other aspects of economic governance. It also provides critical information for international investors, rating agencies, and global economic observers regarding the country's economic resilience and stability.

The role of international financial aid from abroad during the crisis period is essential for any country. Such financial support ensures the solvency of the country, and its ability to fulfill obligations on time, and compensates part of the economic losses incurred due to different shocks that led to the crisis. Since the beginning of the full-scale war in Ukraine, many countries, and regions provided significant financial, humanitarian, and military aid, without which Ukraine could not conduct defensive action, carry about citizens, and maintain the economy.

It is prognosed that the general amount of financial support in the form of grants and loans in 2023 will amount to 45 billion dollars. This resources will be the main source of covering the budget deficit, which will maintain at 29% of GDP in 2023. International help allows to finance the big budget deficit and to maintain the high level of international reserves for the central bank and balance the currency market [15].

It is rather important to understand, that international aid influences the amount of the international reserves, budget deficit. It has a high influence on the governmental policy in the country and macroeconomic stability.

3.3. Exploring the relationship between exchange rate dynamics and trade competitiveness of Ukraine

The main relationship between exchange rate dynamics and trade competitiveness of Ukraine is represented by Vector Autoregressive model (VAR). This model is based on the reproduction of the dynamics of the time series based on its historical values, and long-term memory of series. Thus, a feature of these models is a high empirical level.

Since it was important to investigate the short-term forecast and analyze the relationships between the variables, therefore, the VAR model was chosen. Let's move on to the first stage of building the model - data selection and preparation.

Variables that were included in the model:

- Real effective exchange rate (REER) that shows the competitiveness of national products and services relative to foreign ones. Unit – dimensionless (index);
- Net export (NET_EXP) is the difference between the export volume of the country and its import. Previously, the time series were seasonally adjusted and the data growth rate was taken. Unit – dimensionless;
- Policy rate (POLICY_RATE) is the key rate of the Central Bank that represents the impact of monetary policy on trade in the model. Unit - percentage;
- Consumer price index (CPI) that reflects the annual percentage change in prices of goods and services. Unit - percentage;
- Exchange rate (EX_RATE) is important to include because that affects the relative price of goods between countries and plays an essential role in trade. Unit – UAH/USD;
- Industry index (INDEX_IND), which describes the change in the volume of manufactured products relative to the base period. Unit – dimensionless (index);
- Reserves (RESERVES), the amount of gross international reserves of the Central Bank of Ukraine. Unit – billion USD.

The 7-time series mentioned above were chosen to build the model. The sources for them are the official statistics from the National Bank of Ukraine [23] and the State Statistics Services of Ukraine [24]. The sample research period is from the first month of 2010 to the 12th month of 2022 (2010M01 2022M12). The number of observations is 156 for each time series.

Previously, the all-time series was checked for seasonality. For this, the ACF and PACF correlogram was considered. Sinusoidal oscillations are one of the signs of seasonality. In addition, 12, 24, and 36 lags were statistically significant for certain time series. Therefore, taking into account the presence of seasonality in such time series as net exports, a seasonal adjustment was used.

The next step is to test all time series for stationarity. Since only stationary series can be applied to the VAR model. To do this, it is necessary to check the Dickey-Fuller test and perform Unit root Test in the EViews (Figure 3.5).

Null Hypothesis: Unit root (individual unit root process)
Series: REER, CPI, EX_RATE, NET_EXP, INDEX_IND, POLICY_RATE, RESERVES
Date: 04/08/23 Time: 12:47
Sample: 2010M01 2022M12
Exogenous variables: Individual effects
Automatic selection of maximum lags
Automatic lag length selection based on SIC: 0 to 1
Total number of observations: 1084
Cross-sections included: 7

Method	Statistic	Prob.**
Im, Pesaran and Shin W-stat	-5.73978	0.0000

** Probabilities are computed assuming asympotic normality

Intermediate ADF test results

Series	t-Stat	Prob.	E(t)	E(Var)	Lag	Max Lag	Obs
REER	-2.0984	0.2457	-1.532	0.735	0	13	155
CPI	-5.9326	0.0000	-1.532	0.735	0	13	155
EX_RATE	-0.0014	0.9563	-1.532	0.735	0	13	155
NET_EXP	-12.793	0.0000	-1.532	0.735	0	13	155
INDEX_IND	-0.1698	0.9384	-1.532	0.735	0	13	155
POLICY_RATE	-1.7012	0.4287	-1.530	0.745	1	13	154
RESERVES	-1.0581	0.7314	-1.532	0.735	0	13	155
Average	-3.3934		-1.532	0.736			

Figure 3.5. Dickey-Fuller test in Level

Source: developed by authors

According to the obtained results, it can be concluded that only two time series are stationary in levels - Net export (NET_EXP) and Inflation (CPI). Since the probability of the series < 0.05. The rest of the time series is not stationary in levels. Therefore, we further perform this test in the first differences, which are presented in Figure 3.6.

As a result, in the first differences in values probability, all other previous series (REER, POLICY_RATE, EX_RATE, INDEX_IND, RESERVES) are stationary. Therefore, the CPI and NT_EXPORT time series are stationary in levels (d = 0), and the other time series are stationary in first differences (d= 1).

Null Hypothesis: Unit root (individual unit root process)
Series: REER, CPI, EX_RATE, NET_EXP, INDEX_IND, POLICY_RATE, RESERVES
Date: 04/08/23 Time: 12:47
Sample: 2010M01 2022M12
Exogenous variables: Individual effects
Automatic selection of maximum lags
Automatic lag length selection based on SIC: 0 to 4
Total number of observations: 1070
Cross-sections included: 7

Method	Statistic	Prob.**
Im, Pesaran and Shin W-stat	-28.2891	0.0000

** Probabilities are computed assuming asympotic normality

Intermediate ADF test results

Series	t-Stat	Prob.	E(t)	E(Var)	Lag	Max Lag	Obs
D(REER)	-11.103	0.0000	-1.530	0.745	1	13	153
D(CPI)	-9.9470	0.0000	-1.512	0.761	3	13	151
D(EX_RATE)	-11.233	0.0000	-1.532	0.735	0	13	154
D(NET_EXP)	-10.357	0.0000	-1.495	0.771	4	13	150
D(INDEX_IND)	-11.783	0.0000	-1.532	0.735	0	13	154
D(POLICY_R...	-10.145	0.0000	-1.532	0.735	0	13	154
D(RESERVES)	-10.712	0.0000	-1.532	0.735	0	13	154
Average	-10.754		-1.524	0.745			

Figure 3.6. Dickey-Fuller test in First Difference

Source: developed by authors

Cointegration occurs when two or more variables have long-term relationships. The main prerequisites for availability cointegration relationship – non-stationarity of time series and is the same order of integration. Since a cointegration relationship cannot arise between time series of a different order of integration, the next step is the specification of a VAR model.

Firstly, it was necessary to determine the optimal number of lags to include in the model. For this, the Lag Exclusion Tests and the Lag Length Criteria test were used. It is important to correctly set the maximum number of lags, which is 10% percent of all observations. In our case, it is 15 (out of 153 observations). The obtained results are shown in Figure 3.7.

VAR Lag Order Selection Criteria
Endogenous variables: D(REER) CPI NET_EXP D(POLICY_RATE) D(RESERVES)
Exogenous variables: C D(INDEX_IND)
Date: 04/08/23 Time: 12:52
Sample: 2010M01 2022M12
Included observations: 140

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-957.7224	NA	0.694357	13.82461	14.03472	13.90999
1	-890.1775	128.3353	0.378270	13.21682	13.95223*	13.51567
2	-855.5179	63.37762	0.330070	13.07883	14.33953	13.59114
3	-823.2898	56.62933	0.298856	12.97557	14.76157	13.70134
4	-800.0768	39.13049	0.308770	13.00110	15.31239	13.94034
5	-772.9557	43.78120	0.302967	12.97080	15.80738	14.12350
6	-756.2525	25.77063	0.346816	13.08932	16.45120	14.45549
7	-730.5267	37.85372	0.351275	13.07895	16.96612	14.65858
8	-623.0276	150.4988	0.111493	11.90039	16.31286	13.69349
9	-546.6028	101.5357	0.055675*	11.16575	16.10351	13.17231*
10	-529.4912	21.51168	0.065583	11.27845	16.74150	13.49847
11	-500.7415	34.08898	0.066263	11.22488	17.21322	13.65836
12	-459.2684	46.21288*	0.056664	10.98955*	17.50319	13.63650
13	-439.8337	20.26758	0.067559	11.06905	18.10798	13.92946
14	-425.7907	13.64179	0.088809	11.22558	18.78981	14.29946
15	-397.2054	25.72675	0.097178	11.17436	19.26388	14.46170

Figure 3.7. Lag Order Selection Criteria

Source: developed by authors

The optimal length of the lags is determined at the same time for 5 information criteria – LR (sequential modified LR test statistic), FPE (Final prediction error), AIC (Akaike information criterion), SC (Schwarz information criterion), HQ (Hannan-Quinn information criterion). According to two criteria (FPE and HQ), the optimal number of lags is 9, respectively the other two (LR and AIC) have a maximum length of 12, while SC has a maximum length of 2. In this case, we will include all 12 lags, and then apply the exclusion test lags - Lag Exclusion Tests.

The main indicator of the lag exclusion test is Prob Joint. In the testing process, not all lag with p-value could be included in the model. The final result is presented in Figure 3.8.

VAR Lag Exclusion Wald Tests
Date: 04/08/23 Time: 12:53
Sample (adjusted): 2010M11 2022M12
Included observations: 146 after adjustments

Chi-squared test statistics for lag exclusion:
Numbers in [ ] are p-values

	D(REER)	CPI	NET_EXP	D(POLICY_...	D(RESERVES)	Joint
Lag 1	15.83063 [0.0073]	113.2013 [0.0000]	22.05920 [0.0005]	17.92749 [0.0030]	7.262169 [0.2019]	184.9613 [0.0000]
Lag 2	9.583968 [0.0879]	16.27622 [0.0061]	10.92789 [0.0528]	10.84307 [0.0546]	10.39725 [0.0647]	68.50767 [0.0000]
Lag 3	12.00253 [0.0348]	23.01072 [0.0003]	3.993919 [0.5503]	12.81845 [0.0251]	6.507668 [0.2599]	58.48068 [0.0002]
Lag 6	10.60516 [0.0598]	5.802659 [0.3259]	33.22948 [0.0000]	6.817974 [0.2345]	10.50497 [0.0621]	65.78080 [0.0000]
Lag 7	18.64598 [0.0022]	14.65936 [0.0119]	22.64574 [0.0004]	3.702903 [0.5929]	9.012021 [0.1086]	85.81123 [0.0000]
Lag 8	10.91723 [0.0530]	20.65143 [0.0009]	42.15989 [0.0000]	8.267995 [0.1421]	20.33487 [0.0011]	101.8758 [0.0000]
Lag 9	8.534415 [0.1291]	9.915246 [0.0777]	94.95189 [0.0000]	23.41611 [0.0003]	16.26373 [0.0061]	163.1180 [0.0000]
df	5	5	5	5	5	25

Figure 3.8. Lag Exclusion Wald Tests

Source: developed by authors

As we can observe from the figure that lags 4 and 5 were not included in the model. Since the Joint value for other lags is less than 0.05 or absolute zero, there is no need to discard the lags. At the same time we want to pay attention that for some variables the lag probability is greater than 0.05. However, the overall p-value allows such lags to be included in the model. The next phase was the definition of exogenous and endogenous variables.

A Granger test was performed to determine which of the variables could be exogenous. The test results are shown in Appendix A. Only one variable becomes an exogenous – Index Industry. The probability value was more than 0.05. The theoretical explanation is that the industry does not affect the REER directly. The greater impact has macro indicators such as the exchange rate or policy rate. Other variables remained in the endogenous block. Thus, the final specification is shown in Table 3.3.

Table 3.3. VAR Specification

Parameters	***Value***
VAR type	Standard VAR
Estimation sample	2010M01 2022M12
Endogenous variables	d(reer) cpi net_exp d(policy rate) d(reserves)
Lag Intervals for Endogenous	1 3 6 9
Exogenous variables	c d(index_ind)

Source: developed by authors

It can be seen from the figure that the number of lags is 7 (except 4th and 5th), the index industry is exogenous variables and others are endogenous, and the type of model is Standard VAR.

An important stage for determining the adequacy of the constructed VAR model is checking the residuals for white noise, as well as the normality of the distribution and for the presence of serial correlation. Let's start with the Dickey-Fuller test for residuals models that are tested exclusively in levels. The results is depicted in the Figure 3.9.

Method		Statistic	Prob.**
Im, Pesaran and Shin W-stat		-29.2157	0.0000
Im, Pesaran and Shin t-bar		-12.7335	
T-bar critical values ***:	1% level	-2.40000	
	5% level	-2.15000	
	10% level	-2.01000	

** Probabilities are computed assuming asympotic normality
*** Critical values from original paper

Intermediate ADF test results

Series	t-Stat	Prob.	E(t)	E(Var)	Lag	Max Lag	Obs
RESID01	-12.550	0.0000	-1.532	0.735	0	13	145
RESID02	-13.454	0.0000	-1.532	0.735	0	13	145
RESID03	-12.568	0.0000	-1.532	0.735	0	13	145
RESID04	-12.548	0.0000	-1.532	0.735	0	13	145
RESID05	-12.548	0.0000	-1.532	0.735	0	13	145
Average	-12.733		-1.532	0.735			

Figure 3.9. Dickey-Fuller test for residuals

Source: developed by authors

According to the test results, it can be seen that there are residuals of each separate equation stationary because Prob <0.05. Also, overall Prob value < 0.05. Therefore, the residuals of the constructed VAR model are white noise.

An important indicator of checking the distribution of residuals is when the roots of the characteristic polynomial lie within the boundaries of the unit circle (Figure 3.10).

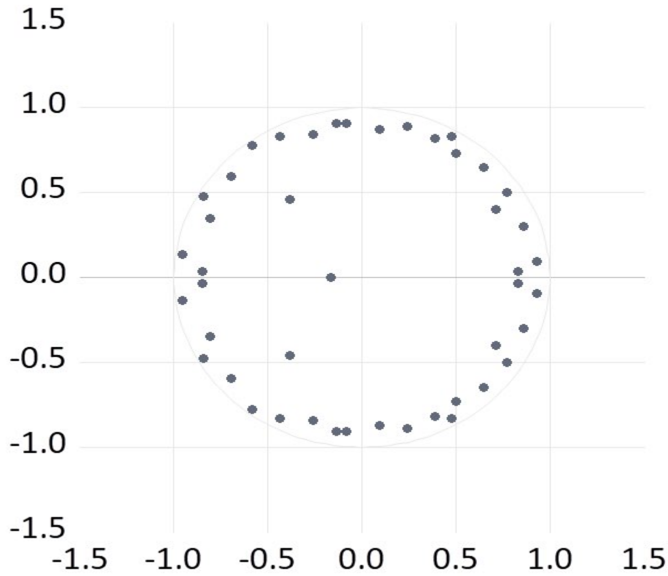

Figure 3.10. AR Characteristic Polynomial

Source: developed by authors

The graph illustrates no root lies outside the unit circle. So, VAR satisfies the stability condition. A serial correlation test showed (Figure 3.11) that it was absent.

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	18.96494	25	0.7988	0.754130	(25, 354.4)	0.7991
2	24.29179	25	0.5026	0.973076	(25, 354.4)	0.5031
3	43.10366	25	0.0136	1.772297	(25, 354.4)	0.0137
4	29.98357	25	0.2249	1.210571	(25, 354.4)	0.2254
5	25.14050	25	0.4545	1.008255	(25, 354.4)	0.4550
6	16.72227	25	0.8916	0.662901	(25, 354.4)	0.8918
7	17.27576	25	0.8715	0.685364	(25, 354.4)	0.8718
8	22.66704	25	0.5970	0.905957	(25, 354.4)	0.5975
9	16.47058	25	0.9001	0.652697	(25, 354.4)	0.9003

Figure 3.11. Dickey-Fuller test for residuals

Source: developed by authors

Based on the results of residual evaluation tests, we can say that the built VAR model is adequate and therefore we can move to the next stage - construction of the impulse response function and dispersion decomposition.

Impulse response functions (Figure 3.12) examine the sensitivity of model indicators on the effect of shocks. For example, how and how much one variable will change under the influence of another change.

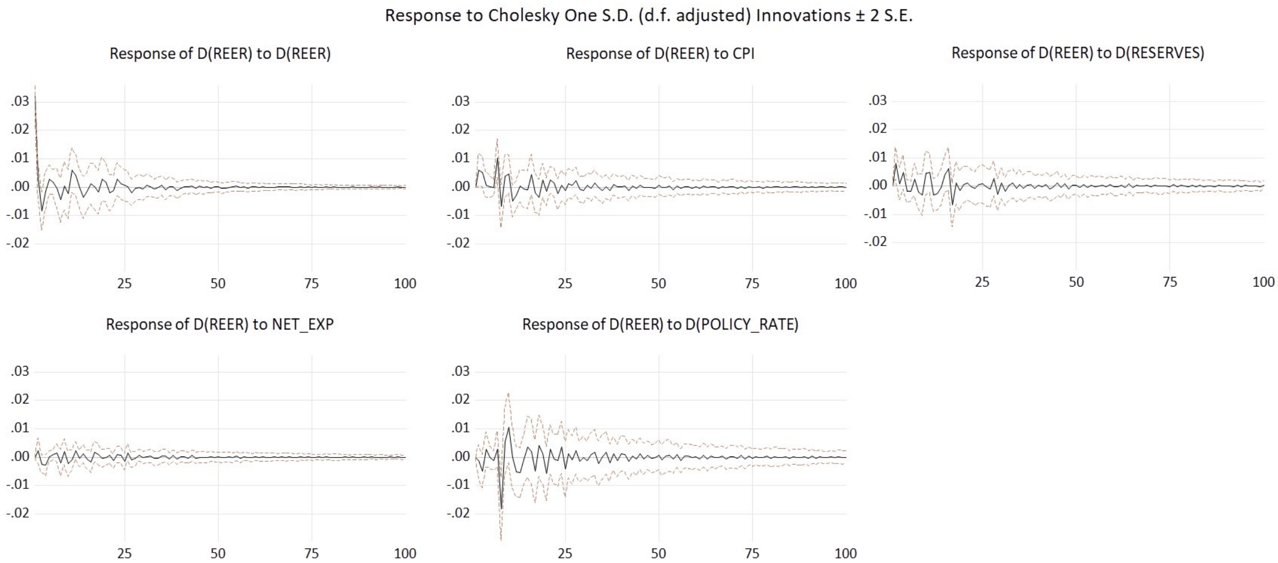

Figure 3.12. Impulse Response to Cholesky One S.D. (d.f. adjusted) Innovations

Source: developed by authors

In this research, we will consider the sensitivity of the REER, which determines the competitive positions of domestic manufacturers in response to a change, and the presence of a shock in the main indicators of the model. Firstly, it is worth noting that the impulse response function has a downward damping effect. The model constructed in this way is stable and adequate. However, it is also worth paying attention to the fact that attenuation occurs in the long term. That is, the effect of shocks has a long-term effect on destabilizing the equilibrium. Let us consider in more detail the behavior of the REER on the response of included variables.

The biggest deviation from equilibrium causes its own shock in the REER. In addition, the effect is the highest. However, attenuation is the fastest. Hence, the self-shock causes the largest deflection and at the same time the fastest decay.

The shock in inflation (CPI) does not cause significant deviations. However, the dynamics of influence are quite volatile and long-lasting. The net export (NET_EXP) variable has the smallest impact. Deviations in the model from equilibrium are insignificant. One important variable is the policy rate.

A shock in the rate initially has a smaller effect on REER, but subsequently increases, disturbing the state of equilibrium. Accordingly, attenuation is more long-lasting. This situation can be explained by the fact that the policy rate does not have a direct impact on the REER but has an impact through other macro-instruments such as the exchange rate, capital investments, and others. For example, with an increase in the policy rate, the attractiveness of investments in the national currency increases, as foreigners can get a higher return on their own investments, and the demand for the national currency increases accordingly. In this way, the appreciation of the currency takes place in accordance with other currencies, and competitiveness increases. However, such a mechanism operates with a certain time lag, which is why the greatest deviation does not occur in the first periods.

A shock in reserves does not lead to significant fluctuations. However, the impact is also long-lasting. The volume of reserves provides a certain buffer, and increased volumes raise confidence in the currency by reducing the risk of default. As a result, this leads to an appreciation of the REER.

To conclude, the largest deviation of the system from the equilibrium state causes a shock in the REER, and the least - net export. One important variable is the impact of the policy rate in addition to such variables as reserves.

The next stage of model building is the modeling of the variance decomposition. When constructing the decomposition, similar to the impulse response function, the order of the variables is essential. Since different combinations can produce different results, it is important to understand the theoretical rationale for modeling. The decomposition results are presented in Figure 3.13.

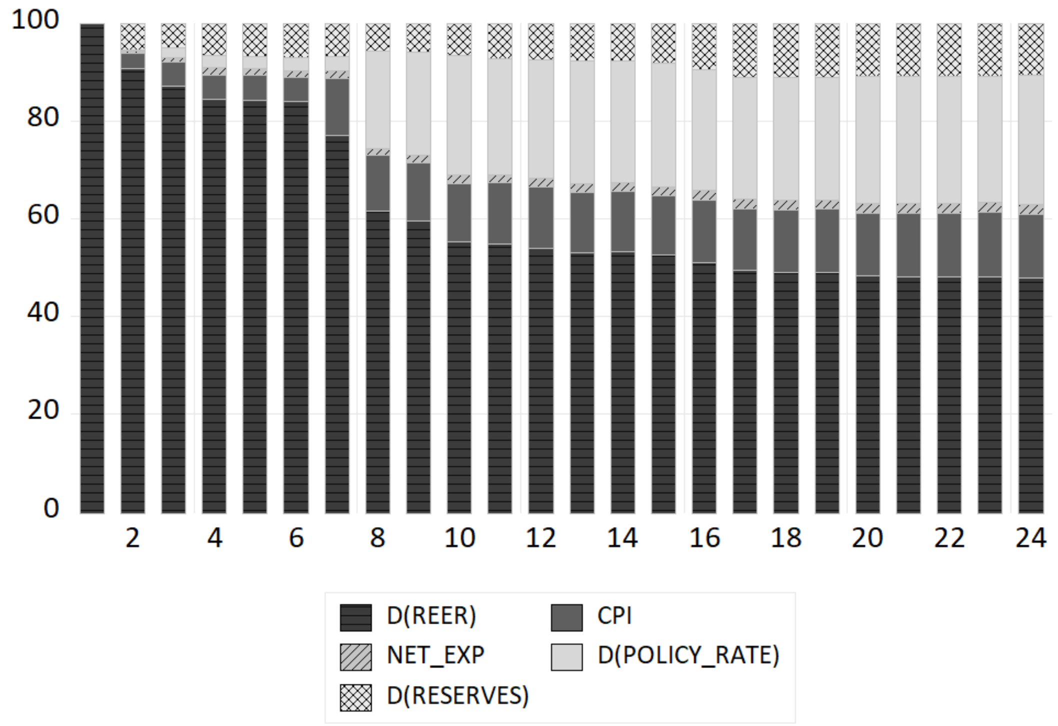

Figure 3.13. Variance Decomposition of REER

Source: developed by authors

From the dynamics of the influence of the variables included in the model (recall that the index industry is an exogenous variable), we can observe that at the end of the period, the policy rate has the greatest influence - 26%, followed by inflation - 13% and reserves - 11%. The influence of net exports is the smallest - 2%. Data dynamics variables increased over time, significant changes occurred in the 8th period. This behavior can be explained by different exchange rate regimes and the corresponding policy rate of the central bank. Thus, when the exchange rate was fixed, the effect of the policy rate on the competitiveness of goods was insignificant. However, under floating exchange rates, the role of the rate has increased.

Firstly, we briefly note why a flexible exchange rate is beneficial for the competitiveness of goods. Under the conditions of such an exchange rate regime, currency devaluation or strengthening can maintain trade competitiveness. For example, under conditions of a trade deficit, a decrease in the exchange rate of the national currency can make exports more attractive and vice versa. Secondly, under the conditions of a flexible exchange rate, the policy rate can influence such macro indicators as inflation, investments, etc., which in turn can strengthen the exchange rate and increase competitiveness. Instead, a fixed exchange rate uses the policy rate to maintain the peg. Therefore, the impact of the policy rate, which is also confirmed by the results of impulse functions, has a significant impact on the competitiveness of national producers and their international position.

3.4 Influence of the exchange rate policy on trade competitiveness of the country

It is worth starting with the fact that, according to the authors, in the post-war period, the optimal exchange rate policy is to return to a floating currency regime in future. At the beginning of the full-scale invasion in February 2022, the National Bank was forced to fix the course in order to avoid panic and support the economy and financial activity of the country. Such actions had a positive result in the first months of the war. However, in the long term, fixing the exchange rate will lead to deepening of the country's economic problems. Thus, the exchange rate of the dollar is an indicator of the purchasing power of the population, the level of competitiveness of goods of national producers, inflationary expectations, etc. In the conditions of a fixed foreign currency regime, there is an accumulation of economic imbalances that are not reflected in the dynamics of the exchange rate.

One example of such imbalances is the deterioration of the real exchange rate due to the high level of inflation in Ukraine compared to its trading partners. This leads to the reducing of the competitive advantages of Ukrainian exporters. In addition, there is a lot of pressure on foreign exchange reserves, which are constantly shrinking. Thus, the proposed option is to switch to a free-floating exchange rate within defined corridors to correct significant deviations.

According to the simulation results, the exchange rate will gradually increase, and the level of competitiveness will decrease. However, in the long run, there will be improvement. In general, the REER indicator is not a valid tool capable of influencing the dynamics of external macro indicators or the country's trading position. Such a conclusion can be drawn based on the correlations tables and the results of econometric modelling. However, this indicator is a powerful analytical