Effects of Exchange Rate Changes on Real Estate Prices in Russia During the Russian-Ukrainian War

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Abstract. As a result of the Russian-Ukrainian war which started at February 24, 2022, some of Russia's economic indicators have been affected, including the ruble's exchange rate, Russia's inflation rate, and GDP. With this in mind, this paper assumes that there is a linear relationship between real estate prices and the exchange rate, inflation rate, and GDP as follows: ln_repx = ß0 + ß1 ln_exr + ß2ln_inf + ß3ln_Y + c.c.. Based on the information collected, the StataSE 15.0 tool is used to perform regression operations to derive the correlation coefficients and to explore the relationship between house prices and each price factor. Afterwards, it was concluded that under the influence of the Russian-Ukrainian war, changes in the exchange rate of the Russian domestic currency against the US dollar would have some negative impact on real estate prices. Overall, these results shed light on guiding further exploration of continuous influence from war on Russia's real estate market and pave a path for government to make efficient response.

Keywords: Real estate, exchange rate, inflation, Russia-Ukrainian war.

1. Introduction

For economists, investors, and policymakers alike, the relationship between real estate prices and exchange rates is crucial, and it even has significant ramifications for the stability and well-being of a nation's economy. Fluctuations in exchange rates directly affect the purchasing power of foreign investors in the real estate markets of other countries' countries [1]. When the national currency depreciates, the purchasing power of the foreign currency increases and the demand for real estate in the home country by investors from other countries increases, which may lead to an increase in real estate prices, especially in popular cities and tourist destinations. On the contrary, when the national currency appreciates, the purchasing power of foreign currencies decreases and the demand for real estate in the home country by investors from other countries decreases, which may dampen the dynamism of the real estate market.

Exchange rate movements affect a country's economic growth and inflation rate, which in turn affects real estate demand [2, 3]. The depreciation of a country's currency is usually accompanied by an increase in exports and economic growth, which can potentially lead to higher income levels and purchasing power of the country's people, which in turn can push up real estate prices. At the same time, currency depreciation may also lead to an increase in the cost of imports, which in turn triggers inflation and increases construction costs, ultimately leading to higher real estate prices.

The exchange rate also affects interest rates and capital flows [4]. Central banks respond to exchange rate fluctuations by adjusting interest rates according to different exchange rate scenarios, and changes in interest rates have a direct impact on the cost of mortgages and the attractiveness of real estate assets to investors. Changes in exchange rates increase the likelihood of foreign exchange risk. This is because changes in foreign exchange rates affect local and international commodity prices, including real estate. The uncertainty associated with investing can have a significant negative impact on investors. The war between Russia and Ukraine began in 2022. Due to Russia's involvement in the conflict in Ukraine, the majority of other European nations have imposed trade and economic sanctions on the country.

Import and export prohibitions as well as the fall of the ruble exchange rate are the primary manifestations. As illustrated in Fig. 1, the ruble-dollar exchange rate fell 42.7% in two weeks on

March 8, falling from the pre-war level of 63.6133 to 111.1091. Inflationary pressures have been exacerbated by the ruble's depreciation. Russia's inflation rate was 9.2% in February 2022. Then, as can be seen in Fig. 2, inflation in Russia increased quickly, reaching a peak of 17.8% in April. This resulted in higher import costs and a decline in consumers' purchasing power, which had a substantial effect on people's daily living standards and raised questions about the true value of their property. Russia's military expenditures during the war were so significant that they prevented the country's capital from leaving. Therefore, the central bank decided to drastically hike interest rates from 9.5% to 20% to encourage citizens to invest in Russia and stop capital outflows [5]. Seen from Fig. 3, the IS-LM model principle states that an increase in interest rates should cause the equilibrium points of the IS and LM curves to shift upward and to the left, indicating that although Russia's move to raise interest rates effectively stopped the capital outflow, output level decreased as interest rates increased.

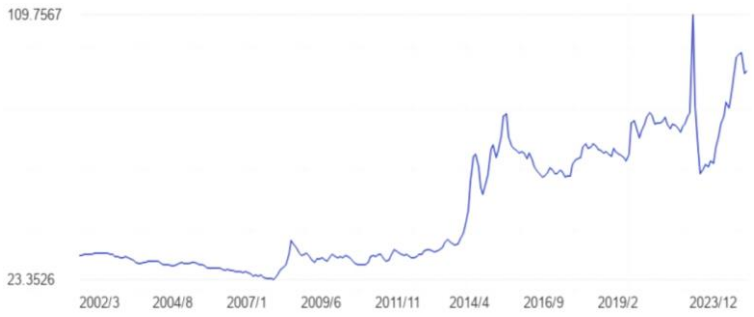

Figure 1. Russian Roubles per USD

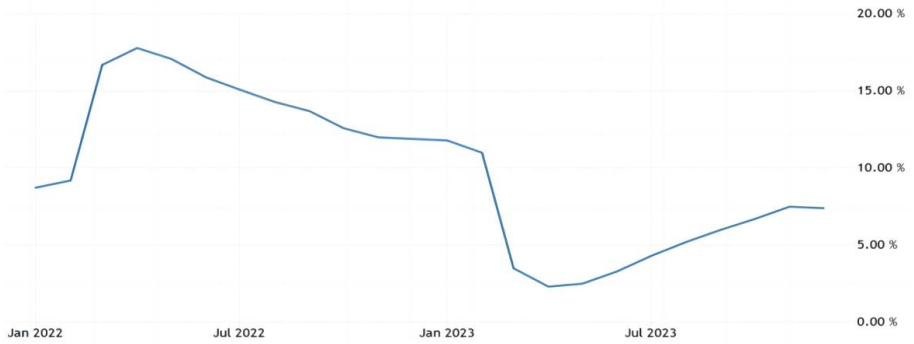

Figure 2. Russia Inflation Rate

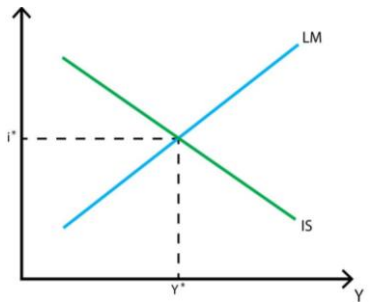

Figure 3. IS-LM Model

In fact, the GDP statistics for Russia as of 2022 shows this trait. Russia's GDP growth rate in the first quarter of 2022 was 3.5%, which was the lowest in the previous nine months. The first quarter saw some resistance to the sanctions imposed on Russia by the US, EU, Japan, and other Western nations due to the crisis between Russia and Ukraine, but the Russian economy was still growing at a reasonable pace. However, as the second quarter got underway, the Russian Federal Statistics Bureau's data revealed that the country's GDP was growing at a negative rate year over year, as illustrated in Figure 4. This resulted in a 0.4% decline in the GDP's overall value during the first half of the year. Russia is not benefiting from the lower level of output when it comes to war, as it must endure the heavy cost of the battlefield and face economic penalties from other nations.

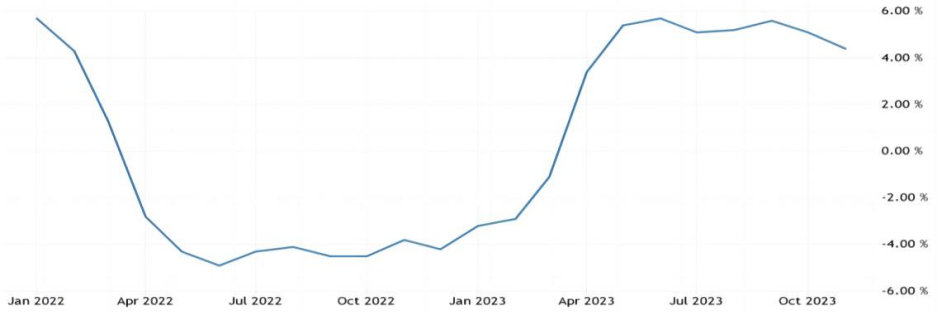

Figure 4. Russia Monthly GDP YoY

The aforementioned data demonstrate that the Russia-Ukrainian War-induced fluctuations in exchange rates had an effect on the GDP growth rate and the inflation rate, and that these effects had varying degrees of influence on the state of the Russian domestic real estate market. Consequently, this study was required to examine the influence of exchange rates on the price of real estate in Russia using this regression equation:

$$ln\_repx=ß0+ß1\ ln\_exr+ß2ln\_inf+ß3ln\_Y+c.c. \quad (1)$$

This study's main goal is to determine how Russia's housing market is impacted by fluctuations in the ruble's value relative to other major trading currencies, particularly the US dollar. The study's specific objectives are to determine other macroeconomic variables that influence housing prices and to examine the relationship between the ruble exchange rate and house prices. This study will encourage more investigation into the ways in which other macroeconomic factors impact Russian house prices and assist investors in making informed judgments when making investments in the country's real estate sector. The purpose of this study is to determine how the value of the ruble in connection to residential real estate prices in Russia is affected. In order to assist the government in creating regulations for the real estate market, it will also look into how the market reacts to fluctuations in the value of the dollar. By taking GDP and inflation into account, this study aims to offer a fair perspective on the developments in housing prices and exchange rates. The exchange rate and property prices from January 2022 to June 2023 are the main subjects of the study. TRADINGECONOMICS.COM, the Bank for International Settlements (2024) and FRED ECNOMIC DATA are three of the study's data sources.

2. Literature Review

In light of the financial engineering background and the empirical quantitative analysis of China's real estate price index from January 2007 to December 2010 for 48 sample points using the Eviews 5.0 tool, Liu concluded from the VAR model that the increase in house prices per unit has a positive contribution to the exchange rate, albeit with a lag of one cycle [6]. Nevertheless, it becomes the opposite effect when there is a two-week lag. The paper indicates that there is a short-term negative correlation between real estate prices and the RMB exchange rate, but a long-term positive correlation. It also forecasts the relationship between the price index and the exchange rate over a two-year period. The paper suggests tightening lending policies, improving the real estate market's supply structure, and bolstering local government and business regulation in this regard [7]. After applying the VAR model to analyze monthly data from July 2005 to December 2012, Zhang concluded that there is a long-term stable and positive correlation between China's real estate prices and the Renminbi exchange rate [8]. The study used China as an example to analyze data from July 2005 to December 2012. The recommendation is that China implement a flexible exchange rate system. In the instance of Ghana, Jack examines the connection between residential real estate and exchange rate volatility by using data from Ghana spanning 32 years, from 1986 to 2017 [9]. Several tests led to the conclusion that inflation has a negative influence on real estate appreciation and that exchange rate volatility has no effect on real estate prices [9].

3. Data and Method

In order to identify meaningful interactions between variables using numerical data, this study interprets changes in the ruble exchange rate in relation to real estate values. The Bank for International Settlements (2024), TRADINGECONOMICS.COM and FRED ECNOMIC DATA are three of the study's data sources. To investigate the relationship between real estate prices and the exchange rate in Russia, this research employs four variables: real estate prices, exchange rate, inflation rate, and GDP growth rate. In order to investigate whether the Russian-Ukrainian war has effect on the real estate market in Russia, this research does two regressions, one of which is before the war began, and the another on is after the war started. The data cycle of regressions are from January of 2003 to July of 2021 and January in 2022 to June in 2023.

3.1. Model Specification

This analysis takes the natural logarithm of the variables in the regression analysis with Eq. (1). The logarithmic transformation can help linearize the nonlinear relationship between the variables. Even if the raw data is nonlinear, the model can use linear regression to estimate the relationship between the variables. In addition, logarithmic transformations can convert the values of variables with large ranges into more compact ranges, which helps to deal with highly skewed data, bringing it closer to a normal distribution and improving the robustness of the statistical analysis. Moreover, logarithmic transformations help stabilize the variance of a variable, especially when the variance of the data increases as the mean increases (heteroscedasticity). The logarithmic transformation reduces the impact of outliers or extreme values because these extreme values have less of an impact on the logarithmic scale than on the original scale. However, the method can only be used to work with positive values. The logarithmic transformation is only applicable to positive values, otherwise it will result in variable data indeed. This is the reason why this study takes direct values for the GDP variable instead of taking its growth rate as a variable [10-12].

Table 1. Collected data during the war

Date	repx	inf	exr	Y	ln_repx	ln_inf	ln_exr	ln_Y
2022-01-01	98909	8.73	76.5	38095.6	11.50196	2.16677	4.33729	10.54785
2022-03-01	109197.56	16.70	104.0	30719.4	11.60091	2.81541	4.64429	10.33265
2022-06-01	116279	15.90	57.2	31247.2	11.66375	2.76632	4.04620	10.34968
2022-09-01	121315	13.70	59.8	33447.8	11.70615	2.61740	4.09134	10.41774
2022-12-01	122343	11.90	65.8	37080.4	11.71458	2.47654	4.18677	10.52084
2023-03-01	127729	3.50	76.1	30165.1	11.75767	1.25276	4.33205	10.31444
2023-06-01	128829	3.30	83.3	32762.9	11.76624	1.19392	4.42269	10.39705

3.2. Collected data

The Russian property prices, exchange rates, inflation rates, and GDP, at quarterly frequencies from 2003. Data sources include official websites such as the Bank for International Settlements. The typical data for war periods is shown in Table. 1, where real estate prices are per square meter per unit, inflation rate measured as percentage, the exchange rate is ruble to dollar, and GDP is in billions of rubles. Since the linear regression models selected for this study apply the logarithmic form of the original data to make the regression more accurate.

Table 2. Result of Correlation Test (before the war)

	ln_repx	**ln_inf**	**ln_exr**	**ln_Y**
ln_repx	1.0000			
ln_inf	-0.3415	1.0000		
ln_exr	0.5999	-0.3580	1.0000	
ln_Y	0.8501	-0.5464	0.5210	1.0000

Table 3. Result of Correlation Test (during the war)

	ln_repx	**ln_inf**	**ln_exr**	**ln_Y**
ln_repx	1.0000			
ln_inf	-0.4937	1.0000		
ln_exr	-0.2252	-0.2404	1.0000	
ln_Y	-0.4230	0.1352	-0.2197	1.0000

4. Results and Discussion

4.1. Correlation Test

It is important to conduct correlation tests of the variables before performing regression analysis. Correlation tests reveal whether there is a linear association between variables and the strength of this association. This helps the researcher to understand the relationship between the variables. If the correlation between variables is strong, it may indicate that they share some underlying trend or pattern, which may influence the researcher's choice of which variables to include in the regression model. In multiple regression analysis, highly correlated explanatory variables (dependent variables) can lead to multicollinearity problems, affecting the stability of the model and the accuracy of the coefficients of the explanatory variables. Removing or combining highly correlated variables can simplify the model and improve its interpretability. The Result of Correlation Test is shown in Table 2 and Table 3 for before and during the war. Before the war (seen from Table 2), for ln_repx and ln_inf, the correlation coefficient between these two variables is -0.3415, indicating a moderate negative correlation between them; for ln_repx and ln_exr, the correlation coefficient of these two variables is 0.5999, indicating a moderate positive correlation between them; for ln_repx and ln_Y, the correlation coefficient is 0.8501, showing a strong positive correlation; for ln_inf and ln_exr, the correlation coefficient is -0.3508, indicating a moderate negative correlation between these two variables; for ln_inf and ln_Y, the correlation coefficient between these two variables is -0.5464, which is a very moderate negative correlation; for ln_exr and ln_Y, the correlation coefficient is 0.5210 which indicates a moderate positive correlation. During the war (shown in Table 3), for ln_repx and ln_inf, the correlation coefficient between these two variables is -0.4937, indicating a moderate negative correlation between them; for ln_repx and ln_exr, the correlation coefficient of these two variables is -0.2252, indicating a weak negative correlation between them; for ln_repx and ln_Y, the correlation coefficient is -0.4230, showing a moderate negative correlation; for ln_inf and ln_exr, the correlation coefficient is -0.2404, indicating a weak negative correlation between these two variables; for ln_inf and ln_Y, the correlation coefficient between these two variables is 0.1352, which is a very weak positive correlation, close to no correlation; for ln_exr and ln_Y, the correlation coefficient is -0.2197 which indicates a weak negative correlation. By comparing the correlation coefficients, it was found that the correlation of some of the variables was different before and during the war.

4.2. Descriptive and Regression Results

The result of descriptive statistics is shown in Table 4 and Table 5. In the presence of heteroskedasticity, the standard errors estimated by traditional least squares regression (OLS) may be underestimated or overestimated. Since standard errors are used to calculate confidence intervals and perform hypothesis testing, this bias can lead to inaccurate widths of confidence intervals as well as unreliable results of statistical significance tests. This study uses the White test [14]. The p-value is 0.2210 (before) and 0.3208 (during), which are both more than 0.05, so the null hypothesis is rejected and heteroskedasticity exists.

Table 4. Descriptive Statistics (before the war)

Variable	Observations	Mean	Std.Dev.	Minimum	Maxmum
repx	75	46850.68	16547.75	12939.39	89004.36
inf	75	2.020589	1.400005	0.1261	8.0988
exr	75	42.44479	17.85642	23.438	78.4489
Y	75	2.01e+07	2856552	1.30e+07	2.54e+07

Table 5. Descriptive Statistics (during the war)

Variable	Observations	Mean	Std.Dev.	Minimum	Maxmum
repx	7	117800.2	10695.82	98909	128829
inf	7	10.53286	5.534217	3.3	16.7
exr	7	74.67428	16.04577	57.18	103.99
Y	7	33359.77	3116.505	30165.1	38095.6

Multicollinearity is a common problem in regression analysis that occurs when two or more explanatory variables are highly correlated. This study uses Variance Inflation Factor (VIF) to detect the problem of multicollinearity. The result is shown in Table 6 and Table 7. The mean value of the VIF test before the war is 1.08, which means it is considered acceptable. The mean value of the VIF test during the war is 1.08, which means there are almost no multicollinearity problems.

Table 6. Result of VIF Test (before the war)

Variable	ln_exr	ln_inf	ln_Y
VIF	1.72	1.44	1.39
1/VIF	0.579963	0.694054	0.720891

Table 7. Result of VIF Test (during the war)

Variable	ln_exr	ln_inf	ln_Y
VIF	1.10	1.07	1.06
1/VIF	0.906518	0.935064	0.944544

Table 8. Result of Regression (before the war)

	ln_repx
ln_inf	0.108 (3.12)**
ln_exr	0.263 (4.25)**
ln_Y	2.456 (10.59)**
_cons	-31.613 (8.20)**
R2	0.78
N	75

* p<0.05; ** p<0.01

Table 9. Result of Regression (during the war)

	ln_repx
ln_inf	-0.074 (2.67)
ln_exr	-0.207 (1.89)
ln_Y	-0.463 (0.83)
_cons	17.540 (2.91)
R2	0.56
N	7

Due to the presence of heteroskedasticity, one adds "robust" to Stata's regression operation instruction. After that, the final regression result is shown in Table 8 and Table 9. The regression shows that the regression between ln_repx, ln_inf, ln_exr and ln_Y is as follows:

$$ln\_repx = -31.613 + 0.108 ln\_inf + 0.263 ln\_exr + 2.456 ln\_Y + c.c. \quad (2)$$

The regression coefficients 0.108, 0.263, and 2.456 indicate the effect of changes in ln_inf, ln_exr, and ln_Y on ln_repx, respectively. In the log-log model, these coefficients can be interpreted as elasticities. The 0.108 indicates that for every 1% change in inflation, the expected percentage change in real estate prices is 0.108%; 0.263 indicates that for every 1% change in the exchange rate, the expected percent change in real estate prices is 0.263%; 2.456 indicates that for every 1% change in GDP, the expected percentage change in real estate prices is 2.456%.

The regression shows that the regression between ln_repx, ln_inf, ln_exr and ln_Y is as follows:

$$ln\_repx=17.54-0.07ln\_inf-0.21ln\_exr-0.46ln\_Y+c.c. \quad (3)$$

The regression coefficients -0.07, -0.21, and -0.46 indicate the effect of changes in ln_inf, ln_exr, and ln_Y on ln_repx, respectively. In the log-log model, these coefficients can be interpreted as elasticities; The -0.07 indicates that for every 1% change in inflation, the expected percentage change in real estate prices is -0.07%; -0.21 indicates that for every 1% change in the exchange rate, the expected percent change in real estate prices is -0.21%; -0.46 indicates that for every 1% change in GDP, the expected percentage change in real estate prices is -0.46%.

4.3. Relation

The regression results before the start of the Russia-Ukrainian war show that the relationship between real estate prices and the exchange rate, inflation and GDP are all positively correlated, which implies that an increase in the exchange rate, inflation and GDP leads to an increase in real estate prices in Russia. However, the regression results after the beginning of the Russian-Ukrainian war show that the relationship between real estate prices and the exchange rate, inflation rate and GDP are all negatively correlated, which means that the growth of the exchange rate, inflation rate and GDP will lead to a decrease in the price of real estate in Russia. The change from rising to falling indicates that the Russo-Ukrainian war had a certain negative impact on the Russian real estate market, changing the relationship from positive to negative. The relation between real estate price and inflation rate is shown in Fig. 5. The relation between real estate price and exchange rate is shown in Fig. 6. The relation between real estate price and GDP is shown in Fig. 7.

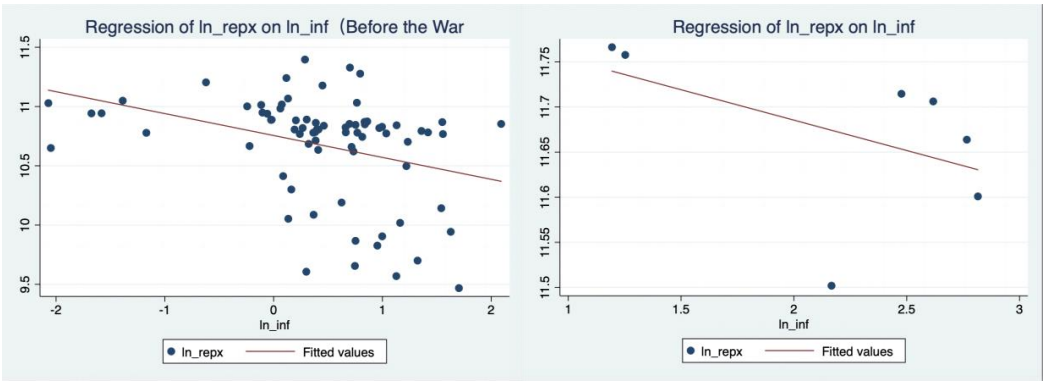

Figure 5. Regression of ln_repx on ln_inf before (left) and during (right)

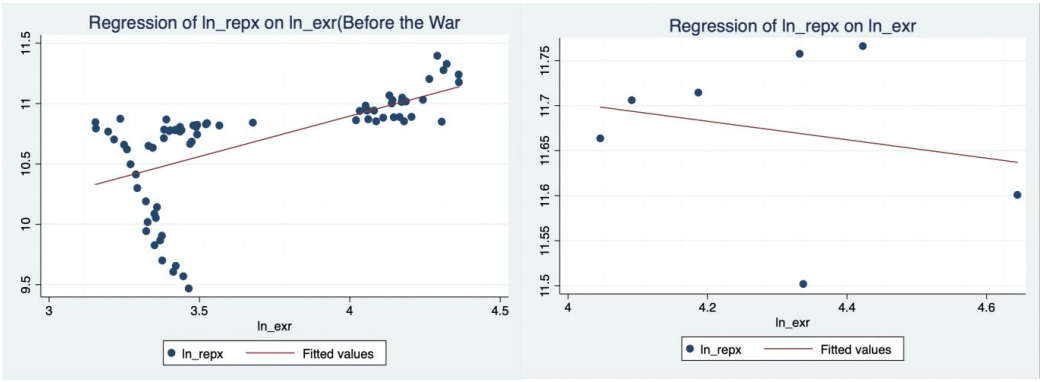

Figure 6. Regression of ln_repx on ln_exr before (left) and during (right)

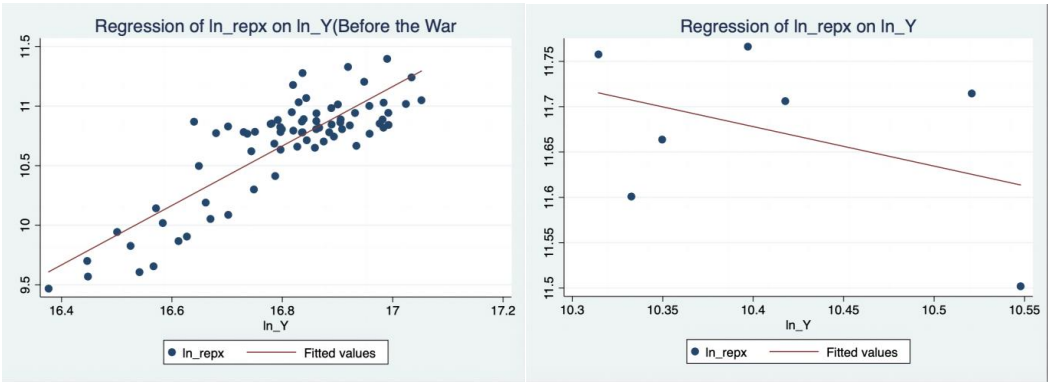

Figure 7. Regression of ln_repx on ln_Y before (left) and during (right)

The regression result of data before the war is consistent with the conclusion posted by Zhang, who presented that there is a positive relationship between real estate price and the exchange rate. This study of data during the war is consistent with the conclusion presented by others that real estate prices are negatively correlated with the RMB exchange rate in the short term. It also coincides with Jack's conclusion, by analyzing Ghana's data for a period of 32 years from 1986 to 2017, concluded through various tests that inflation has a negative impact on real estate appreciation.

4.4. Limitiaons

The model used to regress data during the war is based on seven observations, a small sample size that can lead to instability in the statistical analysis and problems with the reliability of the conclusions. Increasing the sample size can improve the statistical efficacy of the model and the reliability of the results. Significance of F-statistic (Prob > F = 0.0653) indicates the significance level of the F-statistic of the model. Generally, a p-value of less than 0.05 is considered statistically significant. In this model, the p-value of 0.0653 is slightly above 0.05, implying that the model as a whole may not be very significant. R-squared = 0.78 and 0.5601 indicates that the model explains about 78% and 56% of the variance in the target variable. The R-squared value is a measure of the goodness of fit of the model and 0.78&0.5601 indicates that the model has a moderate level of explanatory power. Besides, the data cycle for data during the war: 2022-2023. The data period is short, and the regression results can only reflect the correlation between the variables in the short term and may not be reliable in a long-term scenario. In addition, this study only analyzes the impact of exchange rate, inflation rate and GDP on the real estate market price, the macroeconomic market is a complex environment, which affects the changes of countless variables, and there may be many macroeconomic variables that are not taken into account in this study, which may lead to the regression significance is not high, the prediction is not accurate, and other problems. Since the Russian-Ukrainian war is still not over, the limited nature of the data as well as its effectiveness prevent us from analyzing its long-term economic effects. The research on this issue will require the efforts of many economists to come up with results in the future.

5. Conclusion

Through the analysis of relevant data, this paper believes that the occurrence of the Russian-Ukrainian war has changed the relationship between Russian real estate prices and the ruble exchange rate from a positive correlation to a negative correlation, which has a certain bad influence on the Russian real estate market. The Russian government should combine the war with real-time changes in efforts to maintain the stability of the ruble exchange rate against the dollar, and thus maintain the stability of the Russian real estate market. According to the regression results, the short-term increase of inflation rate and exchange rate during the Russian-Ukrainian war will lead to the decrease of the real estate market price, but the increase of inflation rate is not a good thing, which indicates that the Russian government should fully consider the impact of inflation rate and exchange rate on the real

estate market price when formulating the monetary policy of regulating inflation rate and exchange rate.

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