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BALANCING MONETARY POLICY IN DEFENCE ECONOMICS IN UKRAINE

ABSTRACT

The russian federation's launch of a full-scale war against independent Ukraine on February 24, 2022, has presented unprecedented challenges to the country. In addition to resistance on the battlefield, Ukraine must implement adaptive macroeconomic policies to address the situation. This combination of military and economic efforts not only prevents economic collapse but also maintains fragile macroeconomic stability during wartime. Monetary stability becomes especially important, highlighting the absolute necessity for effective implementation of monetary policy.

This article aims to identify the key characteristics of Ukraine's defence economy and forecast key policy rates and exchange rates during the war.

The prerequisite for forecasting was the analysis of endogenous and exogenous factors determining the current state of the Ukrainian economy: index of business expectations in Ukraine and partner countries, state of international trade and balance of payments, disparities in the labour market, reorientation of the state budget to military needs, devaluation of the national currency, high inflation, increase of financial capital price.

Modelling is based on consumer price index (CPI), household inflation expectations, key policy rate of the National Bank of Ukraine, real and nominal effective exchange rates hryvnia to USA dollar, gross and net international reserves, gross and net foreign exchange market interventions, the UK CPI, the USA CPI, EU CPI, and the weighted average yield of domestic government bonds. The methodology involved the use of the VECM model (Vector Error Correlation Model) and the Bagging machine learning method, adapted to time series. Using this methodology enabled an accurate forecast of the key policy rate.

In determining the optimal exchange rate, a modified formula was used that takes into account the monetary base, total bank deposits, foreign currency deposits in banks, exchange rate in the black market, and international reserves. This modification enabled the prediction of an exchange rate that closely approximates the official exchange rate.

Keywords: macroeconomic instability, monetary policy, inflation, devaluation, monetary transmission mechanism, central banking, impulse response analysis

JEL Classification: E40, E47, E52, E58, E59

INTRODUCTION

Ukraine, as a small open economy, has a long history of applying various types of monetary policy in different situations: during the period of gaining independence in the early 1990s, during the revolutions of 2004 and 2013, and later during the war, launched by the russian federation against Ukraine. When we use the term 'war' in the context of Ukraine, we distinguish its two phases: 2014 and 2022. During the first phase, Crimea was annexed and part of the Donetsk and Luhansk regions was occupied. During the second phase, the war has already covered the entire territory of Ukraine and is actually accompanied by the genocide of the Ukrainian people if we take into account the definition of genocide according to the terminology of The UN: 'killing members of the group, deliberately inflicting on the group conditions of life calculated to bring about its physical destruction in whole or in part, forcibly transferring children [40].

However, both in 2014 and 2022, Ukraine did not give up and fought on the military, economic, and financial fronts. Therefore, handling financial constraints is extremely difficult since the central bank of Ukraine is 'affected by the storm' that has no analogues in world history (the cases of previous wars are not representative since the economies in 1914 and 1939 were different). The experience of the prior phase of the war, which began in 2014, was utterly different. That is why the central bank of Ukraine, under the pressure of an unprecedented depletion of foreign exchange reserves, switched from the exchange rate to inflation targeting. In 2022 reverse transition from inflation targeting to exchange rate targeting was implemented. However, analyzing the practice of the central bank's use of monetary policy instruments proves that the key policy rate remains an important tool [20]. In this article, we intend to identify the peculiarities of Ukraine's defence economy and approaches to forecasting the inflation and exchange rate in the conditions of a full-scale war.

LITERATURE REVIEW

The key feature of the analysis of the monetary policy of Ukraine is defence economics or, in other words, an economy that functions under the conditions of significant spending on the army and waging war, which ultimately results in an increase in state debt. The fiscal nature of wars is demonstrated in Figures 1 – 2, which proves that there are no patterns by which the peculiarities of the fiscal policy of the defence economy could be distinguished. Therefore, the example of the UK (Figure 1) shows that government revenues increase rather than shorten during wars (in particular, grand and victorious for the British Empire, notably the Napoleonic wars and the two World wars). Conversely, during the American Revolutionary War, which the UK lost, British government revenues did not rise (Figure 1). Thus, depending on the policy chosen by the country's government, the tax burden on society in wartime can either increase or decrease.
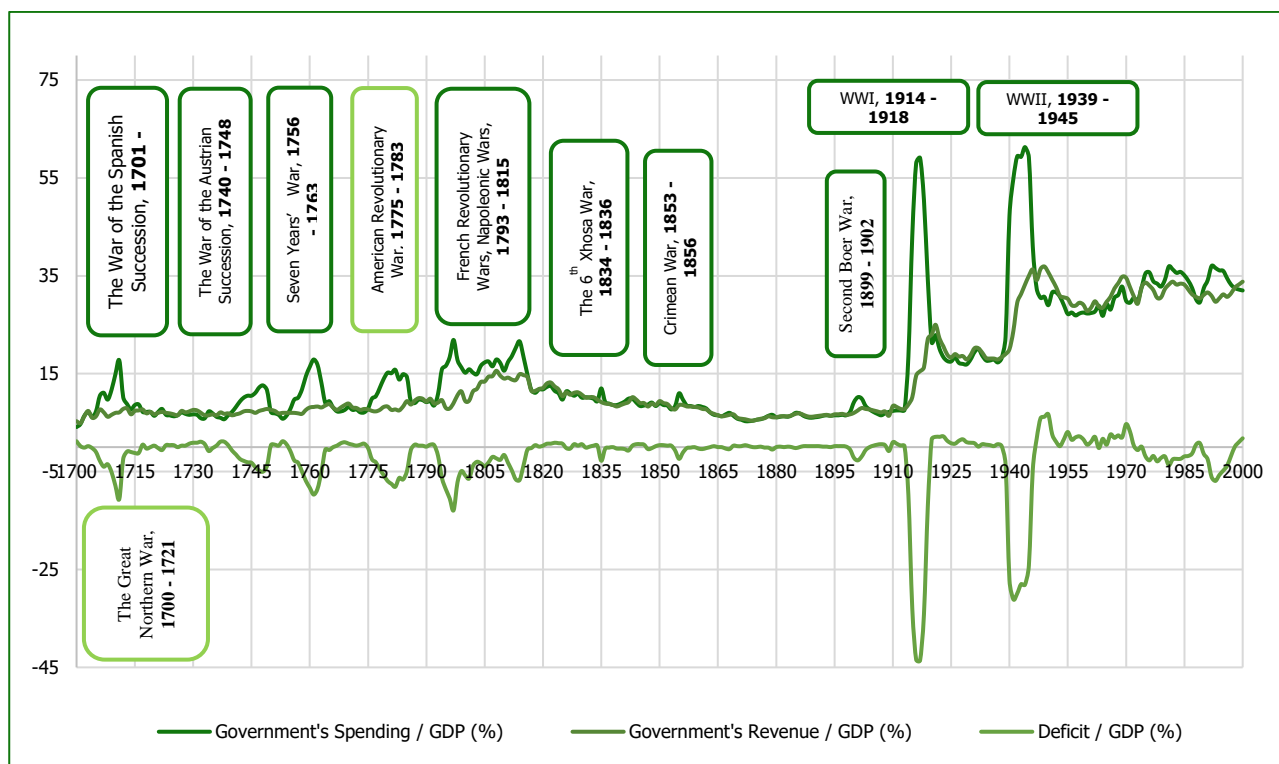

Figure 1. Trends in budget indicators in the United Kingdom in 1700 − 2000. *(Sources: authors' development based on [1])*

Fiscal policy in the US during wars is similar to the British 'model'. All three large-scale and victorious 'shooting wars' (Civil War and two World wars) were accompanied by an increase in expenditure and, in turn, revenues of the federal budget (Figure 2).
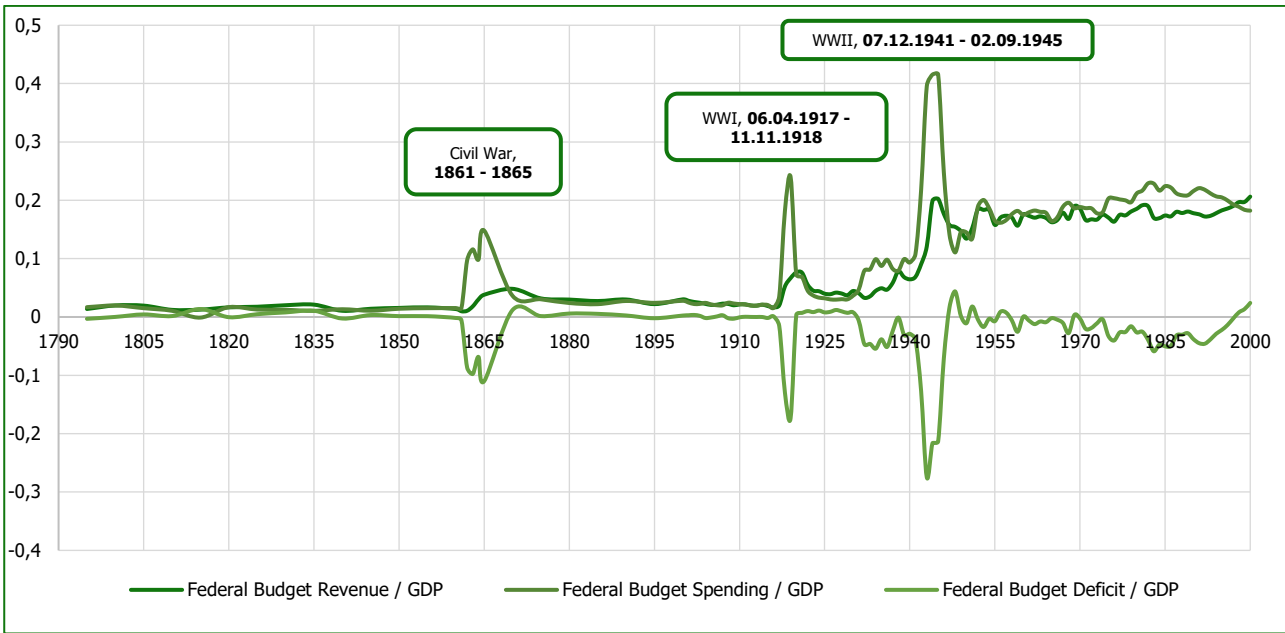
Figure 2. Trends in budget indicators in the USA in 1792 − 2000. *(Sources: authors' development based on [7; 15; 38])*

Consequently, the state fiscal policy in times of defence economics should withstand war shocks and keep the economy from a deep fall. The monetary policy in such conditions should simultaneously achieve its primary goal, price stability, i.e., counteract inflation. However, the inflationary pressure in the world economy was increasing even before the start of the war in Ukraine. The rapid and constant rise in prices, which was observed during the spread of the COVID-19 pandemic (2020 − 2021) and intensified due to the war in Ukraine, threatens sustainable economic development [34].

In general, the rise in inflation is a typical phenomenon during wars, as evidenced by Figures 3-4, and the effectiveness of the key policy rate as a monetary policy tool may be low. Thus, the key policy rate did not play a prominent role as an instrument of monetary policy during the Second World War, notably in Britain, considering that the Bank of England left it unaltered. Instead, the Bank of England actively financed the state budget deficit during the wars, which is demonstrated by the growth of the monetary base (Figure 3).
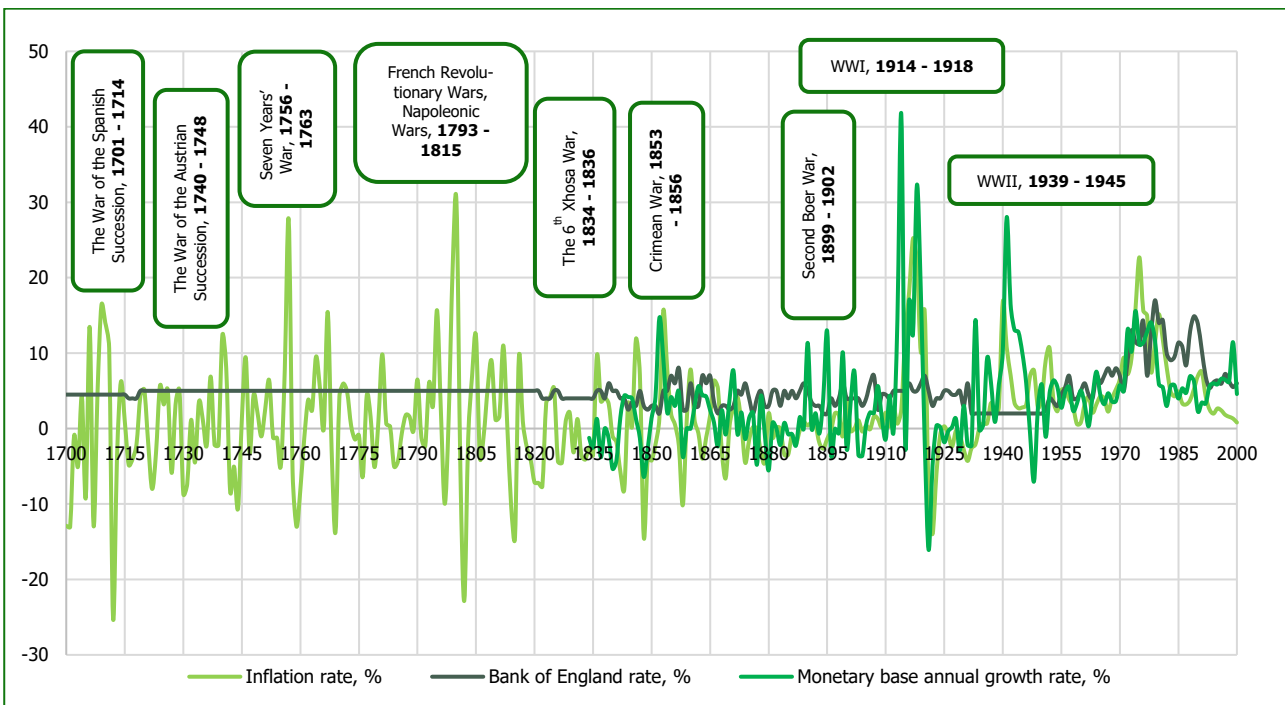

Figure 3. Trends in inflation, monetary base and key policy rate in the United Kingdom in 1700 − 2000. *(Sources: authors' development based on [1])*
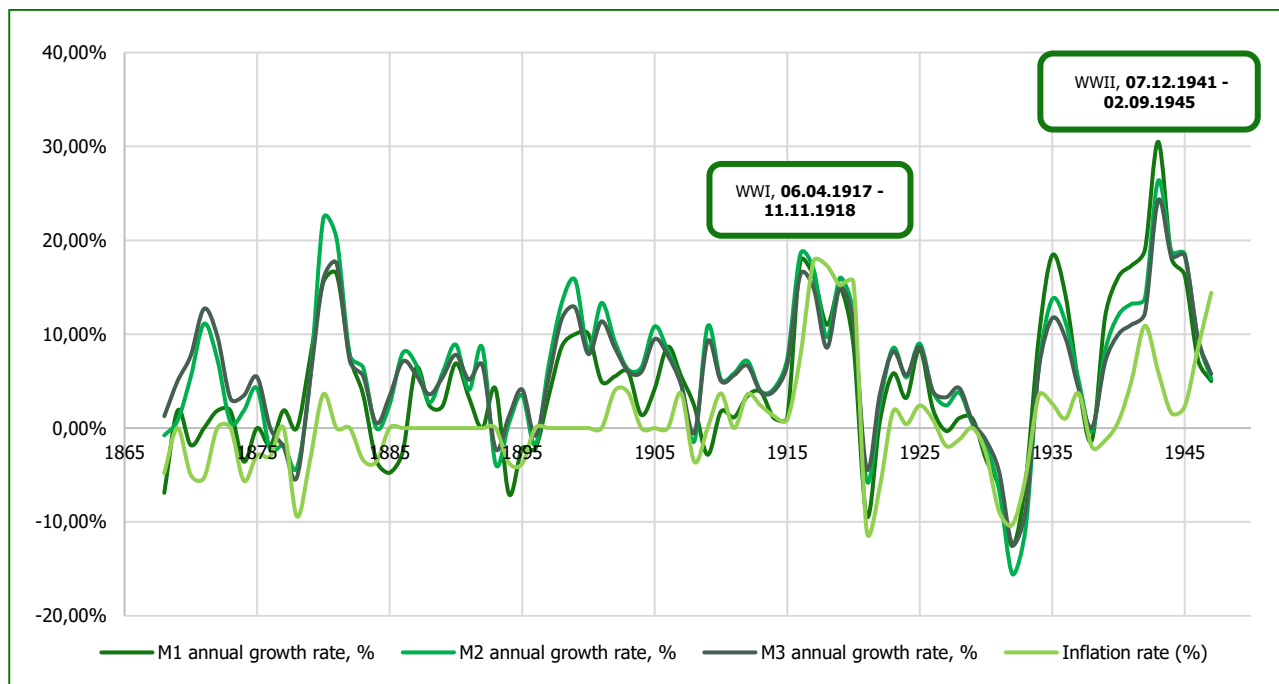
Figure 4. Trends in inflation and monetary base in the USA in 1792 – 2000. (*Sources: authors' development based on [3; 11]*)

The experience of the USA, like that of Britain, shows that monetary aggregates usually grow during wars (especially during the Second World War), mainly reflecting the intensive financing of budget deficits by the US Federal Reserve.

Therefore, Figures 1-4 illustrate that during wars in the past, there was a rapid increase in government spending; increasing tax burden; monetary financing of the budget by the central bank, despite the inflation rise. Monetary policy in such conditions will undoubtedly undergo a dramatic transformation. The main classical tools of monetary policy are 'reserve requirements, open market operations, and standing facilities' according to Adrian, Laxton, and Obstfeld (2018) [2]. However, reserve requirements nowadays are not meant to be an active monetary policy instrument, as most countries have abandoned them. Moreover, they do not play a prominent role under the conditions of defence economics, especially in times of swings of deposits. On the other hand, open market operations are an important monetary policy tool, which is supposed to undergo substantial deformations during the war (Kuznyetsova, A., Klishchuk, O. et al. (2020) [21]). The main problem is that financial markets cannot function properly under martial law (Leigh, Wolfers, and Zitzewitz, 2003 [22]). The reason is that financial markets in the country where the war is being waged practically stop operating, and their main financial instruments are solely government securities. Economic agents, among whom banks are active investors, direct funds into government securities. However, banks cannot effectively perform transformational functions during wartime. On the one hand, a bank run is a constant problem. On the other, placing funds is challenging due to the instability of the profitability of economic agents. Hence this is why government securities become banks' main assets. Therefore, the transmission mechanism of monetary policy undergoes considerable negative changes due to the disruption of the functioning of banks and financial markets (Danylyshyn and Bohdan, 2022 [8]). Accordingly, standing facilities aim to maintain banks' liquidity and stability. As a result, the key policy rate is used more as a tool of macroprudential rather than monetary policy, especially in the initial stages of the war.

In addition to the problems described above, one feature of the war in Ukraine during its second phase is the mass outward labour migration (according to statistical data, it is about eight mln people). This migration was accompanied by unprecedented financial outflows, which are extremely difficult to calculate (banks could become a source of such statistics since Ukrainians abroad continue to use bank cards of Ukrainian banks). However, even assuming that each person spends about 500 US dollars per month, the average monthly outflow can be about four billion US dollars. It indicates the intense pressure on the exchange rate, the stability of which also depends on the level of inflation in the country since shock changes in the exchange rate affect the level of inflation (Volkan, Saatçioğlu, and Korap, 2007 [42]).

Considering the monetary policy of Ukraine today, it is worth noting that the central bank tries to balance between two goals: targeting the exchange rate and targeting inflation. Depending on the situation, targets may be interchanged, which is why in this article, we will focus on forecasting inflation with the changing of the key policy rate, which is the main

instrument of monetary policy for inflation targeting, as well as forecasting the exchange rate, which would be adequate under defence economics.

AIMS AND OBJECTIVES

This article aims to establish the approach to conduct the monetary policy of the National Bank of Ukraine under the defence economy conditions. To achieve this aim, the following objectives have been set:

- to identify the primary features of Ukraine's defence economy;
- to model the key policy rate and inflation;
- to improve the forecast of the exchange rate under a fixed official exchange rate.

METHODS

The research is based on the analysis of macroeconomic indicators of Ukraine, selected countries, and the EU. These include the consumer price index, household inflation expectations, the NBU key policy rate, real and nominal effective exchange rates local currency to USA dollar, gross and net international reserves, gross and net foreign exchange market interventions, the UK CPI, the USA CPI, EU CPI, and the weighted average yield of domestic government bonds.

The data for these indicators were retrieved from the databases of the National Bank of Ukraine, Eurostat, Federal Reserve Economic Data (FRED), the World Bank, and the State Statistics Service of Ukraine. New trading partners of Ukraine were chosen for the study following the Export Strategy of Ukraine, namely the USA, the UK, and countries of the European Union area. Programming languages like Python and R were used to perform the simulation.

Each time series was tested for stationarity using the augmented Dickey-Fuller test. The results demonstrated the non-stationarity of the series so that we were able to apply the VECM model (Vector Error Correlation Model). Meanwhile, some fundamental problems arose accordingly. Firstly, proceeding from the fact that the series length was too small and the number of factors that can be included in the model was limited, the model would have high variance and a tendency to overfit. Secondly, taking into account some possible issues with the atypicality of the data, caused by an inflationary shock that had occurred during the first phase of the war in Ukraine (2014-2015), that is why data in the model started in 2016.

Furthermore, defining the hyperparameters of such a model was expected to be quite difficult. The Bagging machine learning method, adapted to time series, was used to eliminate the mentioned problems. The chosen approach involved building a large number of weak models on a random subset of factors with subsequent aggregation of the results, i.e., ensemble learning. Applying the bagging method allowed us to reduce the variance of the final model.

The abovementioned approach makes it possible to predict inflation well, but it does not permit us to analyze the model. Therefore, the scenario method was also used during the study, notably the analysis of the influence of different key policy rate values on the inflation level.

Ultimately, the Granger causality test, the impulse response function, and the forecast error variance decomposition were used to obtain a more detailed structural analysis of the model.

The basic formulae (1), proposed by Stavytskyy [36; 37] was used to determine the optimal exchange rate in wartime:

$$Predicted\ exchange\ rate = \frac{Monetary\ base + Total\ deposits\ in\ banks}{\frac{Foreign\ currency\ deposits\ in\ banks}{Official\ exchange\ rate} + International\ reserves} \tag{1}$$

Taking into account the fact of a fixed exchange rate and, therefore, the impossibility of using this formula, it was modified using the black-market exchange rate (2).

$$Predicted\ exchange\ rate = \frac{Monetary\ base + Total\ deposits\ in\ banks}{\frac{Foreign\ currency\ deposits\ in\ banks}{Exchange\ rate\ in\ the\ black\ market} + International\ reserves} \tag{2}$$

The black market of currency exchange is a market in which the exchange takes place outside of licensed institutions [23].

RESULTS

Key characteristics of the defence economy of Ukraine

1. Decrease and high volatility of the index of business expectations of partner countries in Ukraine.

Russia's full-scale war against Ukraine affects changes in various economies worldwide and their economic policies. The current situation in Ukraine led to dramatic consequences because of the openness of economies and globalization processes. Notably, a decrease in the index of business expectations of the main partner countries of Ukraine is observed. This indicator demonstrates the attitude to the war of the main trade partners of Ukraine (China, Poland, Germany, and Turkey) and new trade partners by the Export Strategy of Ukraine (the USA, the UK, Japan, and France). Business expectations of these countries decreased during 2022. This trend is most observed in Poland, Germany, the USA, and the UK. Business activity in these countries has slowed, primarily due to russia's full-scale war against Ukraine and the war-induced high inflation rates (Figure 5).
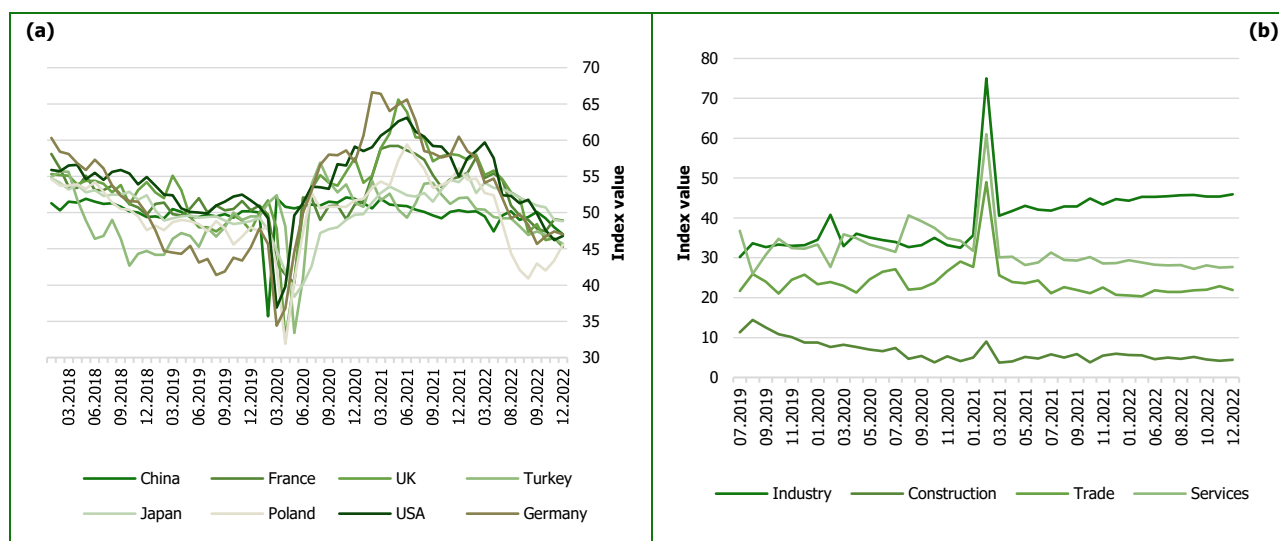

Figure 5. Trends in the business expectations index for partner countries (a) and Ukraine (b). *(Sources: [12; 30])*

Business expectations in Ukraine also demonstrated the adaptation of businesses to shock changes under martial law conditions. In particular, the rapid growth of the business expectations index was observable. The values were 43-53, which is comparatively better than during the Covid-19 massive spread period when the index fell to 19. This tendency is connected with two factors: first and foremost, there was a relocation of businesses to the regions of Ukraine that suffer the least from military actions to preserve business activity; secondly, the digital transformation of the business made it possible to adapt to new realities quickly [41]. Consequently, economic activity in Ukraine began to recover by the end of 2022 and currently shows signs of stabilization at a low level.

2. Loss of positions in international trade.

World trade indicators recovered somewhat after the COVID-19 pandemic crisis (Figure 6). Nevertheless, they decreased during the first half of 2022 due to military factors.

First of all, the existing logistical problems were caused by the loss of part of Ukrainian territories (and withal with minerals, a considerable amount of arable land, and developed business), as well as the termination of air connections, the blocking of sea transportation, the switching of railway operations mainly to the evacuation of people (especially in the first months of the war). Disruption of supply chains resulted in a reduced supply of goods and services, increased business costs, suppressed consumer demand, etc.

Secondly, the seizure of critical infrastructure facilities by the russian forces (Zaporizhska NPP, Kakhovska HPP) and terrorist attacks on energy facilities cause a significant shortage of electricity, hinder normal business operations, and, subsequently, companies' export activities. Although businesses adapt relatively quickly, their energy costs are increasing because autonomous power supply, generators, and alternative sources of communication / Internet require additional capital injections.
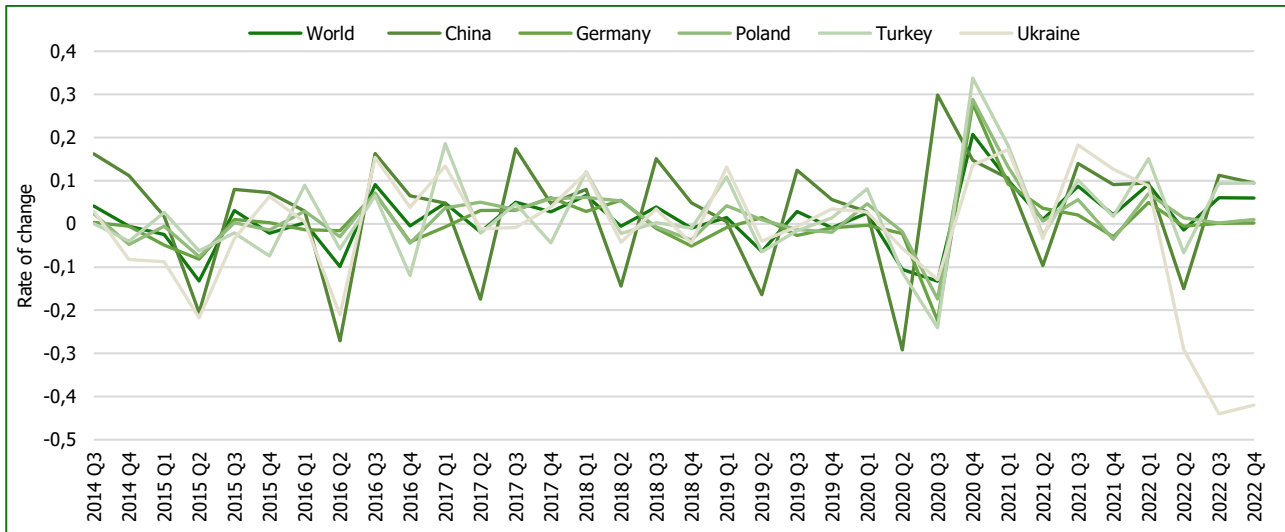
Figure 6. Trends in the rate of international trade. (*Source: [45]*)

Thirdly, the theft by the russian occupiers of a significant part of agricultural products (primarily wheat of the highest quality) in the temporarily occupied territory of the south and east of Ukraine, which traditionally accounted for the lion's share of Ukrainian exports and government revenues, significantly weakened the country's position in international trade.

3. Deterioration of the balance of payments.

The loss of Ukraine's position in international trade during wartime affects the deterioration of the balance of payments. Ukraine's consolidated balance of payments in 2022 had a deficit of USD 2.9 billion. However, the current account and the account of capital and financial transactions were characterized by different dynamics [26].

Thus, in 2022, a dramatic decline in exports was observed (-29.9%), the substitution of products of domestic production with imported ones, and an increase in purchases of alternative energy and fuel sources from abroad. An additional factor restraining the recovery of exports was the shortage of electricity, which affected the production and, accordingly, the export of certain goods (chemical, industrial, and wood products). The most significant drop in exports was in such groups of traditionally exported Ukrainian goods as ferrous and non-ferrous metals (62.6%), mineral products (47.8%), and products of the chemical and engineering industries (47.4% and 40.6%, respectively). The export of food products decreased by 15.5%, mainly due to a decrease in grain exports (by 26.2%), while the export of oil and oilseeds increased (2.5%) [26].

The negative balance of the current account, which was observed in the first months of the war, was combined with a surplus as of the end of 2022 (USD 8.6 billion, or 5.8% of GDP) [26]. The trade deficit was compensated by grants from international partners (primarily from the USA), reductions in investment income payments, and stable transfers from migrant workers. In addition, significant amounts of official international aid generated capital inflows to the financial account (more than USD 31 billion from the start of the full-scale invasion to the end of 2022). Due to stable inflows of international financial aid, especially at the end of 2022, an increase in international reserves is observable (up to USD 27.95 billion as of the end of November 2022) [29].

4. Disparities in the labour market.

The deep recession in the economy led to disparities in the labour market, rising unemployment, and a sharp reduction in the incomes of households in Ukraine. Unfortunately, due to the military operations in 2022, the State Statistics Service of Ukraine did not have the opportunity to conduct a survey of the labour market based on labour force surveys. Therefore, in the absence of such official information, data from other state institutions (NBU, Ministry of Finance of Ukraine, State Employment Service of Ukraine, Pension Fund of Ukraine), as well as job search platforms (WorkUA, OLX, robota.ua) are taken into account to analyze trends in the labour market of Ukraine).

Shelling of Ukrainian territories, physical destruction of enterprises and their owners, and long-term power outages affected the weakening of economic activity and led to a decrease in the demand for labour. In particular, according to the popular job search site WorkUA, the number of vacancies during the first two months of the war decreased significantly (almost seven times). A partial solution to the problem of low demand for labour was the relocation of Ukrainian businesses to

safer regions of the country, which prevented the withdrawal of many companies from the Ukrainian market. Since May 2022, the number of vacancies gradually increased, but in December 2022, it did not reach its pre-war level (29 thousand vacancies in December 2022 against 58.5 thousand vacancies in February 2022) (Figure 7).

Indicators of labour supply also showed multidirectional dynamics. The tendency of the first months of the war to reduce the labour supply was caused, on the one hand, by the physical annihilation of citizens of working age and, on the other hand, by the forced emigration of a significant number of able-bodied Ukrainians abroad, including highly qualified personnel (doctors, teachers, engineers etc.) However, the Ukrainian people overcame the emotional shock of the beginning of the war and showed a willingness to work to maintain an acceptable standard of living and strengthen confidence in their own financial security.
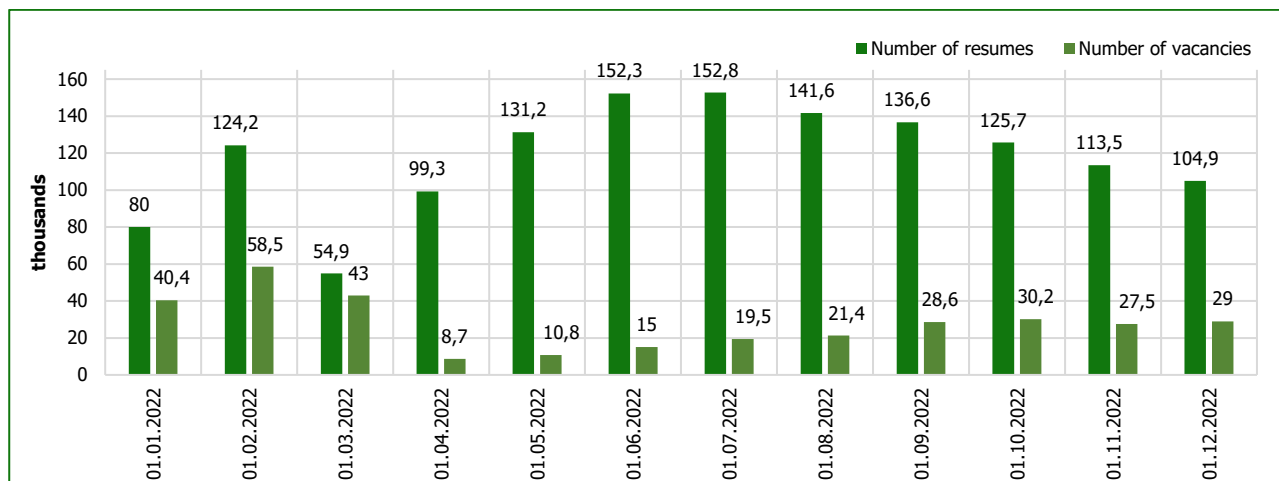

Figure 7. Number of vacancies and résumés on "Work.ua" in 2022. *(Source: [43])*

Disproportions of labour supply and demand *(number of vacancies and résumés)* result in an extraordinary unemployment situation. Given the significant excess of the labour supply over the demand, the unemployment rate in the country increased by leaps and bounds and reached 25.8% at the end of 2022 (against 9.9% in 2021) *[28]*. The recorded level of unemployment is 2.5 times higher than its natural level. Nevertheless, even though a significant part of people has lost their jobs and the number of résumés exceeds the number of vacancies (in theory, this is an increase in unemployment), official statistics record a decline in the number of unemployed in the country (Figure 8). Such a situation has a well-founded explanation. Firstly, official statistics are not based on the actual unemployment rate but only on the registered unemployment rate. Secondly, Ukrainians traditionally take their time to register at the labour exchange and look for work on their own. In addition, such factors as the outflow of the labour force abroad and distrust of official employment should also be taken into account.
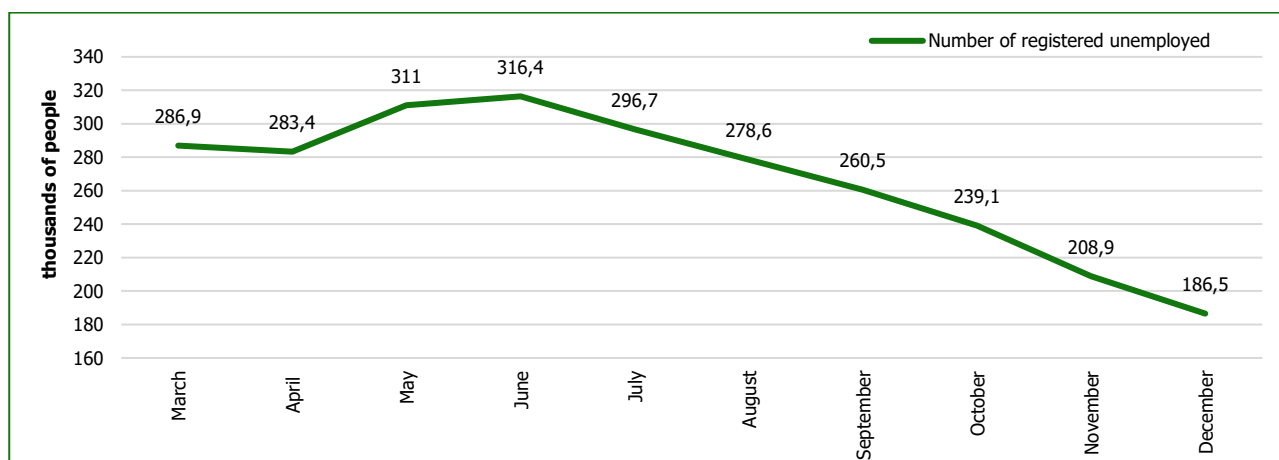

Figure 8. Dynamics of the number of unemployed in Ukraine during the war in 2022, excluding temporarily occupied territories, thousands of people. *(Source: [23])*

Disparities in the labour market caused negative dynamics of nominal and real wages. A total trend towards a decrease in wages is observed in almost all sectors of the economy.

Table 1. Trends in nominal and real wages in Ukraine, %, on average for the period. *(Sources: [28])*							
Indicators	**2019**	**2020**	**2021**	**2022**			
				Q1	**Q2**	**Q3**	**Q4**
Nominal wages	18.4	10.4	20.9	11.3	-2.7	-2.8	-2.7
Real wages	9.8	7.4	10.5	0.1	-17.9	-21.2	-23.1

An indefinite continuation of hostilities in Ukraine may deepen the disparities in the labour market discussed above. Moreover, postponing the return of a significant part of able-bodied citizens back to Ukraine and potential additional migration abroad in the long term will threaten to exacerbate structural problems in the labour market, reduce the country's economic potential, and limit consumer demand.

5. Shift the budget to military needs.

As shown above, war always leads to an increase in government expenditures, but the situation may differ in terms of revenues. Unfortunately, in Ukraine, we are observing the worst possible result: the growth of expenses and the reduction of incomes (Figure 9). It happened for several reasons, one of which was of decisive importance - the massive bombing of the entire territory of Ukraine and the destruction of critical infrastructure resulting in the curtailment of the economic activity of business entities.
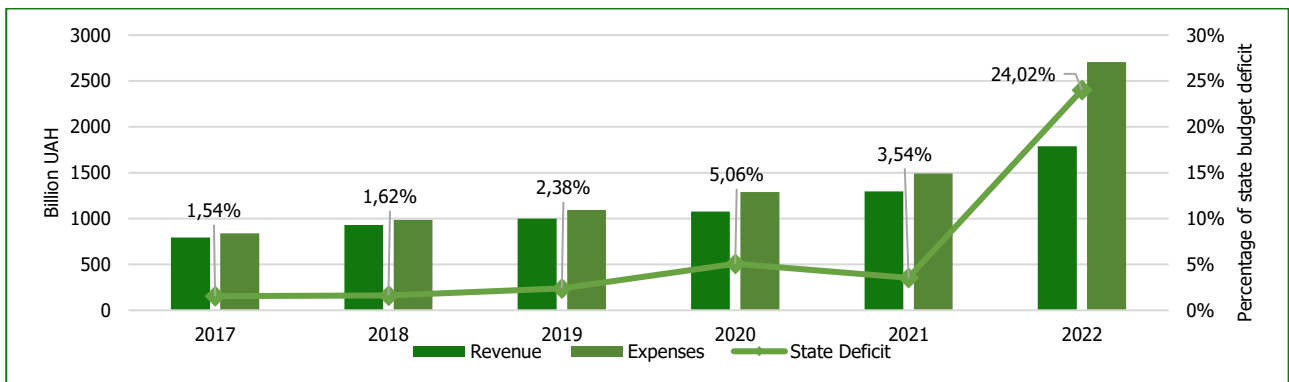

Figure 9. Trends in state budget revenues (bln UAH), state budget expenditure (bln UAH), and the ratio of state budget deficit as a percentage of GDP (%). *(Sources: [25])*

The state budget deficit was financed from various sources (Figure 10). The main sources of funding for the state budget of Ukraine since the beginning of the full-scale invasion of the russian federation on the territory of Ukraine are the emission, carried out by the NBU, bilateral agreements, and grants.
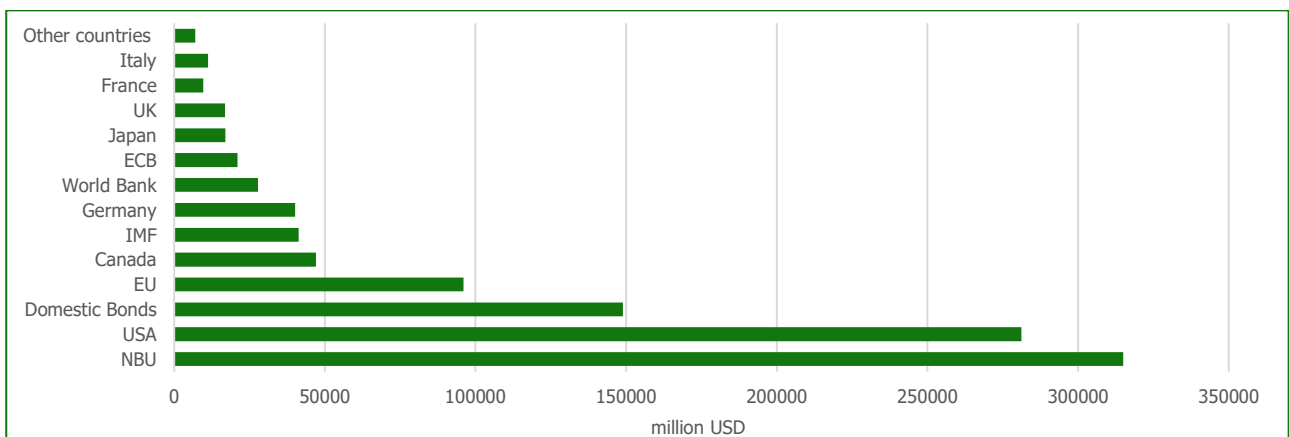

Figure 10. Trends in state budget revenues (million USD), state budget expenditure (million USD), and the ratio of state budget deficit as a percentage of GDP (%). *(Sources: [25])*

6. The devaluation of the national currency.

The devaluation of the national currency in Ukraine is the first thing that typically happens in times of crisis since the population of Ukraine is still focused on foreign currency as a tool for preserving capital [19]. During the first phase of the war, in 2014, the devaluation of the national currency against the US dollar amounted to 49.31% (at the official rate of the National Bank of Ukraine); during the second phase of the war, in 2022 – only 25.41%, despite the significant outflow of financial capital abroad. It is worth noting that the devaluation of the national currency can be restrained not only through the introduction of currency restrictions but also through the ability to maintain the appropriate level of foreign exchange reserves. Thus, if international reserves amounted to USD 30.941 bln on 01.01.2022, they constituted USD 28.494 bln on 01.01.2023. Accordingly, stabilizing foreign exchange reserves is a positive moment amid the devaluation of the national currency.

The choice of the exchange rate as a monetary policy target undoubtedly put pressure on international reserves and the volume of currency interventions (Figure 11).
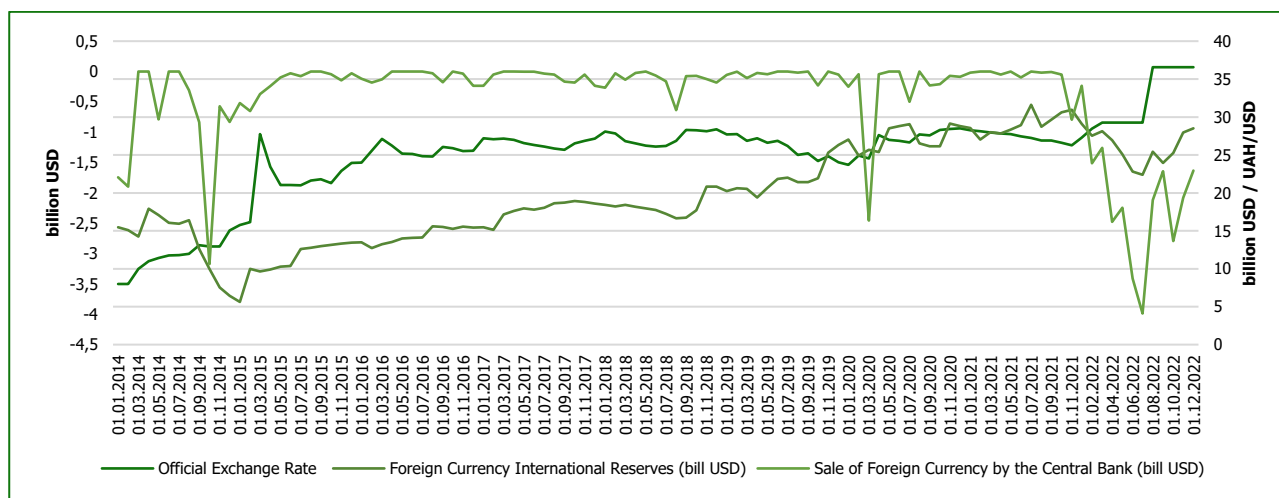

Figure 11. Trends in the foreign exchange rate, and international reserves. *(Sources: [30])*

7. Financial capital's price increase.

Financial capital's price increase is meant to be quite a natural phenomenon in times of war since the risks are increasing. However, there may be multidirectional trends since deposit interest rates may have a downward trend, while lending ought to have an upward trend in the conditions of modern war (Figure 12).
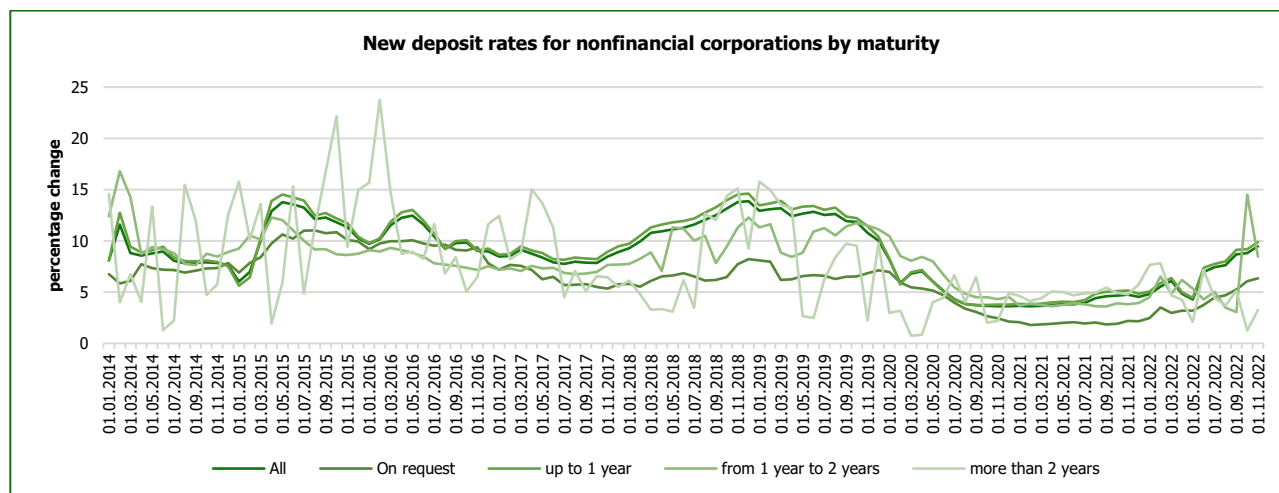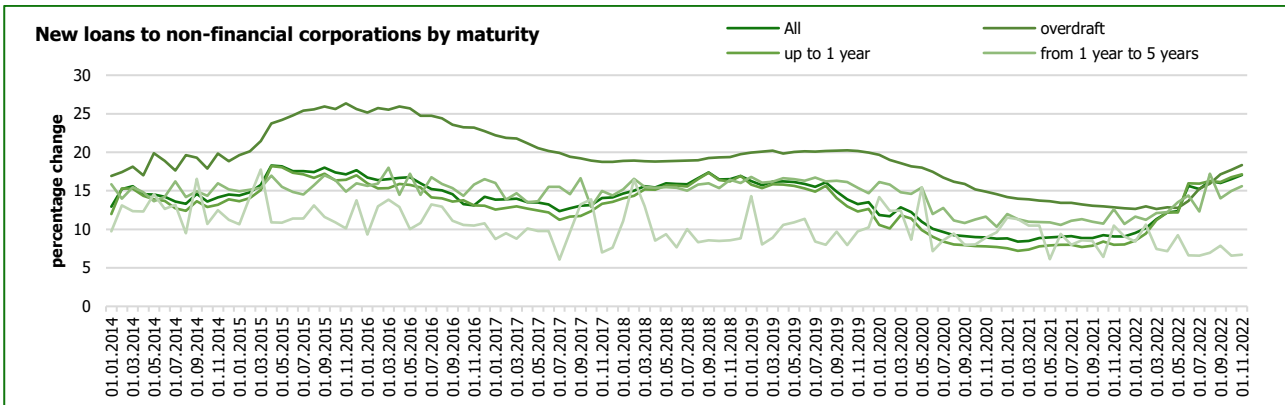

(figure continued on next page)

Figure 12. Trends in interest rates. *(Sources: [30])*

The trend of lowering deposit interest rates can be explained by the fact that banks faced excess liquidity due to caution about lending under conditions of uncertainty in the external environment. In addition, households in the conditions of the war (robbery by the russian military forces, destruction of housing due to russian bombardments) have come to realize that saving money in banks is more guaranteed than in cash. In addition, under martial law, the Deposit Guarantee Fund of Ukraine introduced a 100% guarantee on household deposits. As a result, deposit interest rates are lower than the inflation rate, which according to the National Bank of Ukraine, is 26.6% for the period December 2021-December 2022, and as well as lower than the NBU key policy rate, which was increased on June 3, 2022, from 10% to 25% and remains unchanged until March 2023. The issue of government securities and their pricing, given the pressing problems with the state budget, is specifically essential.

The weighted average interest rate for domestic government bonds of Ukraine denominated in hryvnia, increased sharply in June 2022 because the interest rates on military bonds have been tied to the key policy rate since legislation amendments (June 9, 2022). Rates for other domestic government bonds continue to be lower than the NBU key policy rate. A higher rate would increase the demand for hryvnia assets and, as a result, reduce the demand for foreign currency and the pressure on international reserves. Nonetheless, government debt financing would be more expensive (Figure 13).
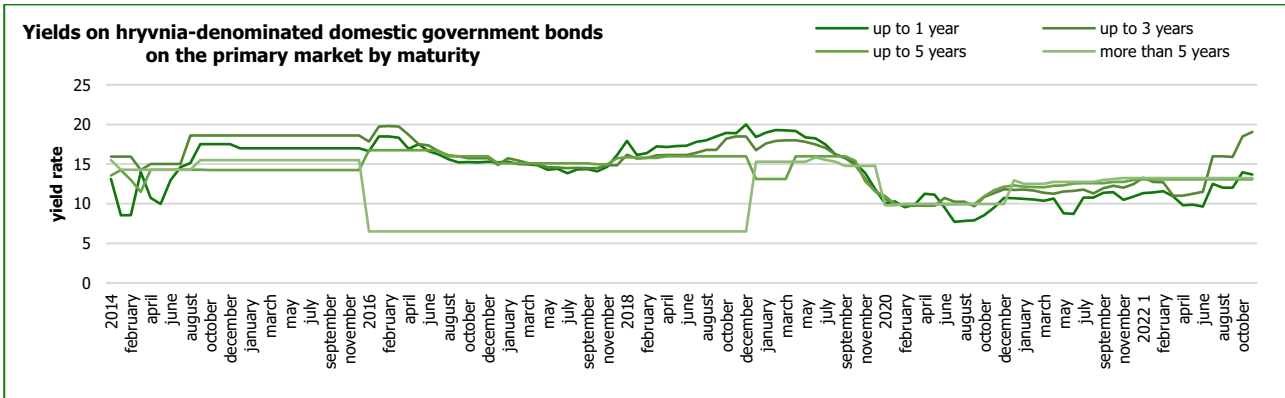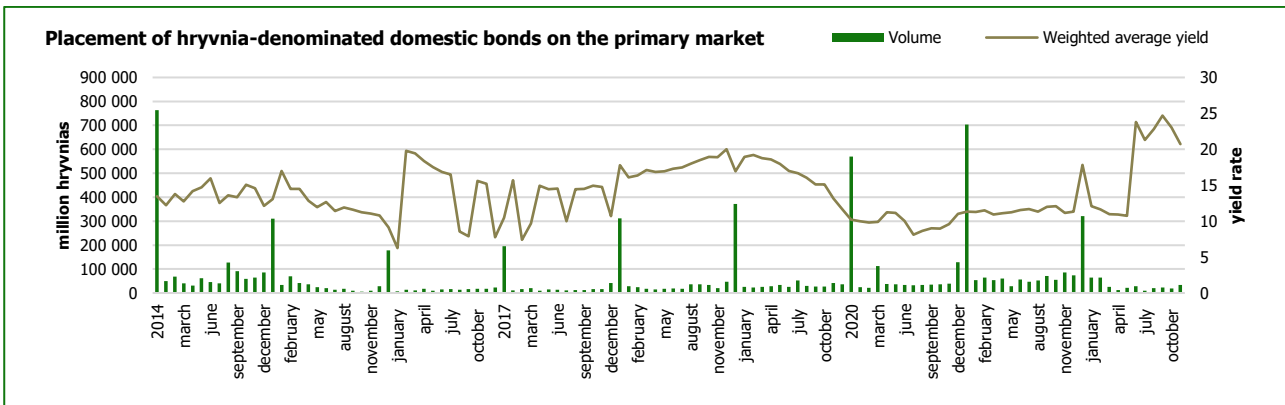
Figure 13. Government bonds characteristics. *(Sources: [30])*

8. Rise in inflation rate.

The war and its consequences caused inflation acceleration in Ukraine. Consumer inflation reached 26.6% in December 2022 [30]. Inflationary expectations deteriorated sharply during the full-scale war (Figure 14). According to the surveys conducted by NBU, financial analysts and enterprises have the highest inflation expectations.

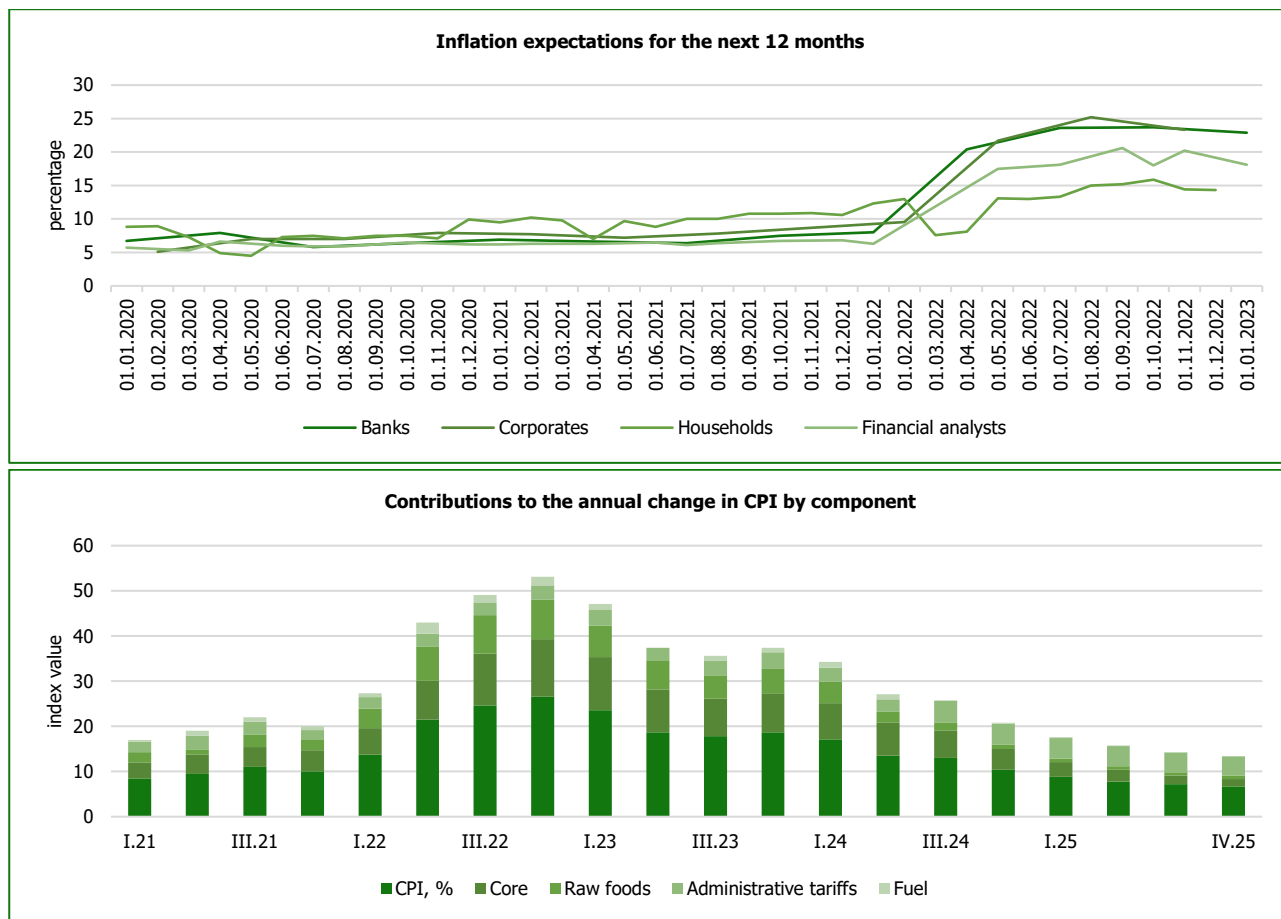**Figure 14. Inflation characteristics.** *(Sources: [30])*

In Ukraine, the relationship between the growth rate of monetary aggregates and the inflation rate is not as significant as in the USA or the EU. However, the sharp growth of M0 and M1 in February-April 2022 may be considered a factor in accelerating inflation in Ukraine (Figure 15).
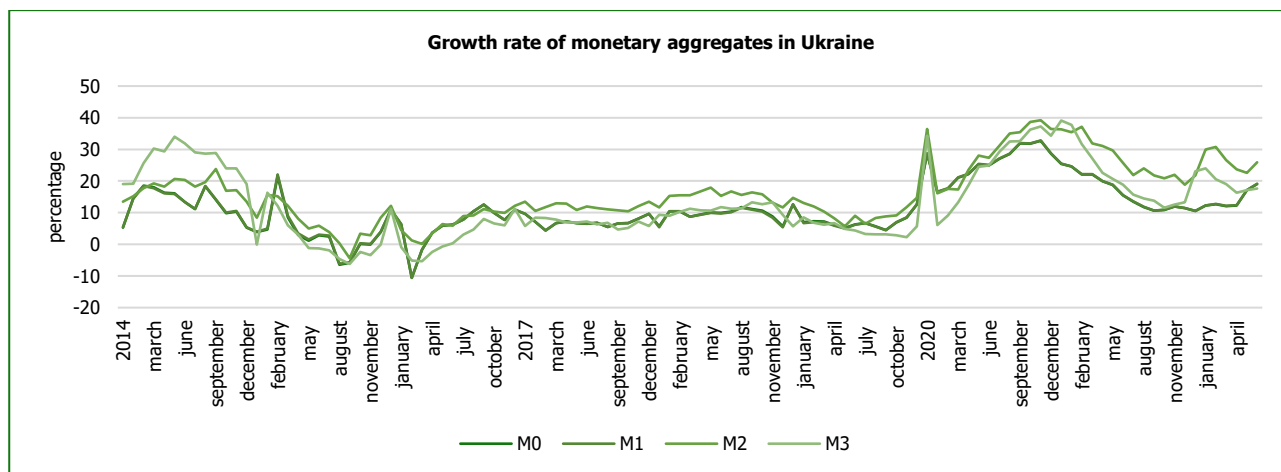

Figure 15. Trends in M0, M1, M2, M3. *(Sources: [30])*

Peculiarities of the transmission mechanism of monetary policy in the defence economy of Ukraine.
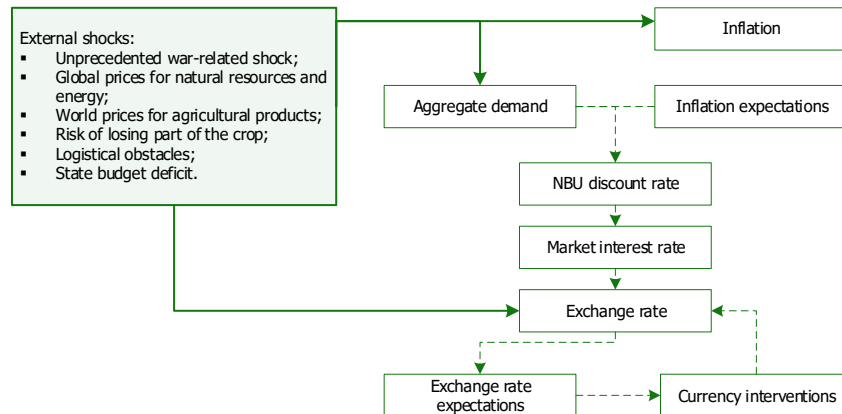

Figure 16. The transmission mechanism of monetary policy under conditions of the defence economy of Ukraine. *(Sources: authors development based on [28; 33])*

Figure 16 shows two main channels of the transmission mechanism of monetary policy, notably the interest rate channel and the exchange rate channel, under the conditions of main shocks (war, rising world prices for natural resources, energy, agricultural products, logistical obstacles, and the deficit of the state budget).

In most cases, the interest rate channel is considered the most effective in developed countries, where financial markets function very well. As we noted above, in wartime, activity on the financial markets is as much curtailed as possible. However, the key policy rate, in this case, plays a different role - the role of a benchmark of the value of money for banks, businesses, and households. Moreover, changes in the key policy rate in one direction or another indicate changes in the type of monetary policy of the central bank, namely expansionary or restrictive. Given that changes in indicative central bank interest rates do not occur often, economic agents can predict what will happen in the coming months to the price of financial resources. Eventually, this will result in changes in the structure of demand, inflation, employment, etc.

The exchange rate channel is quite specific and common, predominantly for developing countries and countries with emerging markets. This channel is currently actively used by the National Bank of Ukraine. Maintaining a fixed exchange rate is ensured primarily by operating international reserves in conditions of an unprecedented outflow of foreign currency abroad and people's attraction to the dollarization of savings.

Forecasting the inflation rate using VEC modelling.

Modelling using the Bagging machine learning method and ensemble learning allowed us to forecast inflation adequately using such factors as household inflation expectations, the NBU key policy rate, real and nominal effective exchange rates local currency to USA dollar, gross and net international reserves, gross and net foreign exchange market interventions, the UK CPI, the USA CPI, EU CPI, and the weighted average yield of domestic government bonds [4; 9; 10; 12; 18; 30]. We used monthly data from 2016 to build the forecast.

The forecast was created for the period from July to December 2022. As a result, the following inflation forecast values were obtained (table): for July, it was 22.10%, August: 23.81%, September: 24.62%, October: 23.63%, November: 23.05%, and December: 22.55%. Confidence intervals (limits of deviation from the predicted level) were calculated for each month. The deviation of the projected inflation rate from the actual is insignificant and falls within the calculated confidence intervals. According to the model, a decrease in the level of inflation at the end of 2022 to 22.55% was predicted, but the actual CPI was 26.6%, however, this value is still within the confidence interval of the model (Table 2).

Table 2. Predicted and actual CPI in Ukraine in July - December 2022.

Indicators	July 2022	August 2022	September 2022	October 2022	November 2022	December 2022
Predicted CPI, %	22.10	23.81	24.62	23.63	23.05	22.55
The lower limit of the confidence interval, %	20.38	22.13	20.10	17.57	13.67	11.73
The upper limit of the confidence interval, %	23.82	25.49	29.14	29.69	32.43	33.37
Actual CPI, %	22.2	23.8	24.6	26.6	26.5	26.6
The variance between predicted and actual CPI, pp.	-0.1	0.01	0.02	−2.97	-3.45	-4.05

Inflation rate forecast under conditions of the change in the key policy rate, based on scenario analysis.

Scenario analysis allows for determining the forecast rate of inflation depending on different levels of the key policy rate. This scenario analysis used key policy rates from 15% to 25%. Afterwards, projected inflation levels were determined based on the VEC mentioned above model's application. According to the results of this analysis, it can be determined that the lowest forecast inflation rate is observed under the key policy rate being equal to 24% and 25%, which is generally logical and corresponds to theoretical principles (Figure 17).
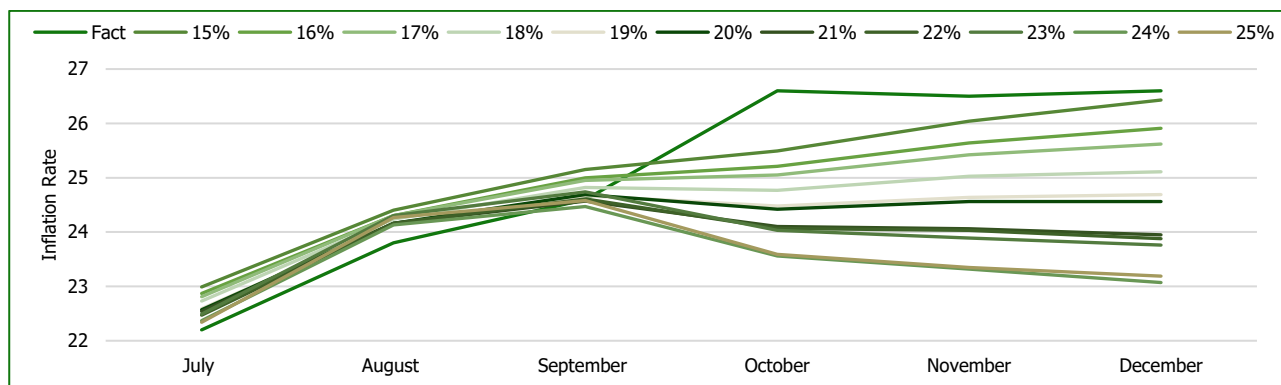

Figure 17. Forecast of CPI under different scenarios for the key policy rate.

Structural analysis of the model.

The application of the Bagging machine learning method allowed us to forecast inflation adequately, but not other indicators, so the best model was chosen. The best model is the one with the smallest mean absolute deviation of the forecast from the forecasts of the ensemble model. The model search algorithm showed that the best model is the model with the following factors: the inflation rate in Ukraine, the inflation rate in the EU, the balance of foreign exchange interventions, the real effective exchange rate, and the key policy rate.

According to this model, we have the following forecasts. Firstly, it can be observed a trend towards a gradual increase in the rate of inflation in the EU countries, which reflects the unstable geopolitical situation, the energy and food crisis; secondly, an increase in the real effective exchange rate, which indicates the devaluation of the hryvnia and a decrease in the competitiveness of Ukrainian goods on the world market; and thirdly, the significant amplitude of fluctuations in the balance of foreign exchange interventions, which indicates the efforts of the NBU to keep the exchange rate at the appropriate level (Figure 18).
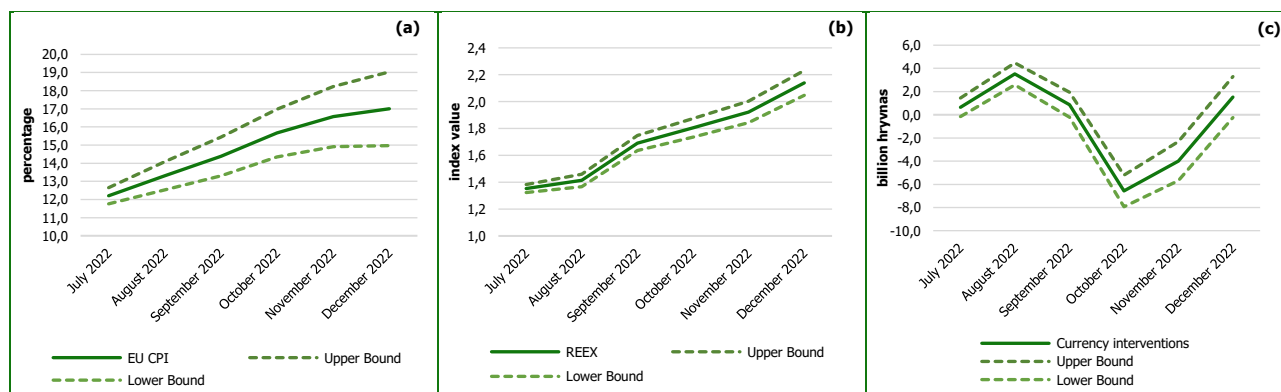
Figure 18. Forecast of inflation in EU countries (a), REEX in Ukraine (b), and the balance of foreign exchange interventions (c) (July – December 2022).

Impulse response functions (IRF).

IRFs were calculated for the following pairs of indicators: CPI response to a change in the key policy rate; REER response to foreign exchange interventions. Impulse response functions show an insignificant effect of the key policy rate on inflation, which is confirmed by the Granger causality test. Therefore, the key policy rate is currently not Ukraine's principal

instrument of monetary policy. Furthermore, according to the model, the rate of inflation in Ukraine substantially depends on the inflation level in the EU; thus, inflationary processes in Ukraine are influenced by the external environment. A significant impact of foreign exchange interventions on REER is observed after six months from the moment of their application; therefore, foreign exchange interventions remain the key tool for maintaining the exchange rate (Figure 19).
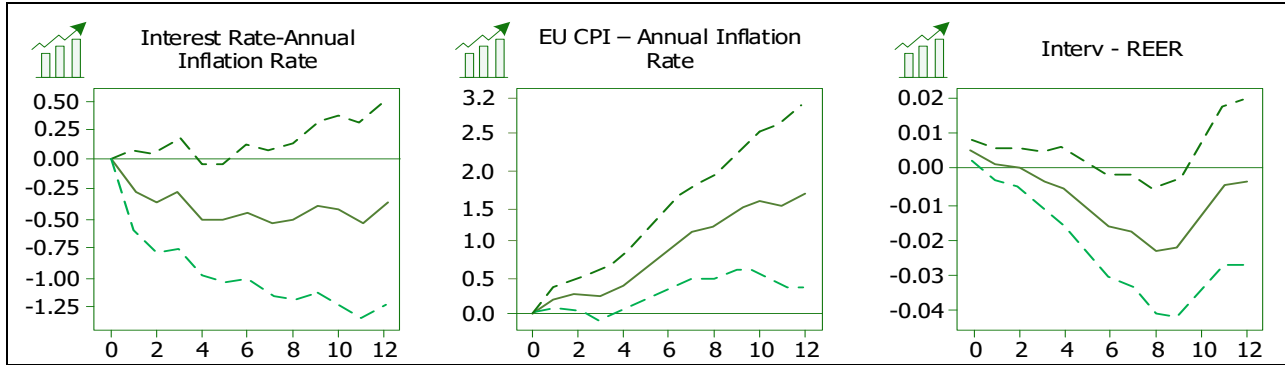

Figure 19. Impulse response functions.

Forecast error variance decomposition (FEVD).

In addition, we considered the indicators for which the impulse response functions were applied from the point of the combined influence of factors over time. Figure 20 shows the dependence of each of the indicators on the set of the remaining indicators. Thus, the variation of inflation in Ukraine is significantly dependent on inflation in the EU, the influence of which only tends to increase over time. The result of the influence of foreign exchange interventions appears starting from the ninth month. The influence of REER cannot be determined; it is variable in each period. The same applies to the key policy rate.

Changes in the real effective exchange rate are principally explained by the influence of foreign exchange interventions conducted by the NBU and inflationary processes in Ukraine. The impact of inflation in the EU is not so distinct; nevertheless, it increases over time. Therefore, the variability of the key policy rate is not so significant for REER and its impact on it is constantly diminishing.

The key policy rate is almost not affected by inflation in Ukraine and REER; however, inflation in the EU has a significant influence on it, which is manifested from the third month and is growing rapidly. The impact of foreign exchange interventions on the key policy rate rises rapidly up to month six and then begins to decline.

Concerning currency interventions, we observe a slightly variable impact of inflation in Ukraine on it. However, the impact of inflation in the EU only grows over time, although it becomes noticeable only in the third month. On the contrary, the influence of REER and the key policy rate decreases over time.

The analysis allows us to conclude that monetary policy instruments affect economic processes with a delay, which is explained by the inertia of these same processes.
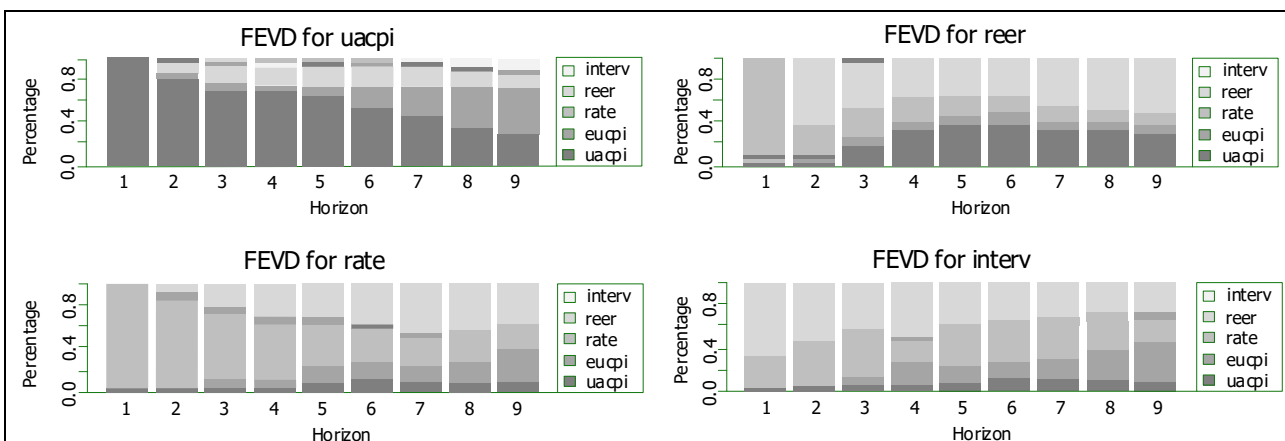

Figure 20. Forecast error variance decomposition.

The optimal exchange rate from January to December 2022 was calculated according to the formula (2) mentioned above (2). As a result, the following optimal values of the exchange rate were found (table): for January, it was UAH 29.8, February - UAH 29.49, March - UAH 34.13, April - UAH 35.71, May - UAH 37.54, June - UAH 37.99, July - UAH 41.51, August - UAH 42.40, September-UAH 43.32, October-UAH 41.07, November-UAH 40.95, December-UAH 41.86. Therefore, the deviation of the calculated exchange rate from the actual in the black market is insignificant (Table 3).

Table 3. Predicted and actual exchange rate in Ukraine in January - December 2022. (*Sources: compiled by the authors based on the [23]*)		
Month	**Actual exchange rate in the black market, ₴**	**Predicted exchange rate in the black market, ₴**	**The variance between predicted and actual exchange rate, ₴**
January 2022	28.27	29.80	1.53
February 2022	27.00	29.49	2.49
March 2022	31.80	34.13	2.33
April 2022	33.50	35.71	2.21
May 2022	35.40	37.54	2.14
June 2022	35.48	37.99	2.51
July 2022	40.00	41.51	1.51
August 2022	40.53	42.40	1.87
September 2022	41.94	43.32	1.38
October 2022	39.75	41.07	1.32
November 2022	40.15	40.95	0.80
December 2022	40.65	41.86	1.21

The adequacy of the model depends on a number of risks: the threat of the loss of new territories or slowdown of the return of lost territories, which will lead to a decrease in production volumes, labor force and economic activity; destruction of infrastructural facilities with a further decrease in the volume of output; strong dependence of inflation on supply shocks in the market of agricultural products (increase in the export of agricultural products in the export structure); the threat of a decrease in cultivated areas and their yield; logistical risks and the possibility of closing (full or partial) the "grain corridor"; risks related to the energy sector; the dependence of inflation on the inflation of trading partner countries, which are affected by their own shocks (energy, food crises etc.); cease of international financial aid from international institutions, which will lead to a significant drop in the government's solvency; termination of cooperation with the IMF (loss of the possibility of debt refinancing in conditions of limited access to financial resources).

DISCUSSION

As these findings are the initial depiction of the peculiarities of the defence economy, they hold significant implications for future research. Further studies could be dedicated to a more comprehensive analysis that maps out the taxonomy of the essential characteristics of the defence economy in greater depth.

In light of these results, it may be worthwhile to stress that applying Bagging can have some limitations if the individual models in the ensemble are highly correlated. Overall, careful consideration of the specific characteristics of the data and the models being used is necessary when applying any ensemble method in order to achieve research goals.

It is important to note that the presented solution is just one of the possible approaches for forecasting exchange rates. Furthermore, this solution is tailored to the highly dollarized economy of Ukraine. Future research could investigate the applicability of this approach to other dollarized economies and consider alternative approaches that may better suit different economic contexts.

Additionally, as research tools and artificial intelligence continue to advance, it will become possible to analyze a much larger number of factors that may impact exchange rates. This opens up new opportunities for more accurate and comprehensive forecasting models. Therefore, it is crucial to continue exploring and improving upon existing methods to enhance our understanding of the complexities of exchange rate fluctuations.

CONCLUSIONS

The current state of the Ukrainian economy can be characterized as a defence economy, one that operates amidst substantial military spending and ongoing warfare. As a result, inflation has accelerated, public debt has risen, and other

challenges have emerged. To address these challenges, fiscal policy must withstand the impact of war shocks and prevent a significant economic downturn. Meanwhile, the monetary policy should focus on maintaining monetary stability, which involves countering inflation and stabilizing the exchange rate.

The research methodology is based on the analysis of macroeconomic indicators: annual consumer inflation, inflation expectations of households, the NBU key policy rate, real and nominal effective exchange rates, gross and net international reserves, the balance of foreign exchange interventions, and the weighted average yield from government securities obtained from the Eurostat databases, Federal Reserve Economic Data, World Bank, National Bank of Ukraine, Ministry of Finance of Ukraine, State Statistics Service of Ukraine.

Analyzing critical characteristics of Ukraine's defence economy leads to several conclusions. Business expectations and activity among Ukraine's main trading partners decreased during 2022, primarily due to russia's full-scale war against Ukraine and the resulting inflation rates. However, business expectations in Ukraine have adapted to the shock changes resulting from martial law. While world trade indicators have somewhat recovered from the COVID-19 pandemic, in 2022, they decreased due to the ongoing war and deepening security risks. The loss of Ukraine's position in international trade during wartime has worsened its balance of payments, with a deficit of USD 2.9 billion in 2022. Nevertheless, the current account and the account of capital and financial transactions exhibited different dynamics.

The deep economic recession led to disparities in the labour market, rising unemployment and a sharp reduction in household incomes. Shelling of Ukrainian territories, physical destruction of enterprises and their owners, and long-term power outages affected the weakening of economic activity in business and led to a decrease in the demand for labour. The supply of labour in the first months of the war was restrained by the physical destruction of the working-age labour force and the forced emigration of a significant number of able-bodied Ukrainians abroad, including highly qualified personnel. However, the population overcame the emotional shock of the beginning of the war and showed a willingness to work to maintain an acceptable standard of living. Despite the fact that a large part of the population lost their jobs and the number of resumes exceeded the number of vacancies, official statistics record a decrease in the number of unemployed in the country.

The state budget of Ukraine has shifted entirely towards military expenditures, resulting in a significant increase in spending and a decrease in revenue. This has led to macroeconomic instability, including inflation, devaluation of the national currency, and higher financial capital costs.

To forecast price stability under martial law, key indicators such as the consumer price index, household inflation expectations, the NBU key policy rate, real and nominal effective exchange rates local currency to USA dollar, gross and net international reserves, gross and net foreign exchange market interventions, the UK CPI, the USA CPI, EU CPI, and the weighted average yield of domestic government bonds were used. The VECM model and the Bagging machine learning method adapted to time series, were utilized for the analysis. These tools enabled an accurate forecast of the discount rate.

Additionally, a modified formula was used to determine the optimal exchange rate, which took into account factors such as the monetary base, total deposits in banks, foreign currency deposits in banks, exchange rates in the black market, and international reserves. This allowed for the prediction of exchange rates that were closely aligned with the official exchange rate.

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БАЛАНСУВАННЯ МОНЕТАРНОЇ ПОЛІТИКИ У ВОЄННІЙ ЕКОНОМІЦІ УКРАЇНИ

Повномасштабна війна, розпочата рф проти незалежної України 24 лютого 2022 року, ставить перед країною нові, небачені досі виклики. Крім опору на полі бою, Україна повинна впроваджувати адаптивну макроекономічну політику для вирішення ситуації. Таке поєднання мілітарних та економічних зусиль допомагає не тільки втримати країну від економічного краху, але й зберегти крихку макроекономічну стабільність в умовах воєнного часу. Монетарна стабільність набуває особливого значення, підкреслюючи абсолютну необхідність ефективної реалізації монетарної політики.

Метою статті є визначення ключових характеристик воєнної економіки України, прогнозування облікової ставки та валютного курсу під час війни. Передумовою прогнозування став аналіз основних ендогенних та екзогенних факторів, які визначають поточний стан української економіки: індекс ділових очікувань в Україні та країнах-партнерах, стан міжнародної торгівлі й платіжного балансу, диспропорції на ринку праці, переорієнтація державного бюджету на воєнні потреби, девальвація національної валюти, висока інфляція, здорожчання фінансового капіталу.

Моделювання базується на індексі споживчих цін (ІСЦ), інфляційних очікуваннях домогосподарств, обліковій ставці Національного банку України, реальному та номінальному ефективних обмінних курсах гривні до долара США, валових і чистих міжнародних резервах, валових і чистих інтервенціях на валютному ринку, ІСЦ Великобританії, ІСЦ США, ІСЦ ЄС і середньозваженій дохідності внутрішніх державних облігацій. Методологія передбачає застосування моделі VECM (Vector Error Correlation Model) та методу машинного навчання Bagging, адаптованого до часових рядів. Застосування цієї методології дозволило адекватно спрогнозувати облікову ставку.

При визначенні оптимального валютного курсу використано модифіковану формулу, яка враховує грошову базу, загальні банківські депозити, валютні депозити в банках, обмінний курс на чорному ринку та міжнародні резерви. Ця модифікація дозволила передбачити валютний курс, який був максимально наближений до офіційного валютного курсу.

Ключові слова: макроекономічна нестабільність, монетарна політика, інфляція, девальвація, механізм монетарної трансмісії, центральний банк, імпульсний аналіз

JEL Класифікація: E40, E47, E52, E58, E59