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EVALUATING THE EFFECTIVENESS OF THE CZECH NATIONAL BANK'S MONETARY POLICY: A LONGITUDINAL STUDY SINCE 1997

Florin ALIU [1], Pavel ROUSEK [1], Artor NUHIU [2] ✉

[1] *Institute of Technology and Business, School of Expertness and Valuation, Ceské Budejovice, Czech Republic*
[2] *Financial Law Department, Faculty of Law, University of Prishtina, Prishtina, Kosovo*

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Abstract. *Purpose* – This study examines the effectiveness of the Czech National Bank's (CNB hereafter) monetary policy with a focus on its adaptive responses to macroeconomic indicators such as inflation, unemployment, economic growth, interbank rate, imports, exports, and exchange rates. The two-week repo rate served as the primary instrument for the analysis period from January 1997 to July 2023.

Research methodology – The research employs a Vector Autoregression (VAR) model, complemented by Impulse Response Functions (IRF), Forecast Error Variance Decomposition (FEVD), Granger Causality and Johansen Cointegration Tests to analyse quarterly data on the dynamic interactions between the CNB's two-week repo rate and key economic indicators.

Findings – The research results show that the CNB monetary policies have mainly been effective in managing inflation targeting and sustaining economic stability. The considerable influence achieved through proactive policy adjustments to unemployment and interbank rates.

Research limitations – External macroeconomic shocks not accounted for in the VAR model might influence the study results. Furthermore, the findings are specific exclusively to the Czech economy and may not be directly applicable to other countries with distinct economic structures or monetary policy frameworks.

Practical implications – The research highlights the importance of predicting repo rate adjustments in response to changes in unemployment and interbank rates. CNB could use these findings to improve the understanding of policy changes and increase their effectiveness.

Originality/Value – The findings offer valuable insights for policymakers, governments, and banking industry participants seeking to enhance monetary policy efficiency.

Keywords: Czech National Bank, monetary policy, inflation targeting, two-week repo rate, VAR modeling.

JEL Classification: E52, E58.

✉Corresponding author. E-mail: *artor.nuhiu@uni-pr.edu*

1. Introduction

Since the 1990s, a considerable number of central banks worldwide have initiated the adoption of inflation targeting regimes. This approach provides several benefits, including enhancing central banks' autonomy and increasing the transparency of monetary policy through improved communication between policymakers and the public (Born et al., 2011; Bernanke & Mishkin, 1997; Taylor, 1993). Inflation targeting contributes to price stability by reducing the length of high inflation and maintaining rates within the target range (Guo & Lim, 2024). In recent decades, the low inflation rates in developed countries have resulted from independent central banks' adoption of policy rules. However, compared to other monetary policy approaches, the inflation targeting objective might achieve a lower inflation rate because of

lower economic output and higher unemployment (Bernanke & Mishkin, 1997). Since the late 1980s, central bank independence has become a critical institutional issue for fighting inflation and encouraging monetary policy reforms in central banks worldwide (Goodfriend, 2007). The success of the inflation targeting largely relies on the central bank's credibility. Several studies in emerging economies have shown that higher central bank credibility leads to lower inflation expectations and improves the effectiveness of inflation targeting (Güler, 2021). The wavelet coherence has revealed a surprising positive relationship between monetary policy rates and inflation in developing economies, highlighting the need for central bank actions to mitigate supply-side shocks (Islam & Ahmed, 2023). Central banks can utilize foreign exchange interventions to ease the impact of exchange rate depreciation, lower inflation, and reduce the immediate need for monetary policy responses (Fidrmuc & Horváth, 2008; Kočenda & Valachy, 2006). The accumulation of high levels of foreign exchange reserves enables central banks to intervene effectively in foreign exchange markets and maintain stability without the risk of depleting reserves below optimal levels (Krušković, 2022). Strategic reserve management is particularly vital for countries facing higher volatility in global markets.

The Czech Republic, as a small open economy both in trade and finance, finds itself challenged by the impact of sustained high inflation and resultant interest rate differentials. This scenario induces significant volatility in the exchange rate and instability across financial markets, which are highly sensitive to the risk premiums associated with short-term capital flows (Šimáková, 2024; Andrieș et al., 2017; Nasir et al., 2015). Such conditions underscore the importance of maintaining price stability to forestall the adverse effects on domestic economic development, growth, and price stability. This study aims to evaluate the Czech National Bank's (CNB) efforts over the past two decades to achieve and maintain such stability, particularly in alignment with the broader economic integration into the European Union (EU). Inflation, when high and volatile, inflicts considerable economic costs, exacerbating uncertainties in future pricing and elevating nominal interest rates, which in turn necessitate a higher risk premium on financial markets (Wang & Hausken, 2023; Cho, 2020). The persistence of inflation and depreciation expectations significantly influences the decision-making processes within the Czech economy, prompting a shift towards short-term financial investments and speculative activities rather than long-term real economic investments. These dynamics are further complicated by the tax distortions and the implicit tax burden on savers, making the case for stringent monetary and price stability even more compelling. Since 2010, the CNB has set a gradual trajectory towards lower inflation, aiming for a long-term target of 2% to stabilize the inflation rate to a level commensurate with its EU counterparts (CNB, n.d.). Moreover, the long-term economic strategy of the Czech Republic, as it aims for Economic and Monetary Union (EMU) integration, demands a harmonized approach to monetary policy to align with the stages of European integration. This research reviews the realism of these targets, the methodologies adopted by the CNB, and the effectiveness of these monetary policy strategies.

In the context of the EU, the actions undertaken by the European Central Bank (ECB) have subsequent effects on the entire European financial system. The Securities Markets Program demonstrates the most significant spillover effects among the ECB measures, influencing various aspects of the financial markets, exceeding their immediate targets. Meanwhile, the

Direct Monetary Transactions Program has the longest-lasting impact on financial markets (Grabowski & Stawasz-Grabowska, 2021). These programs demonstrate the ECB's fundamental role in shaping the stability and dynamics of Europe's financial environment. Euro-area countries with high debt burdens, such as Greece and Italy, have seen increases in government debt despite decreases in interest payments, which presents challenges for the European Central Bank's monetary policy adjustments (Yakubovskiy et al., 2020). As the Czech Republic prepares for Economic and Monetary Union (EMU) accession, maintaining price and financial stability is crucial, irrespective of the integration process. The nation's long-term economic strategy, which heavily focuses on stability targets, must align with the phased requirements of EU integration (Szkorupová et al., 2024). This alignment is essential for meeting the EU criteria and ensuring a stable economic environment for adopting the euro.

Although the EU accession does not specify quantitative benchmarks for stability, it is imperative to establish conditions that minimize inflation and interest rate differentials during the preliminary phases. It is essential to integrate the Czech currency with the euro and adapt to potential changes in the Exchange Rate Mechanism II (ERM II) rules (Szkorupová et al., 2024). The rapid transition from EU membership to EMU inclusion highlights the importance of adhering to the Maastricht convergence criteria, which dictate specific limits on inflation and nominal long-term interest rates relative to the lowest rates in the EU (Siklos, 2010; Soukiazis & Castro, 2005). Moreover, candidate countries must participate in the ERM system two years before EMU entry and meet its stability criteria. The European Central Bank (ECB) defines price stability as inflation below 2%, considering ongoing price adjustments and quality changes in goods and services (Benigno et al., 2023). This benchmark is essential as the Czech Republic advances towards EMU membership, necessitating realistic evaluations and negotiations regarding the costs and effects of each integration phase (Szkorupová et al., 2024; Campos et al., 2019). Aligning with the EU standards enables a smoother transition and ensures that the Czech Republic's monetary foundations are sufficiently robust to support its long-term financial stability and economic prosperity.

The study aims to provide a comprehensive examination of the CNB's two-decade-long monetary policy, assessing its effectiveness in fostering economic stability and growth within the economic environment of the Czech Republic and evaluating its competence and alignment with the economic parameters set by the EU. This research is significant as it explains how a small, open economy manages its monetary policy in an environment characterized by high inflation and essential exchange rate volatility. The study's relevance is strengthened by examining CNB's strategic alignment with the EU's economic policies and assessing how these strategies have impacted domestic economic stability, growth, and inflation. Moreover, exploring the CNB's approach to inflation targeting and its efforts to stabilize inflation at the EU level addresses a critical aspect of national economic policies. Therefore, the study aims to address the following research questions:

RQ1: Do the CNB's adjustments to the two-week repo rate (WRR) significantly reduce inflation (CPI) and unemployment (UNM)?

RQ2: Do interbank rate (IRB) movements mediate how changes in the WRR affect macroeconomic outcomes?

The rest of the paper is organized as follows: Section 2 provides an overview of the literature of existing studies and theories regarding the effectiveness of monetary policy and its influence on key macroeconomic indicators such as inflation, unemployment, and economic growth. Section 3 describes the methodology, including data collection and methods used. Section 4 presents and discusses the findings, and Section 5 concludes the paper while acknowledging the study's limitations.

2. Literature review

Monetary policy instruments guide the central bank's supply of money in determining economic outcomes, particularly in small open economies like the Czech Republic. In this context, external factors such as exchange rate volatility and international trade dynamics can significantly affect domestic stability. Born et al. (2011) document that inflation targeting imposes special challenges on small open economies in general. The CNB was created in the early 1990s alongside the transformation of the Czech Republic into a market economy, in part to address some of these challenges, and has a primary mandate to achieve price stability while also fostering economic growth. This literature review examines key studies on the effectiveness of monetary policy, with a special focus on the strategies employed by the CNB and their impact on main macroeconomic indicators such as inflation, unemployment, and economic growth. The choice of monetary policy strategy has a significant impact on economic activity. Several recent studies (Fawaz & Rahnamamoghadam, 2024; Zuniga & Senbet, 2023; Grabowski & Stawasz-Grabowska, 2021; Güler, 2021; Barattieri et al., 2021; Challe, 2020; Yakubovskiy et al., 2020) have evaluated the effectiveness of monetary policy in various global economic contexts. Each study contributes to a broader understanding of monetary policy dynamics, central bank strategies, and their implications for economic indicators such as GDP growth, inflation, and unemployment. On the other hand, economic growth impacts reducing unemployment, known as Okun's Law (Arifi et al., 2023). Amaral et al. (2022) provide a detailed analysis of the short-term and long-term effects of expansionary monetary policies in the United States. Their findings illustrate that such policies can spur immediate economic growth and lead to longer-term inflationary pressures. This dual effect highlights the delicate balance central banks must maintain between stimulating growth and controlling inflation. Their findings are supported by the study of Guo and Lim (2024), who demonstrated that inflation targeting can effectively shorten the duration of high inflation episodes, suggesting that well-executed inflation targeting strategies are crucial for maintaining price stability over time. Gürkaynak et al. (2021) examined the surprising effects of monetary policy on exchange rates, stating that unexpected policy tightening can lead to currency depreciation, contrary to traditional expectations. Their finding is essential for central banks to consider, as it suggests that the market's perception of the central bank's actions can significantly influence currency stability. Similarly, Güler (2021) emphasized the importance of central bank credibility in shaping inflation expectations, arguing that when a central bank is perceived as credible, it can more effectively anchor inflation expectations, thereby enhancing the overall effectiveness of its monetary policy. Grabowski and Stawasz-Grabowska (2021) investigate the spillover effects of the European Central Bank's policies on Central and Eastern European

countries, identifying significant impacts from unconventional monetary measures like sovereign debt purchases. They suggest that policies enacted by major central banks can have far-reaching effects beyond their borders, affecting financial markets in neighboring regions. Yakubovskiy et al. (2020) confirm these findings, remarking that ECB policies have generally positively impacted economic indicators in Eastern European countries, enhancing growth and reducing debt ratios. The studies by Barattieri et al. (2021) and Cacciatore and Ghironi (2021) explored the macroeconomic impacts of trade policies and economic integration. They found that protectionism acts as a supply shock, negatively affecting output and raising inflation, thus providing evidence against using protectionist measures as economic stimulants. On the other hand, Cacciatore and Ghironi (2021) emphasize the benefits of financial integration, showing that reduced trade costs and increased business cycle synchronization among trading partners can lower the optimal average inflation rate, aligning closely with the outcomes desired by monetary policy (Šimáková, 2024). The collective findings from these studies emphasize the complex nature of monetary policy and its varied impacts on economic stability, inflation, and growth.

The primary goal of optimal monetary policy is to ease the deflationary spiral and align the changes in an imperfect insurance-based economy (Challe, 2020). In a small, open economy, various factors significantly influence inflation expectations. These factors include projections of exchange rates, actual inflation rates, past inflation expectations, economic growth, labor market conditions, money supply, oil price shocks, and fiscal policy (Cao et al., 2023). Nasir et al. (2020) explored the economic behavior within small open economies, mainly how economic agents form their expectations. Their findings suggest that in these economies, individuals and businesses tend to develop what are known as adaptive expectations. It means that rather than predicting future economic conditions based on all available data, agents in these environments typically adjust their expectations based on past experiences and trends. When it comes to predicting exchange rates, Andrieș et al. (2017) found that the current real exchange rate, a measure that accounts for inflation differentials between countries, is a significant predictor of future changes in the nominal exchange rate, which is the rate at which one currency can be exchanged for another. The actual exchange rate's predictive ability extends beyond nominal exchange rates to include future inflation rates (Aliu et al., 2024). One important factor contributing to this discrepancy is the disruption in foreign demand for dollar-denominated bonds (Eichenbaum et al., 2021). Interestingly, Islam et al. (2022) found that when central banks raise interest rates, the currency depreciates instead of appreciating, contrary to standard economic expectations. Their findings suggest that this anomaly could be explained by an "information effect," indicating that market participants interpret interest rate hikes as tools for controlling inflation or stabilizing the currency and as signals of potential economic crises. This interpretation can lead to a loss of confidence and currency depreciation despite the rate increase. Under the New Keynesian two-country model, different information assumptions can be consistent with observed currency behavior on days when the U.S. Federal Reserve (FED) and the European Central Bank (ECB) announce monetary policy decisions (Adil et al., 2021; Aloy & Dufrénot, 2015). There are also differences observed in how asset prices behave. Despite considering the impact of information on longer-term interest rates, other factors as emphasized by Gürkaynak et al. (2021), continue to

influence exchange rates, highlighting a gap between event study analysis and model-based asset pricing mechanisms.

The literature examined above discusses the complex nature of monetary policy in affecting economic outcomes, especially with small open economies. While recent studies analyzed offer valuable insights into the broader effectiveness of monetary policy instruments, there remains a research gap concerning the Czech Republic's specific experience. The CNB's role in balancing domestic economic stability with the demands of EU integration calls for a context-specific analysis. Therefore, our work employs a Vector Autoregression (VAR) model to examine the dynamic relationships between the CNB's two-week repo rate and key economic indicators. This approach aims to improve our understanding of monetary policy effectiveness, thereby contributing to academic discourse and practical policy considerations.

3. Methodology

The methodology of this study is divided into two Sections: Section 3.1 covers data collection and descriptive statistics, while Section 3.2 explains the methods used.

3.1. Data

The series is quarterly and covers the period from January 1, 1997, to June 1, 2023. Data is collected from the World Bank (n.d.). The two-week repo rate (WRR) and interbank rate (IRB) are the primary independent variables, while inflation (CPI) and unemployment (UNM) and gdp growth (GDP) are key dependent variables. Control variables include money supply (M3), imports (IMP), exports (EXP), and exchange rates (CZK/USD). Table 1 includes standard descriptive statistics, unit roots, and diagnostic tests. Three different types of unit root tests were used: the Augmented Dickey-Fuller test (ADF), the Phillips-Perron test (P.P.), and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests. Most series are nonstationary at the level (I0) but become stationary only after the first differentiation.

The ADF test indicates that unemployment (UNM) and two-week repo rate (WRR) do not have a unit root at the level, while the KPSS and P.P. tests show the opposite. The three tests (ADF, KPSS, and P.P.) use four lag variables. In the cases of ADF and P.P., the *p*-value should be less than the 5% significance level. However, for the KPSS test, the *p*-value must exceed 5%. The Jarque-Bera (J.B.) test indicates that the series does not follow a normal distribution except for the CZK/USD pair. Skewness and kurtosis underscore the absence of symmetry in the series. Low kurtosis suggests that the data has fewer outliers and lighter tails. The CPI, WWR, IRB, and CZK are right-skewed, while the remaining series is left-skewed. Figure 1 below presents quarterly fluctuations across nine economic variables, reflecting a comprehensive overview of the Czech economy's performance. The two-week repo rate (WRR) and the inter-bank rate (IRB) show significant volatility, which aligns with the Czech National Bank's monetary policy adjustments during periods of economic stress, such as the 2008 financial crisis and recent inflationary pressures.

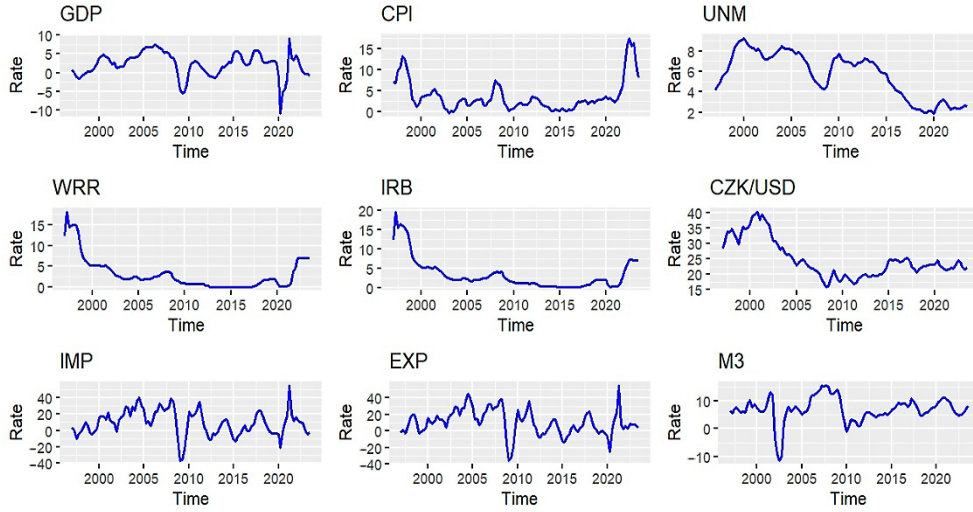
Standard descriptive statistics are calculated from raw data, with each variable comprising 111 observations. The average quarterly economic growth in the Czech Republic during these years was 2.23%, while unemployment was close to the natural rate of 5.65%. The

Table 1. Unit root test and descriptive statistics (source: authors' elaboration)

	ADF (Level)	KPSS (Level)	P.P. (Level)	ADF (1st Diff)	KPSS (1st Diff)	P.P. (1st Diff)	JB	ARCH effect	Ljung-Box	Pierce-Box
GDP	–3.07 (*0.130*)	0.13 (*0.1*)	–23.92 (0.023)	–7.89 (*0.01*)	0.04 (*0.1*)	–96.36 (*0.01*)	927.7 (*0.00*)	35.78 (*0.000*)	0.57 (*0.447*)	0.56 (*0.45*)
UNM	–3.69 (*0.028*)	1.52 (*0.01*)	–12.58 (*0.386*)	–6.33 (*0.01*)	0.18 (*0.1*)	–37.31 (*0.01*)	11.44 (*0.00*)	22.29 (*0.034*)	50.85 (*0.000*)	49.51 (*0.00*)
CPI	–2.39 (*0.412*)	0.261 (*0.1*)	–13.70 (*0.321*)	–3.88 (*0.01*)	0.15 (*0.1*)	–63.89 (*0.01*)	56.32 (*0.00*)	42.10 (*0.000*)	20.07 (*0.000*)	19.54 (*0.00*)
WRR	–3.92 (*0.015*)	0.90 (*0.01*)	–4.11 (*0.878*)	–4.83 (*0.01*)	0.49 (*0.1*)	–141.71 (*0.01*)	936.3 (*0.00*)	36.88 (*0.000*)	2.03 (*0.153*)	1.98 (*0.15*)
IRB	–3.78 (*0.022*)	0.90 (*0.01*)	–4.55 (*0.852*)	–4.69 (*0.01*)	0.42 (*0.1*)	–66.29 (*0.01*)	1573 (*0.00*)	20.80 (*0.053*)	5.25 (*0.021*)	5.11 (*0.02*)
CZK	–1.31 (*0.860*)	1.137 (*0.01*)	–4.50 (*0.830*)	–38.81 (*0.01*)	0.17 (*0.1*)	–80.85 (*0.01*)	3.108 (*0.21*)	16.11 (*0.186*)	9.69 (*0.001*)	9.43 (*0.00*)
IMP	–3.37 (*0.061*)	0.20 (*0.1*)	–5.73 (*0.01*)	–38.81 (*0.01*)	0.02 (*0.1*)	–74.14 (*0.01*)	30.67 (*0.00*)	36.96 (*0.000*)	3.05 (*0.080*)	2.97 (*0.08*)
EXP	–3.09 (*0.121*)	0.35 (*0.096*)	–5.82 (*0.01*)	–41.58 (*0.01*)	0.03 (*0.1*)	–46.19 (*0.01*)	108.5 (*0.00*)	25.70 (*0.011*)	3.46 (*0.062*)	3.37 (*0.06*)
M3	–2.48 (*0.373*)	0.07 (*0.1*)	–5.01 (*0.01*)	–39.23 (*0.01*)	0.02 (*0.1*)	–54.73 (*0.01*)	1736 (*0.00*)	25.98 (*0.010*)	16.84 (*0.000*)	16.39 (*0.00*)
	n	Mean	Sd	Skew	Kurtosis	Min	Max	Range	Se	Med
GDP	111	2.23	3.21	–0.88	1.67	–10.80	9.18	19.98	0.31	2.74
UNM	111	5.65	2.23	–0.32	–1.32	1.90	9.27	7.37	0.22	6.47
CPI	111	3.63	3.76	1.93	3.43	–0.39	17.58	17.97	0.36	2.55
WRR	111	3.12	3.81	1.97	3.75	0.05	18.20	18.15	0.37	2.00
IRB	111	3.43	3.97	2.11	4.36	0.28	19.67	19.39	0.38	2.13
CZK	111	0.06	11.4	0.25	–0.47	–24.20	26.41	50.61	1.10	0.91
IMP	111	9.42	15.4	–0.12	0.53	–36.58	54.86	91.43	1.49	9.64
EXP	111	10.6	15.3	–0.09	0.72	–35.81	55.38	91.19	1.45	9.13
M3	111	6.98	4.55	–13.01	3.98	–11.43	15.54	29.97	0.44	6.76

Note: The table shows the results of the unit-roots test and descriptive statistics for the variables in the dataset. The data covers the period from January 1, 1997, to June 1, 2023, based on quarterly series. The unit root test was conducted on the level and first-differenced logarithmic data. Three types of stationary tests were performed: the Augmented Dickey-Fuller test (ADF), the Phillips-Perron test (P.P.), and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests. Two lags were manually set for the ADF test for each series, while the P.P. and KPSS tests automatically determined the number of lags in R studio. The Jarque-Bera test (J.B.) was used to assess the symmetry of the data, test for heteroscedasticity using the ARCH effect, and test for serial correlation using Ljung-Box and Pierce-Box tests. The table includes the minimum (Min), maximum (Max), standard deviation (Std), skewness (Skew), kurtosis, number of observations (n), median (Med), range, and standard error (Se).

Consumer Price Index (CPI) was 3.63%, with this average being significantly impacted by the Russia-Ukraine war. The interbank rate (IRB) exceeds the CNB's two-week repo rate by 0.31 percentage points. The reason is that interbank lending should always carry higher costs than borrowing from the central bank. The minimum economic growth of –10.8% is associated with the COVID-19 pandemic outbreak in 2020, while the maximum increase of 9.18% is linked with the post-COVID-19 period. Sequentially, the most significant changes between quarters (Sd) were experienced in imports (IMP), followed by exports (EXP) and the CZK/USD. The same variables also exhibit the highest standard error (Se) level.



Note: The figure displays nine variables in the system categorized by data level. The series is based on 111 observations using quarterly data. The variables include gross domestic product (GDP), Consumer Price Index (CPI), unemployment (UNM), two-week repo rate (WRR), inter-bank rate (IRB), F.X. pair Czech crown towards U.S. dollar (CZK/USD), imports (IMP), exports (EXP), and money supply (M3). The plots were created in R Studio using the "ggplot2", "tseries," and "tidyverse" packages.

Figure 1. The time series of the nine variables spanning from January 1, 1997, to June 1, 2023 (source: authors' elaboration)

3.2. Methods

The methods used include the Vector Autoregression Model (VAR), impulse response function (IRF), forecast error variance decomposition (FEVD), Granger Causality Test, and Johansen Cointegration. All the variables used in our work were based on the quarterly first differential frequencies. The VAR is a system of equations with time series where endogenous variables are a function of their lags and lags of other variables in the system. It is a widely used technique for assessing and simulating macroeconomic shocks without placing restrictions on endogenous variables, and it is denoted as VAR(p), where the p stands for the autoregressive lags in the system. The following Equation represents a bivariate VAR with two endogenous variables:

$$y_t = a_1 + a_{11} y_{t-1} + a_{12} x_{t-1} + u_t; \tag{1}$$

$$x_t = a_2 + a_{21} y_{t-1} + a_{22} x_{t-1} + v_t, \tag{2}$$

where u_t and v_t represent shocks or impulses that can be estimated by OLS (Ordinary Least Squares) for each equation. All the variables in VAR are endogenous, meaning there are no exogenous variables. This Equation can also be expressed as a matrix:

$$\begin{bmatrix} y_t \\ x_t \end{bmatrix} = \begin{bmatrix} a_1 \\ a_2 \end{bmatrix} + \begin{bmatrix} b_{11} b_{12} \\ b_{21} b_{22} \end{bmatrix} \begin{bmatrix} y_{t-1} \\ x_{t-1} \end{bmatrix} \begin{bmatrix} u_t \\ v_t \end{bmatrix}. \tag{3}$$

The VAR model is an OLS that runs separately for each equation, with lagged values positioned on the right-hand side. Determining the number of lags is crucial when constructing the VAR model. In our case, we determined the number of lags using information criteria such as the Akaike Information Criterion (AIC), Hannan-Quinn (H.Q.), Schwarz (S.C.), and Akaike Final Prediction Error (FPE). To implement the VAR model in the R program, we used the "*vars*" library command, which also allows for generating diagnostic tests. Before conducting VAR, the data are tested for stationarity, autocorrelation, normality, and stability.

The Johansen Cointegration test measures the long-term relationship between nonstationary time series variables (Engle & Granger, 1987). When two variables are related in the long run, they form a cointegration relationship. Cointegration occurs when two or more time-series variables maintain significant long-term relationships. The Equation for capturing this phenomenon is as follows:

$$x_v = B_1 x_{v-1} + e_v; \tag{4}$$

where,

$$\Delta x_v = B_1 x_{v-1} - x_{v-1} + e_v; \tag{5}$$

$$= \left(B_1 - I\right) x_{v-1} + e_v. \tag{6}$$

The Equations in this methodology use the vectors x_v and e_v. We can have a maximum of three independent vectors when there are three endogenous variables. A rank equal to zero indicates no cointegration relationship, while a rank equal to one indicates one cointegration relation. The Johansen methodology consists of two tests: trace statistics and maximum eigenvalue. These tests are carried out in the R program using the '*urca*' package and the '*ca. jo*' commands. After these tests, the '*VARselect*' command is used to determine the optimal number of lags, which is crucial for accurate forecasting.

4. Results

The findings are organized into three distinct Sections. Section 4.1 examines the outcomes of VAR regressions using nine autoregressive models. Section 4.2 presents estimations from the impulse response function (IRF), while Section 4.3 delves into forecast error variance decomposition (FEVD). Additionally, Section 4.4 includes robustness tests.

4.1. VAR regressions results

This study serves two primary purposes: first, it assesses whether the Czech Central Bank (CNB) has responded to unemployment, inflation, economic growth, interbank rate, exchange rate, imports, and exports. Second, it evaluates the effectiveness of the CNB's response. This Section presents the VAR (I) estimations based on nine system variables. Figure A2 in the Appendix indicates that the model is stable, with all the residuals falling within the 95% confidence band. The model is built using an autoregressive lag, determined by the most significant number of iterations in the information criteria (I.C.). The Akaike Information Criterion (AIC), Hannan-Quin (H.Q.), Schwarz (S.C.), and Akaike Final Prediction Error (FPE) all suggest using a lag in the model (AIC = 1, H.Q. = 1, SC = 1, and FPE = 2). The series are quarterly and

cover the period from January 1, 1997, to June 1, 2023. To ensure stationarity assumption, the series used are based on first differencing.

Table 2 presents VAR (I) results where the nine variables are influenced by each other and their autoregressive lags. Based on R-square and adjusted R-square, UNM's model (Model 2) leads with 57.3% and 53.5% explanatory power, respectively, followed by CPI's model (Model 3) with 44.3% and 39.2%. Our finding reveals the significant influence of the two-week repo rate (WRR L1) and the interbank rate (IRB L1) on the gross domestic product (GDP) at the 5% significance level. It emphasizes the role of monetary policy in economic growth, further strengthened by the fact that banks are the primary source of financing consumption and business activities in the Czech Republic. These results are supported by the studies (Amaral et al., 2022; Islam et al., 2022; Nasir et al., 2020) but contradict the findings of Challe (2020) and Goodfriend (2007). Conversely, the country's capital market needs to be more utilized in financing business activities, given its size and the low efficiency in fund allocation. The unemployment rate (UNM) is impacted by its lag, IRB, and WWR at a 1% significance level. The central bank has effectively reduced unemployment and promoted economic growth during this period. The GDP lag affects UNM at 10%, likely due to the country's unemployment being primarily around or very close to the natural unemployment rate. This supports the findings of Guo and Lim (2024) but contradicts the findings of Cacciatore and Ghironi (2021). Maintaining price stability with low and steady inflation is the primary goal of the Czech National Bank. WRR and IMP influence the Consumer Price Index (CPI) to the extent of 1%, while EXP and the CZK/USD have a 5% influence. Therefore, the central bank's monetary actions have proven effective in controlling inflation. As expected, CPI is affected by CZK/USD and IMP, as they play a crucial role in determining the prices within the consumer basket.

The Czech Republic functions as an open economy, meaning that changes in the prices and volume of imports directly impact the CPI. Even though most trade is with European Union member states, 15% is with the USA (Šimáková, 2024; CNB, 2024). Additionally, the Czech financial system is interconnected with that of the USA through the capital market, where most financial institutions diversify their portfolios. In this context, any depreciation or appreciation of the Czech crown against the U.S. dollar directly affects the CPI. To this end, the monetary policy has effectively boosted economic growth, reduced unemployment, and mitigated inflation.

In our research, the effectiveness and response of the Czech National Bank (CNB) are assessed using a two-week repo rate (WRR). This rate represents the maximum at which banks' bids can be met in the tender. The repo rate is the interest rate at which the central bank lends money to commercial banks. Banks can acquire loans from the CNB by selling qualifying securities.

It is worth noting that WRR is not influenced by its past decisions (WRR L1), particularly those made three months ago. The WRR, a vital tool in the CNB's mandate, is influenced by the first lag of UNM at a 1% significance level, CPI at 5%, and IRB at 5%. The CNB, in line with its mandate, has adjusted the WRR in response to changes in UNM, CPI, and IRB. This strategic approach allows the bank to effectively manage the unemployment rate (UNM), maintain price stability (CPI), and regulate banking system liquidity via the interbank rate (IRB). The IRB, on the other hand, significantly follows and influences movements in the WRR,

Table 2. VAR (I) estimation results of first differenced series (source: authors' elaboration)

Variables	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)	Model (8)	Model (9)
	GDP	UNM	CPI	WRR	IRB	CZKUSD	IMP	EXP	M3
GDP.L1	0.001 (*0.130*)	–0.026* (*0.016*)	–0.020 (*0.077*)	–0.034 (*0.062*)	–0.021 (*0.065*)	1.074** (*0.437*)	–1.253* (*0.634*)	–2.329*** (*0.654*)	0.027 (*0.161*)
UNM.L1	0.907 (*0.597*)	0.610*** (*0.071*)	0.114 (*0.351*)	–0.850*** (*0.285*)	–1.010*** (*0.298*)	0.602 (*0.298*)	3.296 (*2.907*)	3.912 (*3.000*)	–0.189 (*0.739*)
CPI.L1	–0.080 (*0.143*)	–0.006 (*0.017*)	0.344*** (*0.084*)	0.139** (*0.068*)	0.120* (*0.071*)	–0.460 (*0.480*)	0.319 (*0.696*)	0.204 (*0.718*)	–0.025 (*0.177*)
WRR.L1	1.125** (*0.490*)	–0.207*** (*0.059*)	0.824*** (*0.288*)	0.352 (*0.234*)	0.894*** (*0.244*)	–2.271 (*1.646*)	4.800* (*2.386*)	4.760* (*2.462*)	–0.435 (*0.607*)
IRB.L1	–1.069** (*0.422*)	0.152*** (*0.050*)	–0.212 (*0.248*)	–0.480** (*0.202*)	–0.982*** (*0.210*)	3.488** (*1.417*)	–5.598*** (*2.055*)	–4.919** (*2.120*)	0.458 (*0.522*)
CZK/USD.L1	–0.004 (*0.038*)	0.002 (*0.005*)	0.049** (*0.009*)	0.002 (*0.018*)	0.004 (*0.019*)	0.289** (*0.127*)	0.007 (*0.184*)	0.114 (*0.190*)	0.053 (*0.047*)
IMP.L1	–0.000 (*0.061*)	–0.012* (*0.007*)	0.111*** (*0.036*)	0.038 (*0.029*)	0.037 (*0.030*)	0.444** (*0.203*)	–0.353 (*0.295*)	–0.257 (*0.304*)	–0.021 (*0.075*)
EXP.L1	0.019 (*0.058*)	0.010 (*0.007*)	–0.082** (*0.034*)	–0.038 (*0.027*)	–0.036 (*0.029*)	–0.610*** (*0.193*)	0.682** (*0.280*)	0.706** (*0.289*)	–0.002 (*0.071*)
M3.L1	–0.016 (*0.076*)	0.003 (*0.009*)	0.024 (*0.045*)	0.036 (*0.038*)	0.044 (*0.255*)	–0.013 (*0.045*)	–0.114 (*0.367*)	0.035 (*0.379*)	0.369*** (*0.093*)
const	–0.005 (*0.183*)	–0.008 (*0.022*)	0.082 (*0.108*)	–0.075 (*0.087*)	–0.074 (*0.091*)	0.042 (*0.614*)	–0.209 (*0.890*)	0.005 (*0.919*)	0.011 (*0.226*)
Observations	110	110	110	110	110	110	110	110	110
R^2	0.110	0.573	0.443	0.323	0.321	0.338	0.225	0.242	0.170
Adjusted R^2	0.029	0.535	0.392	0.163	0.260	0.279	0.155	0.174	0.096
Residual Std. Error (df = 100)	1.906	0.228	1.121	0.910	0.950	6.400	9.277	9.574	2.359
F Statistic (df = 9; 100)	1.368*	14.92***	8.82***	3.36***	5.68***	3.22***	2.27**	1.624	1.624

Notes: The table indicates the estimated coefficients and standard errors from a VAR (I) based on nine autoregressive models. When tested for structural breaks, the residuals stand within the 95% confidence band, indicating a stable model. The table contains nine variables (GDP, UNM, CPI, WRR, IRB, CZK/USD, IMP, EXP, and M3) based on one lag (L1). The sample covers the period from January 1, 1997, to June 1, 2023, based on quarterly series. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

as supported by the findings of Cao et al. (2023). The repo rate is the interest rate banks lend each other for short-term loans. This rate helps banks manage their liquidity and meet reserve requirements. The value of the Czech crown relative to the U.S. dollar (CZK/USD) is not solely determined by the IRB. Economic growth, trade balance (import vs. export), and capital flow are other factors. These factors, along with the influence of the IRB, collectively shape the CZK/USD exchange rate. As expected, the performance of EXP and IMP depends on GDP, WRR, and IRB. GDP has a much more significant impact on EXP, while WRR has a more substantial influence on IMP. These results support the findings of Andrieș et al. (2017)

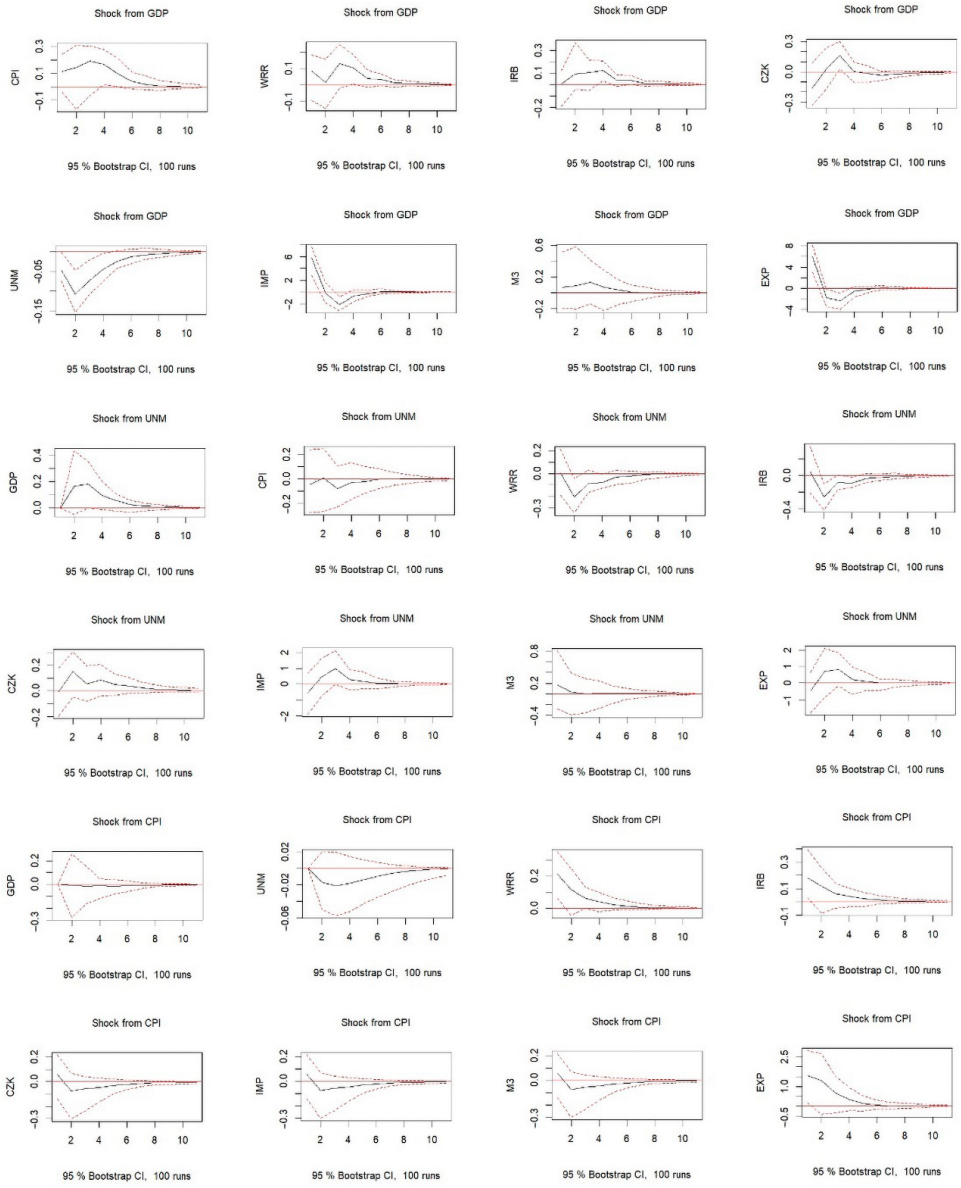
and Šimáková (2024) but contradict the conclusions of Gürkaynak et al. (2021). By adjusting the two-week repo rate, the CNB targets UNM, CPI, and IRB while affecting almost the Czech economy. M3, known as 'near money,' does not impact the network. It is worth noting that many central banks have chosen to report this figure no longer.

4.2. IRF estimations

To understand VAR regression results comprehensively, it is crucial to incorporate the impulse response function (IRF). Figure 2 illustrates the impact of positive shocks from GDP, UNM, and CPI on related variables through a lag in the system. The IRF estimations are based on a 95% confidence band and cover the following ten periods. The one standard deviation positive shock to GDP leads to an increase of almost 6% in both imports (IMP) and exports (EXP). This effect diminishes after six months. Conversely, a positive shock in GDP leads to a 0.10% drop in unemployment, confirming the relationship outlined by Okun's law. It means that the positive shock of GDP on UNM remains significant for eight quarters. GDP is a comprehensive measure of all economic activities and is crucial in influencing imports, exports, and unemployment. To this end, GDP has a more powerful impact on imports and exports than unemployment. This is because unemployment in the Czech Republic has consistently maintained a level close to the natural rate, averaging 5.9%. Our estimates for the Czech Republic contrast those of Arifi et al. (2023) regarding the causal relationship between unemployment and inflation in Western Balkan countries. Their findings indicate that economic growth in these countries does not lead to a reduction in unemployment. They attribute this to the high level of informality in the labor market and the overall economy. The increase in economic activity in the first two quarters strengthened the Czech crown against the U.S. dollar but later caused it to devalue. These findings correspond with the conclusions of Šimáková (2024) and Islam et al. (2021) that emphasize a direct relationship between economic activity and currency strength, highlighting both initial strengthening and subsequent devaluation of the koruna. On the other hand, the contrasting conclusions of Barattieri et al. (2021) and Campos et al. (2019) underscore the need for further research to fully understand this relationship's complexities. Their findings suggest that trade policies and other macroeconomic factors may be more crucial in determining exchange rate movements, showing a more complex and less direct relationship between economic growth and currency value. The impact of the GDP on CZK/USD dies out after four quarters (12 months). However, the effect of GDP on CPI, WRR, and IRB remains to be seen due to a high margin of error.

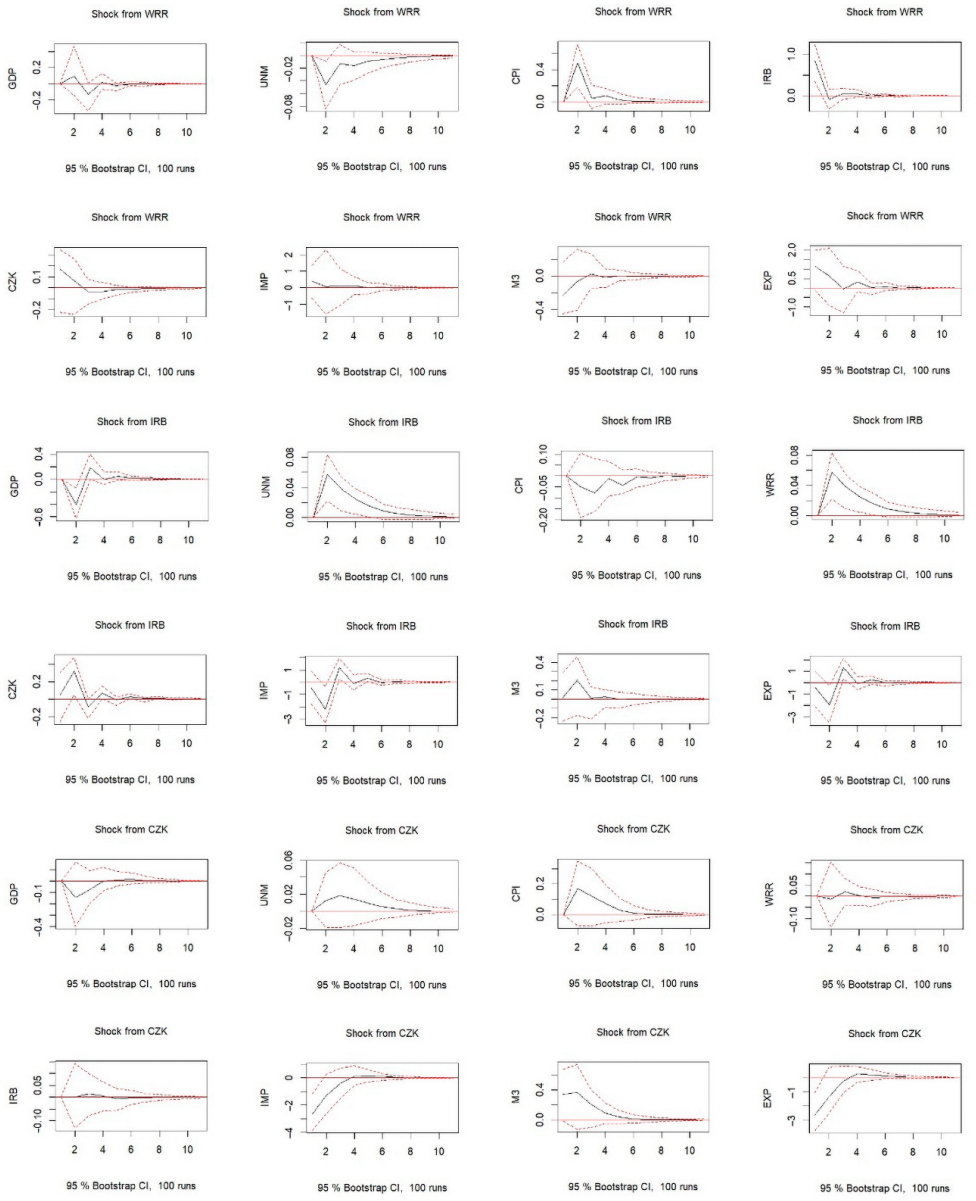
A higher unemployment rate (positive UNM shock) indicates economic difficulties. Estimations suggest that an increase in UNM only significantly impacts WRR and IRB. A one standard deviation shock in UNM results in a decrease of 0.2% in WRR and 0.3% in IRB. When the unemployment rate increases by 1%, the CNB lowers WRR by 0.2%, while commercial banks lower the interbank rate by 0.3%. In other words, when the unemployment rate worsens, the CNB lowers the two-week repo rate, followed by commercial banks relaxing interbank lending. These results correspond with the findings of Guo and Lim (2024) and Nasir et al. (2020), which support the notion that central banks, including the CNB, respond to rising unemployment by lowering interest rates to stimulate economic activity. However, it is clear that the IRB does not respond to UNM's changes but instead aligns with the movements of the WRR. Conversely, UNM has a weaker impact on CZK/USD, EXP, and IMP but does not affect GDP,

M3, and CPI movements. Figure A1 in the Appendix shows the impulse response functions for imports (IMP), exports (EXP), and money supply (M3), providing additional insights into how these key macroeconomic variables react to external shocks.



Note: The figure displays impulse response function (IRF) plots for variables such as GDP, UNM, and CPI. The IRF shocks are bounded between two variables using a 95% confidence band and simulated with 100 trials. The estimates are derived from differenced series and cover the period from January 1, 1997, to June 1, 2023. The red line represents the distance from the trend line (black) and denotes the margin of error. These results were obtained using the "vars" package and the "irf" function in R studio.

Figure 2. IRF shocks generated from GDP, UNM, and CPI (source: authors' elaboration)



Note: The figure displays impulse response function (IRF) plots for WRR, IRB, and CZK/USD variables. The IRF shocks are bounded between two variables using a 95% confidence band and simulated with 100 trials. The estimates are derived from quarterly differenced series and cover the period from January 1, 1997, to June 1, 2023. The red line represents the distance from the trend line (black) and denotes the margin of error. These results were obtained using the "vars" package and the "irf" function in R studio.

Figure 3. IRF shocks produced by WRR, IRB, and CZK/USD (source: authors' elaboration)

The Consumer Price Index (CPI) tracks the changes in prices of goods and services consumed by urban households. In 2022, the inflation rate in the Czech Republic soared to 17.58%, primarily attributed to the economic and energy crisis exacerbated by the war in Ukraine. IRF indicates that CPI does not impact GDP and UNM but significantly affects WRR, IRB, CZK/USD, M3, IMP, and EXP. When the CPI increases by 1% above the allowed target, the CNB increases the WRR by 0.2% and decreases M3 by about 0.05%. As expected, inflation exceeding 2% prompts the central bank to tighten lending activities and reduce the money supply in circulation. WRR's response to CPI shock diminishes after six quarters or 18 months as CNB gradually lowers interest rates. A higher WRR would not be fully effective if commercial banks did not follow the same policy. During the same period, the IRB increases, indicating tightening credit lines between banks. Higher CPI tends to reduce the volume of imports and increase exports. In general, increasing inflation devalues the Czech crown, which stimulates export growth.

Figure 3 illustrates the impact of WRR, IRB, and CZK/USD on other variables. The positive shock on WRR demonstrates the efficacy of CBN's monetary actions. The increase in WRR by 1% standard deviation causes the GDP to decrease by less than 0.1%. The effect of WRR on GDP lives up to 12 months and then disappears. The impact of WRR on the consumer price index (CPI) is intriguing. The softening effect on the inflation rate is only achieved after six months. The inflation rate keeps increasing for up to six months, even with CNB's intervention. After six months, inflation continues to increase with the pace of continuous decline. The WRR effect on CPI disappears after 15 months when inflation returns to the central bank's target. Prices have been increasing yearly, so a positive impact on the WRR would not be expected to affect the CPI negatively. Our data from January 1, 1997, to July 1, 2023, indicates that the Czech Republic has never experienced deflation. The effect of CNB on financial stability is achieved by tightening or easing interbank lending. An increase in the WRR of just 1% has a similar impact to an IRB increase, indicating that commercial banks closely track the CNB's actions.

The IRB is crucial in facilitating interbank borrowing to ensure adequate liquidity for immediate needs and enabling lending when banks have surplus funds. IRB significantly affects GDP, UNM, EXP, IMP, CZK/USD, and WRR, but not CPI and M3. A positive shock to the IRB will slow economic growth and increase unemployment. These findings were expected, as an increase in the interbank lending rate signals potential problems in the real economy or the financial system. However, a 1% increase in the IRB led to a 0.3% depreciation of the Czech crown against the U.S. dollar, a 2% decrease in imports and a 1.8% decrease in exports. IRB is the most influential variable compared to others due to commercial banks' importance and weight in the Czech economy. As expected, the impact of CZK/USD is presented with the only effect on IMP and EXP.

4.3. FEVD estimations

In this Section, we analyze the results of the forecast error variance decomposition (FEVD) based on one lag and for six periods. FEVD highlights how each variable contributes to the other variables in the autoregression. The findings for the following ten periods (quarters) are

Table 3. Forecast error variance decomposition (FEVD) for the nine variables (source: authors' elaboration)

CPI									
p	*GDP*	*UNM*	*CPI*	*WRR*	*IRB*	*CZK*	*IMP*	*EXP*	*M3*
1	0.008	0.000	0.988	0.000	0.000	0.000	0.000	0.000	0.000
2	0.017	0.001	0.779	0.120	0.000	0.022	0.028	0.027	0.001
3	0.029	0.005	0.744	0.112	0.002	0.035	0.028	0.039	0.002
4	0.041	0.006	0.726	0.111	0.003	0.038	0.027	0.043	0.002
5	0.046	0.006	0.720	0.110	0.003	0.038	0.027	0.044	0.002
6	0.047	0.006	0.719	0.110	0.003	0.038	0.027	0.044	0.002
WRR									
p	*GDP*	*UNM*	*CPI*	*WRR*	*IRB*	*CZK*	*IMP*	*EXP*	*M3*
1	0.008	0.000	0.050	0.940	0.000	0.000	0.000	0.000	0.000
2	0.007	0.048	0.058	0.837	0.035	0.001	0.001	0.012	0.003
3	0.024	0.052	0.060	0.809	0.038	0.001	0.001	0.013	0.003
4	0.033	0.057	0.072	0.775	0.042	0.002	0.001	0.013	0.003
5	0.035	0.058	0.086	0.771	0.049	0.002	0.001	0.014	0.003
6	0.036	0.058	0.086	0.771	0.049	0.002	0.001	0.014	0.003
IRB									
p	*GDP*	*UNM*	*CPI*	*WRR*	*IRB*	*CZK*	*IMP*	*EXP*	*M3*
1	0.000	0.002	0.034	0.817	0.145	0.000	0.000	0.000	0.000
2	0.007	0.063	0.038	0.650	0.221	0.001	0.002	0.009	0.005
3	0.016	0.063	0.040	0.626	0.229	0.001	0.002	0.011	0.005
4	0.028	0.070	0.040	0.604	0.235	0.001	0.002	0.012	0.005
5	0.029	0.071	0.041	0.602	0.234	0.001	0.002	0.012	0.005
6	0.030	0.071	0.041	0.602	0.234	0.001	0.002	0.012	0.005
IMP									
p	*GDP*	*UNM*	*CPI*	*WRR*	*IRB*	*CZK*	*IMP*	*EXP*	*M3*
1	0.397	0.003	0.008	0.001	0.002	0.225	0.360	0.000	0.000
2	0.341	0.004	0.017	0.001	0.052	0.222	0.325	0.035	0.001
3	0.356	0.012	0.018	0.002	0.061	0.206	0.305	0.036	0.001
4	0.357	0.013	0.018	0.002	0.062	0.205	0.303	0.036	0.001
5	0.357	0.013	0.018	0.002	0.062	0.205	0.302	0.036	0.001
6	0.357	0.013	0.018	0.002	0.062	0.205	0.302	0.036	0.001
EXP									
p	*GDP*	*UNM*	*CPI*	*WRR*	*IRB*	*CZK*	*IMP*	*EXP*	*M3*
1	0.388	0.002	0.020	0.015	0.002	0.246	0.243	0.080	0.000
2	0.350	0.004	0.029	0.015	0.034	0.223	0.227	0.101	0.000
3	0.367	0.009	0.029	0.015	0.050	0.221	0.221	0.095	0.000
4	0.367	0.009	0.029	0.016	0.050	0.210	0.220	0.095	0.000
5	0.367	0.009	0.029	0.016	0.051	0.210	0.220	0.095	0.000
6	0.367	0.009	0.029	0.016	0.051	0.210	0.220	0.095	0.000

Note: The table highlights results using nine variables based on a VAR (I) variance decomposition (FEVD). The data covers the period from January 1, 1997, to June 1, 2023, and is based on quarterly differenced series. The FEVD is constructed using a one-lag for the six periods (*p*) ahead, equivalent to one year and six months.

not presented because no variance exists after six periods. This suggests that the system's effects remain significant for 1.6 years and then diminish. The findings from FEVD are consistent with those from IRF and regression, demonstrating minor discrepancies.

Table 3 presents the FEVD for nine key variables: GDP, Unemployment (UNM), Consumer Price Index (CPI), Wage Rate Risk (WRR), Interest Rate Base (IRB), Czech Koruna (CZK), Imports (IMP), Exports (EXP), and Money Supply (M3). These variables are analyzed using a Vector Autoregression (VAR) model with one lag, covering a dataset from January 1, 1997, to June 1, 2023, based on quarterly differenced series. The results highlight the dominance of CPI in the initial periods, reflecting its strong influence on other variables. Contrarily, variables like GDP and Imports show significant cross-variable impacts, underscoring our model's interconnectedness of economic indicators. The decomposition provides insights into how shocks to one variable can explain the forecast error variance in others over six periods ahead, equivalent to one year and six months.

The interbank rate is heavily influenced by changes in the WRR, ranging from 81.7% to 60.2%. As a result, the interbank rate is highly responsive to the CNB's announcements regarding WRR movements. The CNB's decisions on the WRR significantly impact the ease with which banks lend to each other. Fluctuations in EXP and IMP are heavily influenced by changes in GDP and the CZK/USD pair. These findings support the conclusions of Cao et al. (2023) and Nasir et al. (2020) but are in contrast with the conclusions of Barattieri et al. (2021) and Challe (2020). Like IRF estimations, an increase in GDP is anticipated to impact busting exports and imports directly. In summary, monetary policy seeks to lower the acceleration of price increase (CPI) and unemployment (UNM), enhance economic growth (GDP), and uphold financial stability (IRB).

4.4. Robustness tests

This Section examines the Granger causality and Johansen cointegration tests to validate the result's robustness. Similar to the previous tests, the analysis uses different data covering the period from January 1, 1997, to June 1, 2023. Table A1 in the Appendix shows the results of Granger tests, where each variable is tested in a group. These group tests are designed to assess each variable as a potential cause of all the others within the network. It is worth noting that the individual tests, which indicate how each variable can cause another, may differ from group tests. The estimates show that only GDP, UNM, CZK/USD, and M3 Granger cause other variables in the group. Notably, the results concerning M3 are surprising, considering it was insignificant in prior tests.

Table 4 includes the results of the Johansen cointegration test using maximal eigenvalue and trace statistics. In both tests, the test statistic exceeds the critical values at the 10%, 5%, and 1% significance levels. It implies that the variables used establish a cointegrating relationship, and deviations from this equilibrium relationship tend to revert to the mean. The Table 4 results show the existence of at least eight cointegration relations.

Table 4. Johansen Cointegration test with trace statistics and maximal eigenvalue (source: authors' elaboration)

Test type: trace statistic, without linear trend and constant in cointegration				
Test statistic and critical values of the test:				
	Test	10%	5%	1%
r <= 8	18.78	7.52	9.24	12.97
r <= 7	49.50	17.85	19.96	24.60
r <= 6	85.43	32.00	34.91	41.07
r <= 5	129.78	49.65	53.12	60.16
r <= 4	175.97	71.86	76.07	84.45
r <= 3	230.04	97.86	102.14	111.01
r <= 2	303.82	126.58	131.70	143.09
r <= 1	385.37	159.48	165.58	177.20
r = 0	507.66	196.37	202.92	215.74
Test type: maximal eigenvalue statistic (lambda max), without linear trend and constant in cointegration				
Test statistic and critical values of the test:				
	Test	10%	5%	1%
r <= 8	18.78	7.52	9.24	12.97
r <= 7	30.72	13.75	15.67	20.20
r <= 6	35.93	19.77	22.00	26.81
r <= 5	44.36	25.56	28.14	33.24
r <= 4	46.19	31.66	34.40	39.79
r <= 3	54.07	37.45	40.30	46.82
r <= 2	73.78	43.25	46.45	51.91
r <= 1	81.55	48.91	52.00	57.95
r = 0	122.30	54.35	57.42	63.71

Note: This table presents the Johansen cointegration tests with trace statistics and maximal eigenvalue for the nine variables in the network. The results are based on a quarterly differenced series from January 1, 1997, to July 1, 2023. The estimations are analyzed using the "urca" and "vars" packages in R Studio.

5. Conclusions

In the early 1990s, Eastern European countries, including the Czech Republic, transitioned from a centralized price management system to a free market economy. This shift democratized political life and established independent institutions such as the Czech National Bank (CNB). Given these factors, we have investigated the importance and role of CNB in the Czech economy. In addressing the study's title, it is evident that the CNB has diligently followed its mandate, prioritizing the inflation rate over the interbank and unemployment rates. When the CPI increases by 1% above the allowed target, the CNB's response is clear. They first raise the two-week repo rate by 0.2%, and the same movement quickly follows this in the interbank rate. However, when the unemployment rate increases by 1%, the CNB gradually reduces the

two-week repo rate by 0.2% over a six-month interval. As the interbank rate adjusts in line with the two-week repo rate, a 1% increase in unemployment leads to a 0.3% decrease in the interbank rate. While the CNB's decision aligns with its mandate, the critical question is whether its actions have been successful. In this context, a 1% increase in the two-week repo rate can weaken economic growth by 0.1% and increase unemployment by about 0.05%. The effects on smoothing inflation are only effective after six months. Moreover, a 1% increase in the two-week repo rate is usually followed by a 0.9% increase in the interbank rate. It emphasizes the CNB's broader influence, not just on inflation and unemployment, but also on the liquidity of the banking industry through the interbank rate. The impulse response function results are consistent with the variance decomposition and Granger test, with minor differences. The results contribute to the Czech Republic's ongoing dilemma and temptation to join the Eurozone. Findings present reliable signals for the government to cooperate with an essential and credible actor, such as CNB, to mitigate the effects of international shocks.

According to our estimates, the interbank rate is the most influential variable in the network, primarily due to the substantial weight of commercial banks in the Czech financial system. Like other European countries, the Czech Republic relies more on the banking system for financing investments and private consumption. It is important to note that changes mainly influence the CZK/USD pair in GDP and imports. Even though the Czech Republic has strong trade ties with the Eurozone, most bank portfolios are in U.S. dollars. Interestingly, tests indicate that the M3 money supply does not significantly impact any of the other eight variables in the system. It may be because market participants do not closely follow this indicator. Additionally, some central banks, such as the Federal Reserve in the United States, no longer measure this metric. In the future, studies could compare the effectiveness of the CNB to that of other Eastern EU member states. These countries have a shared history under the communist regime, transition to democracy in the early 1990s, and joined the EU around the same time. One limitation of this study is the use of quarterly data and the limited number of observations. It would be more interesting to test the effectiveness of monetary policy in the post-COVID-19 period, particularly when inflation begins to accelerate in the Czech Republic and beyond.

Author contributions

FA and AN contributed by handling the literature write-up, conducting statistical analysis, and drafted the manuscript. FA, PR and AN contributed to guide throughout the manuscript preparation, supervision, and validation. PR and FA deal with data collection and data screening process and participated in its design and coordination and helped to draft the manuscript. All authors read and approved the final version of the manuscript.

Disclosure statement

The authors declare that they do not have any competing financial, professional, or personal interests from other parties.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

References

Adil, M. H., Hatekar, N. R., & Ghosh, T. (2021). The role of money in the monetary policy: A new Keynesian and new monetarist perspective. In W. A. Barnett & B. S. Sergi (Eds.), *Environmental, social, and governance perspectives on economic development in Asia: Vol. 29A. International Symposia in Economic Theory and Econometrics* (pp. 37–67). Emerald Publishing. https://doi.org/10.1108/S1571-03862021000029A018

Aliu, F., Kučera, J., & J., Horák, J. (2024). Exchange rate instabilities during the Russia-Ukraine war: Evidence from V4 countries. *Heliyon*, *10*(3), Article e25476. https://doi.org/10.1016/j.heliyon.2024.e25476

Aloy, M., & Dufrénot, G. (2015). A comparison of the Fed's and ECB's strategies during the subprime crisis. In *Monetary policy in the context of the financial crisis: New challenges and lessons: Vol. 24. International Symposia in Economic Theory and Econometrics* (pp. 419–449). Emerald Publishing. https://doi.org/10.1108/S1571-038620150000024024

Amaral, A., Dyhoum, T. E., Abdou, H. A., & Aljohani, H. M. (2022). Modeling the relationship between monetary policy and GDP in the USA using statistical methods. *Mathematics*, *10*(21), Article 4137. https://doi.org/10.3390/math10214137

Andrieș, A. M., Căpraru, B., Ihnatov, I., & Tiwari, A. K. (2017). The relationship between exchange rates and interest rates in a small open emerging economy: The case of Romania. *Economic Modelling*, *67*, 261–274. https://doi.org/10.1016/j.econmod.2016.12.025

Arifi, D., Xhixha, H., & Aliu, F. (2023). Testing Okun's Law: Evidence from the Western Balkan countries. *SAGE Open*, *13*(4). https://doi.org/10.1177/21582440231208332

Barattieri, A., Cacciatore, M., & Ghironi, F. (2021). Protectionism and the business cycle. *Journal of International Economics*, *129*, Article 103417. https://doi.org/10.1016/j.jinteco.2020.103417

Benigno, P., Canofari, P., Di Bartolomeo, G., & Messori, M. (2023). The ECB's new inflation target from a short- and long-term perspective. *Journal of Policy Modeling*, *45*(2), 286–304. https://doi.org/10.1016/j.jpolmod.2023.03.004

Bernanke, B. S., & Mishkin, F. S. (1997). Inflation targeting: A new framework for monetary policy? *Journal of Economic Perspectives*, *11*(2), 97–116. https://doi.org/10.1257/jep.11.2.97

Born, A., Jahan, S., & Gemayel, E. R. (2011). What can low-income countries expect from adoption inflation targeting? *IMF Working Papers*, (276). https://doi.org/10.5089/9781463925932.001

Cacciatore, M., & Ghironi, F. (2021). Trade, unemployment, and monetary policy. *Journal of International Economics*, *132*, Article 103488. https://doi.org/10.1016/j.jinteco.2021.103488

Cao, J., Dinger, V., Gómez, T., Gric, Z., Hodula, M., Jara, A., Juelsrud, R., Liaudinskas, K., Malovaná, S., & Terajima, Y. (2023). Monetary policy spillover to small open economies: Is the transmission different under low interest rates? *Journal of Financial Stability*, *65*, Article 101116. https://doi.org/10.1016/j.jfs.2023.101116

Campos, N. F., Coricelli, F., & Moretti, L. (2019). Institutional integration and economic growth in Europe. *Journal of Monetary Economics*, *103*, 88–104. https://doi.org/10.1016/j.jmoneco.2018.08.001

Challe, E. (2020). Uninsured unemployment risk and optimal monetary policy in a zero-liquidity economy. *American Economic Journal: Macroeconomics*, *12*(2), 241–283. https://doi.org/10.1257/mac.20180207

Czech National Bank. (n.d.). *The Czech National Bank past and present*. Retrieved July 4, 2024, from https://www.cnb.cz/en/about_cnb/publications/the-czech-national-bank-past-and-present/

Cho, S. (2020). Natural interest rate, potential GDP growth rate, and long-term monetary policy stance. *Journal of Economic Theory and Econometrics*, *31*(2), 40–69.

Eichenbaum, M. S., Johannsen, B. K., & Rebelo, S. T. (2021). Monetary policy and the predictability of nominal exchange rates. *Review of Economic Studies*, *88*(1), 192–228. https://doi.org/10.1093/restud/rdaa024

Engle, R. F., & Granger, C. W. J. (1987). Co-integration and error correction: Representation, estimation, and testing. *Econometrica*, *55*(2), 251–276. https://doi.org/10.2307/1913236

Fawaz, F., & Rahnamamoghadam, M. (2024). A refinement of the relationship between central bank independence, inflation, and income inequality in developing countries. *Journal of Central Banking Theory and Practice*, *13*(1), 117–131. https://doi.org/10.2478/jcbtp-2024-0006

Fidrmuc, J., & Horváth, R. (2008) Volatility of exchange rates in selected new EU members: Evidence from daily data. *Economic Systems*, *32*(1), 103–118. https://doi.org/10.1016/j.ecosys.2007.09.004

Goodfriend, M. (2007). How the world achieved consensus on monetary policy. *Journal of Economic Perspectives*, *21*(4), 47–68. https://doi.org/10.1257/jep.21.4.47

Grabowski, W., & Stawasz-Grabowska, E. (2021). How have the European central bank's monetary policies been affecting financial markets in CEE-3 countries? *Eurasian Economic Review*, *11*, 43–83. https://doi.org/10.1007/s40822-020-00160-3

Güler, A. (2021). Does monetary policy credibility help in anchoring inflation expectations? Evidence from six inflation targeting emerging economies. *Journal of Central Banking Theory and Practice*, *10*(1), 93–111. https://doi.org/10.2478/jcbtp-2021-0005

Guo, M., & Lim, E.-S. (2024). Does inflation targeting matter for price stability? *International Review of Economics and Finance*, *91*, 1015–1032. https://doi.org/10.1016/j.iref.2024.01.035

Gürkaynak, R. S., Kara, A. H., Kısacıkoğlu, B., & Lee, S. S. (2021). Monetary policy surprises and exchange rate behavior. *Journal of International Economics*, *130*, Article 103443. https://doi.org/10.1016/j.jinteco.2021.103443

Islam, M. S., Hossain, M. E., Chakrobortty, S., & Ema, N. S. (2022). Does the monetary policy have any short-run and long-run effect on economic growth? A developing and a developed country perspective. *Asian Journal of Economics and Banking*, *6*(1), 26–49. https://doi.org/10.1108/AJEB-02-2021-0014

Islam, T. U., & Ahmed, D. (2023). Inflation targeting: A time-frequency causal investigation. *PLoS ONE*, *18*(12), Article e0295453. https://doi.org/10.1371/journal.pone.0295453

Kočenda, E., & Valachy, J. (2006). Exchange rate volatility and regime change: A Visegrad comparison. *Journal of Comparative Economics*, *34*(4), 727–753. https://doi.org/10.1016/j.jce.2006.07.003

Krušković, B. D. (2022). Central Bank intervention in the inflation targeting. *Journal of Central Banking Theory and Practice*, *11*(1), 67–85. https://doi.org/10.2478/jcbtp-2022-0003

Nasir, M. A., Ahmad, M., Ahmad, F., & Wu, J. (2015). Financial and economic stability as 'two sides of a coin': Non-crisis regime evidence from the UK based on VECM. *Journal of Financial Economic Policy*, *7*(4), 327–353. https://doi.org/10.1108/JFEP-01-2015-0006

Nasir, M. A., Duc Huynh, T. L., & Vo, X. V. (2020). Exchange rate pass-through & management of inflation expectations in a small open inflation targeting economy. *International Review of Economics and Finance*, *69*, 178–188. https://doi.org/10.1016/j.iref.2020.04.010

Siklos, P. L. (2010). Meeting Maastricht: Nominal convergence of the new member states toward EMU. *Economic Modelling*, *27*(2), 507–515. https://doi.org/10.1016/j.econmod.2009.11.003

Šimáková, J. (2024). The role of exchange rate in contemporary Czechia's foreign trade. In D. Stavárek & M. Tvrdoň (Eds.), *Modeling economic growth in contemporary Czechia* (pp. 51–69). Emerald Publishing. https://doi.org/10.1108/978-1-83753-840-920241004

Soukiazis, E., & Castro, V. (2005). How the Maastricht criteria and the stability and growth pact affected real convergence in the European Union: A panel data analysis. *Journal of Policy Modeling*, *27*(3), 385–399. https://doi.org/10.1016/j.jpolmod.2005.01.002

Szkorupová, Z., Krkošková, R., & Szarowská, I. (2024). Nominal and real convergence of Czechia with the euro area. In D. Stavárek & M. Tvrdoň (Eds.), *Modeling economic growth in contemporary Czechia* (pp. 17–34). Emerald Publishing. https://doi.org/10.1108/978-1-83753-840-920241002

Taylor, J. B. (1993). Discretion versus policy rules in practice. *Carnegie-Rochester Conference Series on Public Policy*, *39*, 195–214. https://doi.org/10.1016/0167-2231(93)90009-L

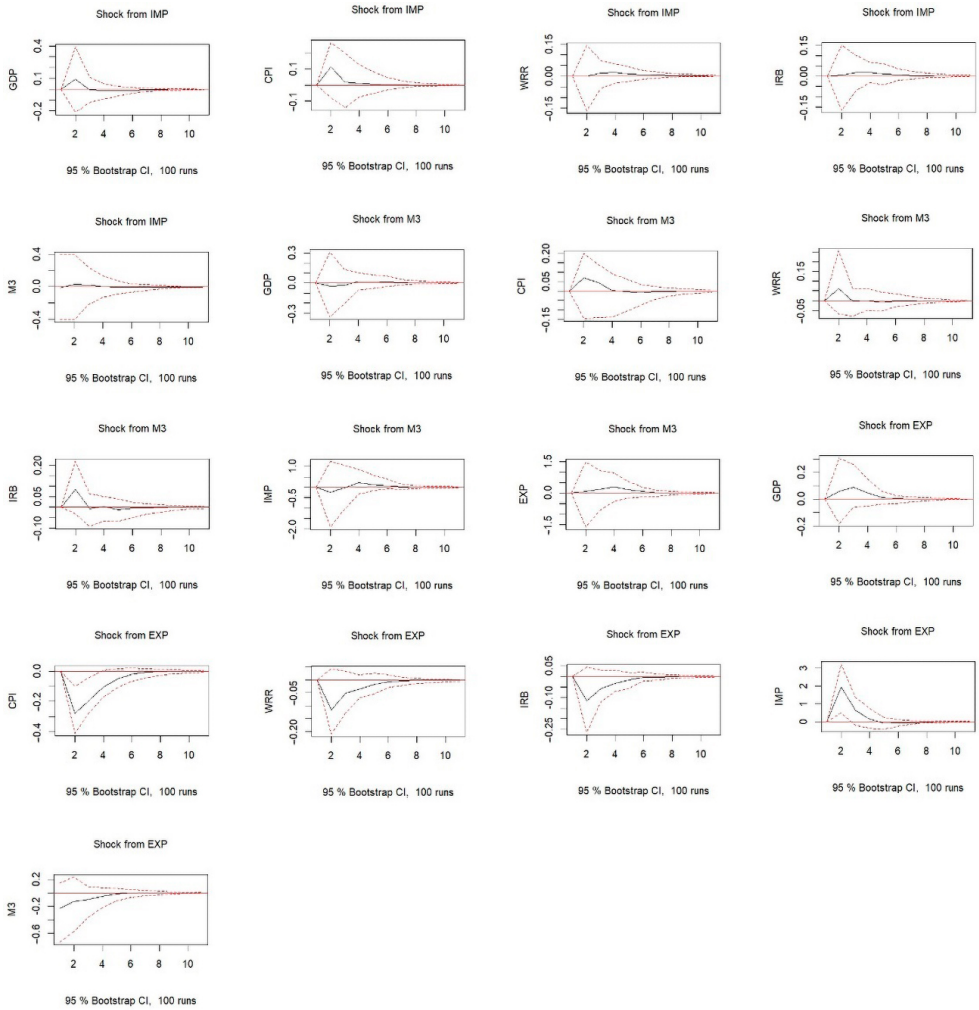
Wang, G., & Hausken, K. (2023). Modeling which factors impact interest rates. *Journal of Central Banking Theory and Practice*, *12*(2), 211–237. https://doi.org/10.2478/jcbtp-2023-0020

World Bank. (n.d.). *World Bank Open Data*. Retrieved July 8, 2024, from https://data.worldbank.org/

Yakubovskiy, S., Alekseievska, H., & Tsevukh, J. (2020). Impact of the European Central Bank monetary policy on the financial indicators of the eastern European countries. *Journal Global Policy and Governance*, *9*(1), 37–49. https://doi.org/10.14666/2194-7759-9-1-003

Zuniga, M. C., & Senbet, D. (2023). Does the effectiveness of monetary policy depend on the choice of policy instrument? Empirical evidence from South Korea. *Journal of Central Banking Theory and Practice*, *12*(2), 239–265. https://doi.org/10.2478/jcbtp-2023-0021

APPENDIX



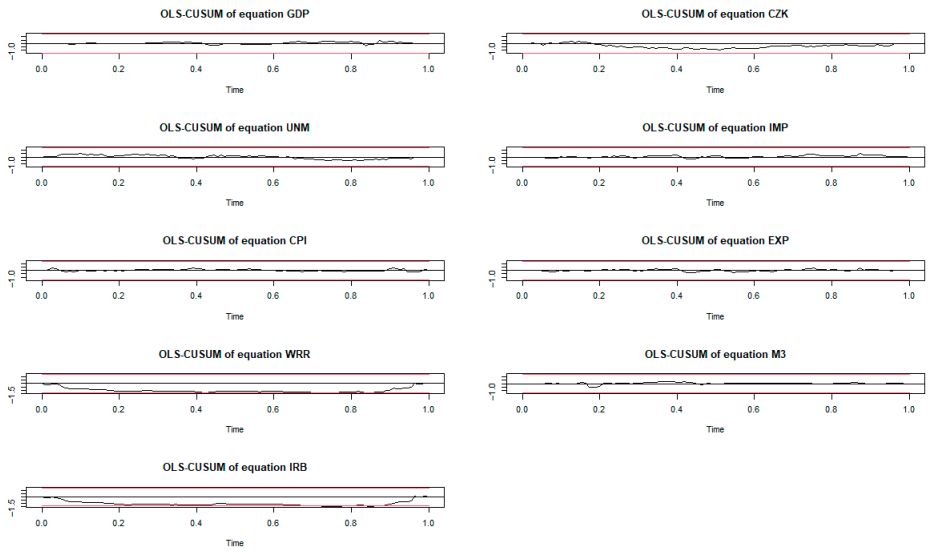
Note: The figure displays impulse response function (IRF) plots for IMP, EXP, and M3 variables. The IRF shocks are bounded between two variables using a 95% confidence band and simulated with 100 trials. The estimates are derived with differenced series and cover the period from January 1, 1997, to June 1, 2023. The red line represents the distance from the trend line (black) and denotes the margin of error. These results were obtained using the "vars" package and the "irf" function in R studio.

Figure A1. IRF shocks produced by IMP, EXP, and M3 (source: authors' elaboration)

Table A1. Granger causality tests for the system of variables (source: authors' elaboration)

Hypothesis testing	*p*-value	H_0
Granger causality H_0: GDP does not Granger-cause *UNM, CPI, WRR, IRB, CZK, IMP, EXP, and M3*	4.976 (*0.000*)	Accepted
Granger causality H_0: UNM does not Granger-cause *GDP, CPI, WRR, IRB, CZK, IMP, EXP, and M3*	2.593 (*0.008*)	Accepted
Granger causality H_0: CPI does not Granger-cause *GDP, UNM, WRR, IRB, CZK, IMP, EXP, and M3*	1.005 (*0.434*)	Rejected
Granger causality H_0: WRR does not Granger-cause *GDP, UNM, CPI, IRB, CZK, IMP, EXP, and M3*	4.699 (*0.786*)	Rejected
Granger causality H_0: IRB does not Granger-cause *GDP, UNM, CPI, WRR, CZK, IMP, EXP, and M3*	3.179 (*0.001*)	Accepted
Granger causality H_0: CZK do not Granger-cause *GDP, UNM, CPI, WRR, IRB, IMP, EXP, and M3*	1.312 (*0.233*)	Rejected
Granger causality H_0: IMP does not Granger-cause *GDP, UNM, CPI, WRR, IRB, CZK, EXP, and M3*	2.254 (*0.021*)	Accepted
Granger causality H_0: EXP do not Granger-cause *GDP, UNM, CPI, WRR, IRB, CZK, IMP and M3*	2.782 (*0.004*)	Accepted
Granger causality H_0: M3 do not Granger-cause *GDP, UNM, CPI, WRR, IRB, CZK, IMP, and EXP*	0.256 (*0.923*)	Rejected

Note: The table presents the results of the Granger causality test, where each variable is tested against all other variables in the system. The data consists of quarterly observations for nine variables covering the period from January 1, 1997, to June 1, 2023. The tests were performed on the logarithmic return series, and the results were analyzed using the "urca" package in R studio.



Note: This figure displays our model's stability (structural breaks) for nine variables: GDP, UNM, CPI, WRR, IRB, CZK/USD, EXP, IMP, and M3. The plots were created in R Studio using the "vars" package and the "stability" function. The red lines indicate the 95 % confidence band, while the black lines show the movements of the residuals. The series spans from February 1, 2022, to February 1, 2023.

Figure A2. Structural breaks based on the OLS-CUSUM type (source*:* authors' elaboration)