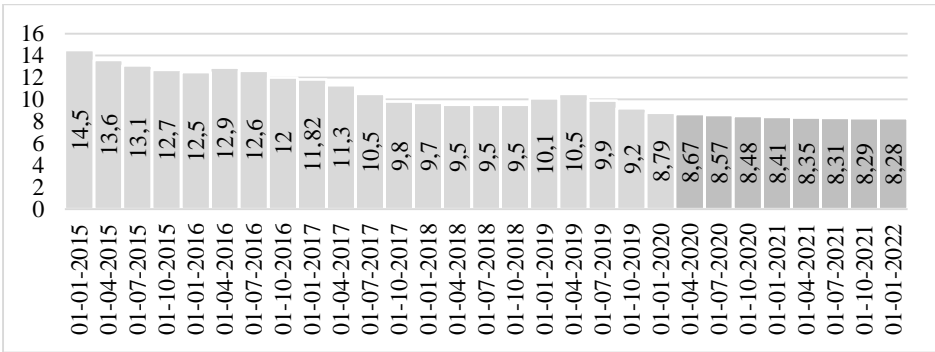


Figure1. The forecast of the average rate on mortgage loans in 2020-2022, %.

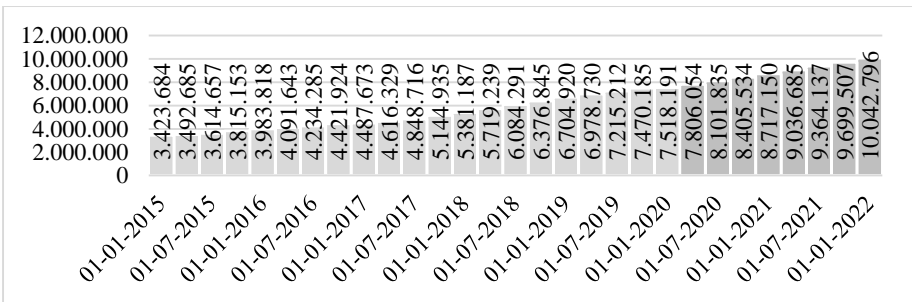


Figure2. The mortgage debt forecast for 2020-2022, million rubles

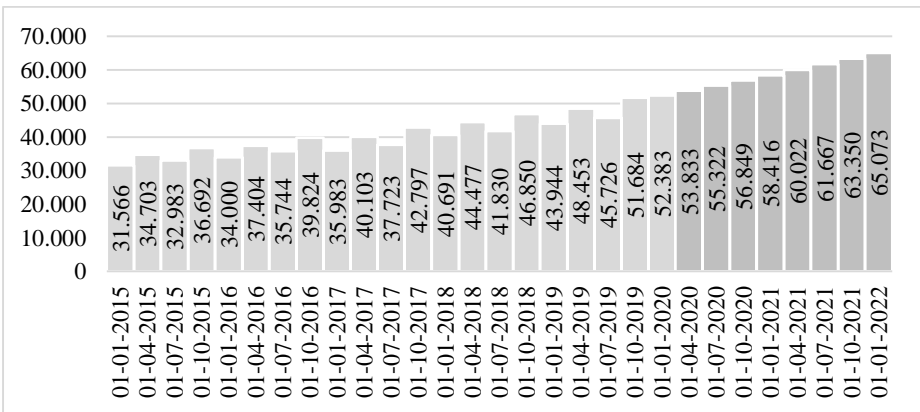


Figure 3. The forecast of the average monthly nominal salary for 2020-2022, rubles.

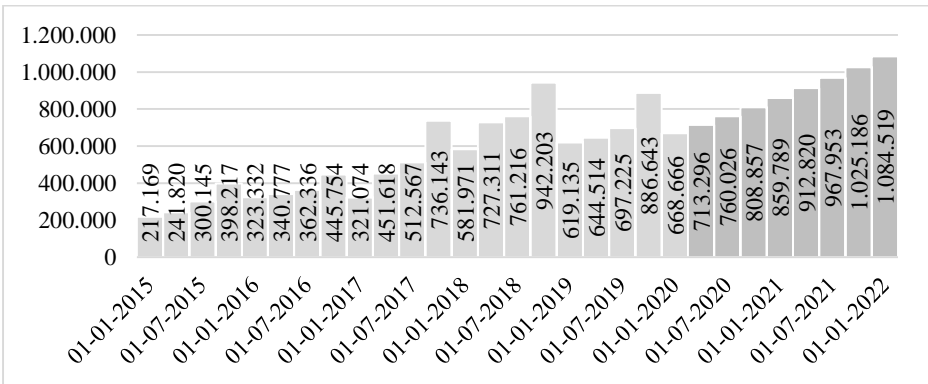


Figure 4. The forecast of the mortgage loans volume for 2020-2022, million rubles

## CONCLUSION

The dynamics of the mortgage loans granted volume has positive dynamic, which indicates that in the future, the market for housing mortgage lending will continue to actively develop and increase. The connections defined predict two main conclusions. First, the lack of correlation between the volume of mortgage loans and most macro-indicators shows possible positive trends for the development of the mortgage market. Second, the direct relationship between the volume of mortgage loans and mortgage debt may indicate the problem of a "credit" bubble.

## Acknowledgements

The work is performed according to the Russian Government Program of Competitive Growth of Kazan Federal University.

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