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September

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Foreword by the Governor

Exactly four years have passed since the publication of the first National Bank of Serbia's Working Papers Bulletin. From today's perspective, I can say that through this publication we have sought to familiarise the professional public with research in various areas and fields of activity of the National Bank – monetary policy, macroeconomics, financial markets, supervision of the banking system, payment systems – and that we have covered a wide range of current topics discussed at the global level as well, using advanced techniques of empirical analysis. The research activities within the institution I lead provide a solid basis for analysing the impact of various factors and risks on the Serbian economy and for making decisions in these turbulent times.

We have continued the same practice in this issue of the Bulletin. One of the important questions for monetary policy makers around the world in recent years concerns the level of the neutral interest rate – the rate at which monetary policy is neither restrictive nor expansionary. In the first paper in this issue, the authors assess the level of the neutral rate for Serbia for the period 2008–2024, using several approaches – the HLW model, which links the neutral interest rate to potential output; two versions of small structural models that also take into account the effect of real appreciation on the neutral interest rate; as well as a vector autoregression model with time-varying parameters (TVP-VAR). The common conclusion is that the neutral interest rate showed a declining trend in the first years after the global financial crisis of 2008, up until the beginning of 2014. After that, structural models that include the real exchange rate in estimating the neutral interest rate, as well as the TVP-VAR model, point to a relatively low neutral interest rate or even its continued downward trajectory. A common feature of all the estimated models is that in the past two years the neutral rate has shown an upward trend, but according to most models the real neutral rate still remains lower than the real repo rate and the interest rate in the interbank money market, BELIBOR.

The second paper in the Bulletin looks into the impact of fiscal policy on economic activity in Serbia, with a special focus on the analysis of asymmetry in effects, i.e. whether there is a difference in the strength of fiscal policy's impact on economic activity depending on whether fiscal policy is expansionary or restrictive. By applying a nonlinear autoregressive distributed lag model (NARDL), with control variables (real effective exchange rate, consumer price index, and the key policy rate), it was established that fiscal policy in Serbia has symmetric effects in both the short and long run. The estimated coefficients of this model show that a 1% increase in public spending leads to GDP growth of 0.55% in the long run, while a reduction in public spending contributes to a 0.47% decrease in GDP. The effects of fiscal policy on aggregate demand suggest that a countercyclical approach – increasing government expenditures during recessions and rationalising them during expansions – can contribute to more stable economic growth while preserving fiscal sustainability.

As can be seen, the papers in the new Bulletin continue to cover a wide range of topics. Going forward, we will remain committed to presenting studies that provide in-depth analyses of the relationships between various economic and non-economic variables, employing advanced quantitative techniques and other analytical tools. It is my hope that these contributions will help our readers gain a deeper understanding of macroeconomic trends, the factors that strongly influence monetary policy decision-making, as well as a range of issues and solutions related to the other functions of the National Bank of Serbia.

Dr Jorgovanka Tabaković, Governor

WORKING PAPERS:

National Bank of Serbia

NEUTRAL INTEREST RATE ESTIMATE FOR SERBIA

Jelena Momčilović, Nikša Košutić, Mirjana Miletić

Available at www.nbs.rs

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Neutral interest rate estimate for Serbia

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Abstract: The aim of this paper is to estimate the neutral interest rate for Serbia using various methods and to compare the resulting estimates. The analysis was conducted for a period of the previous 17 years (2008–2024), and the following models were used for the estimation: the HLW model, two versions of quarterly small structural models that account for the effect of real exchange rate appreciation on the level of the neutral interest rate (the so-called Penn effect in economic literature), as well as a time-varying parameter vector autoregression model TVP-VAR. The results of the analysis show that including the equilibrium real exchange rate as an explanatory variable results in a lower estimate of the neutral interest rate compared to the HLW model. Furthermore, according to most of the estimated models, monetary policy remains restrictive.

According to all the estimated models, as has been the case for other countries, the neutral interest rate in Serbia exhibited a declining trend in the initial years following the 2008 global economic crisis until the beginning of 2014. Thereafter, the models that include the real exchange rate for neutral interest rate estimate, as well as the TVP-VAR model, indicate a relatively low neutral interest rate or even a continuation of its declining trajectory. An exception is the HLW model, which suggests that, as a result of growth in potential output, the neutral interest rate displayed an upward trend until the coronavirus pandemic. A common characteristic of all the estimated models is that the neutral rate has been on an upward trajectory over the last two years; however, for most models (with the exception of the HLW model, which estimates the neutral rate at a higher level) the estimate of the neutral (real) rate is below or around 1%..

Key words: neutral interest rate, monetary policy, inflation, output gap, real appreciation, QPM, HLW approach.
[JEL Code]: E47, E58, E37

Non-Technical Summary

In global professional literature, one of the most prominent topics is that of the neutral interest rate. Its importance stems from the fact that it serves to assess the monetary policy stance. When making monetary policy decisions and evaluating the monetary policy stance, it is not sufficient to know only the direction in which the policy rate will be changed. To achieve the desired effect within the monetary policy cycle, it is most often necessary to adjust the policy rate multiple times, which can take several months or even years, to ensure its level is adequate for achieving the intended effect on monetary conditions, and thereby on economic activity and inflation. It is therefore essential to determine the level of the neutral interest rate, which is most commonly defined as the interest rate consistent with stable inflation at target and full utilisation of productive capacities – i.e. the rate at which monetary policy is neither restrictive nor expansionary.

Prior to the outbreak of the coronavirus pandemic, both nominal and real policy rates of central banks were exceptionally low in both developed and emerging economies. In such circumstances, the question increasingly arose: was the decline driven by a fall in the neutral interest rate, or by persistent economic shocks? This, in turn, raised the question of the level of the neutral rate itself. Similarly, following the sharp increase in central bank policy rates in response to elevated global inflation following the pandemic, a new question emerged: what will happen to the neutral interest rate in the period ahead – namely, whether it is realistic to assume it will return to its pre-pandemic level.

As the neutral interest rate is a theoretical concept and is not a rate directly set by monetary authorities, nor a rate at which transactions are conducted, it is not directly observable and must be estimated. One of the most commonly used methods for estimating the neutral interest rate is the approach of Laubach and Williams (2003), and subsequently Holston, Laubach and Williams (2017), where the neutral rate is linked to potential output. However, in small, open economies like Serbia, periods of high economic growth and substantial foreign capital inflows are typically accompanied by appreciation of the real exchange rate, a phenomenon known in economic theory as the Penn effect. Practically, besides the yields achievable from production, foreign investors also realise a part of their yields from the real appreciation of the currency of the country they invest in.

Given the importance of the neutral interest rate concept for monetary policy conduct, this paper estimates the level of the neutral interest rate for Serbia over the past 17 years (Q1 2008 – Q4 2024). Our estimate is based on several models. The first model, which the NBS also uses for its medium-term inflation projection, was adapted to estimate the trend of the real interest rate incorporating the Penn effect – i.e. including the equilibrium real exchange rate, as considered in the paper of Hlédik and Vlček (2018). The second model follows the approach proposed by Bulíř and Vlček (2024), which also incorporates the equilibrium real exchange rate into a small structural model with four core equations (a Phillips curve equation, an IS curve equation, an uncovered interest parity equation, and a Taylor rule equation). The third is based on the approach of Holston, Laubach and Williams (2017), which links the real interest rate to potential output, and finally, an estimate of a time-varying parameter vector autoregression model (TVP-VAR).

The estimates of the neutral interest rate for Serbia based on the above methods were largely consistent until the beginning of 2014 and displayed a declining trend, which was also a characteristic of Western countries and the rest of the CSEE region, primarily due to reduced potential output and low investment. Thereafter, the models that include the real exchange rate for estimating the neutral interest rate, as well as the TVP-VAR model, indicate a relatively low neutral interest rate or even a continuation of its declining trajectory. In contrast, according to the HLW model, the neutral interest rate exhibited an upward trend until the coronavirus pandemic, driven mainly by potential output growth. A common feature of all the estimated models is that the neutral rate has recorded an upward trend over the last two years; however, for most models (with the exception of the HLW model) the estimate of the neutral (real) rate is below 1%. The results of the analysis show that for estimating the neutral interest rate in Serbia, it is more appropriate to use models that also account for the effect of real appreciation, as the estimate obtained from the HLW model is quite volatile for the observed period, especially considering that Serbia recorded significant FDI inflows during the analysed period and that foreign companies also achieved a part of their yields from the real appreciation of the dinar.

Contents

1 Introduction

Following the outbreak of the coronavirus pandemic, global inflationary pressures increased significantly, resulting in monetary policy tightening by most central banks worldwide. Concurrently, the level of public debt in many countries also rose, given the substantial fiscal stimulus packages provided to facilitate economic recovery from the pandemic. In the pre-pandemic period, many economies recorded a considerable decline in real interest rates, which had already sparked a debate on whether such a trend was the result of a fundamental decline in the neutral interest rate (r*) or was instead a consequence of economic shocks. As the period since the pandemic's outbreak has driven interest rates higher, the question of the level of the neutral rate has gained additional significance for the conduct of monetary policy. Consequently, central banks' interest in this topic has increased markedly over the past several years.

The neutral interest rate is estimated for two key reasons. First, an estimate of the neutral rate allows for an assessment of the monetary policy stance and, second, it indicates the level to which policy rates should converge in the long run. In this way, the neutral interest rate plays a significant role in a central bank's communication with the public and can help anchor inflation expectations around the inflation target. As a government typically services its obligations on loans and bond issuances over a longer horizon, the concept of the neutral rate is also important for fiscal policy, as it can assist in determining the government's total financing costs and in assessing public debt sustainability.

The concept of the neutral interest rate was introduced into economic theory by Wicksell (1936), who defined it as the rate consistent with a stable price level, while it was incorporated into modern macroeconomic theory by Woodford (2003), who linked it to the monetary policy rule within the New Keynesian paradigm.

According to one of the most commonly used definitions, the neutral interest rate represents the rate that would prevail in the long run in the absence of business cycle fluctuations – i.e. the interest rate that is consistent with stable inflation at target and output growth equal to potential growth [Borio, 2021]. Practically, it is the rate at which monetary policy is neither restrictive nor expansionary. Underestimating the neutral interest rate leads to an overheating of the economy and rising inflation because monetary policy is more expansionary than it should be, while overestimating it results in higher unemployment and a slowdown in economic growth. An alternative definition describes it as the rate that balances the level of investment and savings.

The neutral rate is often equated with the long-run equilibrium interest rate and with the natural rate of interest (r*), although differences exist depending on the definition. The neutral interest rate is more oriented towards the medium term, where the effects of economic shocks that cannot be fully isolated still persist, whereas the long-run interest rate (the natural rate) depends solely on structural factors. In the long run, the neutral interest rate converges to the natural rate of interest.

The neutral interest rate is an analytical concept; it is not an interest rate for which data are available and which can be observed, but is instead estimated based on the movements of the economic fundamentals that determine it. These include potential output, productivity, demographic factors, the saving-investment balance, risk premia, fiscal indicators etc. Generally, factors that lead to increased saving and decreased investment contribute to a lower neutral interest rate. Thus, lower potential output leads to lower investment by affecting a lower marginal return on capital, which in turn increases saving. Similarly, longer life expectancy increases saving, whereas a growing working-age population works in the opposite direction. Financial factors, such as a higher country risk premium, as well as a persistently larger fiscal deficit and public debt that necessitate fiscal consolidation, also act to increase saving. Greater income inequality operates in the same direction, due to a higher propensity to save among higher-income groups. Lower productivity also contributes to a lower neutral interest rate by reducing potential output and, consequently, the propensity to invest.

Due to the variety of estimation methods, which often yield significantly different results, it is challenging to precisely assess the true level of the neutral interest rate. Furthermore, as it depends on multiple factors, it is not constant but evolves over time, albeit at a considerably slower pace than the policy rate set by the central bank. Moreover, the neutral interest rate is generally independent of monetary policy decisions, as monetary policy is neutral in the long run and does not affect real macroeconomic variables.

The first group of models for estimating the neutral interest rate comprises structural and econometric models. One of the most commonly used methods within this group is the approach by Laubach and Williams (2003), and subsequently Holston, Laubach and Williams (2017), based on a small New Keynesian structural model. According to this model, the neutral interest rate is derived by combining the real interest rate and the output gap via an IS curve for a closed economy, as well as the output gap and inflation via a Phillips curve. This method separates trend and cyclical component, with the neutral interest rate and potential output representing the trend of the component of the interest rate and economic activity. This approach has been used to estimate the neutral rate for the Federal Reserve System and many other central banks, including those of small, open economies. The second group of models is based on financial market perceptions, where the neutral rate is interpreted as the expected real interest rate derived from the term structure of nominal and real interest rates, i.e. adjusted for the term premium. The third group consists of survey-based methods, where professional forecasters are directly asked about their long-term expectations for central bank policy rates and inflation; the median difference between these estimates provides an assessment of the neutral rate.

Economists agree that the neutral interest rate had a declining trend in previous decades and was at a historically lowest level immediately prior to the coronavirus pandemic. In developed and some emerging economies, the fall in the neutral rate over the past three–four decades was primarily influenced by demographic factors and declining total factor productivity, with specific factors accounting for differences in levels. Consequently, central bank policy rates also reached their lowest levels in the pre-pandemic period. However, following the tightening of monetary policy by central banks in response to heightened global inflationary pressures, the question arises as to whether the neutral rate in these countries has also increased and what level can be expected in the period ahead. There is no consensus among economists on these questions. Most analysts agree that it is unlikely the neutral rate will fall below its pre-pandemic level in the coming period, with some even suggesting it could rise. Factors cited as potentially driving an increase in the neutral rate include the supply of safe assets, the weakening of some drivers of income inequality, and rising investment necessary for the transition to a green economy.

Given the importance of this concept for the conduct of monetary policy, this paper estimates the level of the neutral interest rate for Serbia over the past 17 years. Our estimation is based on several models. The first is a QPM used by the NBS for its medium-term inflation projection, adapted to estimate the real interest rate trend in a manner similar to Hlédik and Vlček (2018). The second follows the approach and model proposed by Bulíř and Vlček (2024), and the third is based on the approach of Holston, Laubach and Williams (2017). Finally, we also estimated the neutral interest rate using a TVP-VAR model.

The working paper is structured as follows. The section following this introduction provides a literature review concerning estimates of the neutral interest rate for other countries. The third section presents different conceptual approaches to estimating the neutral rate, some of which we employed for our own estimate. The fourth section contains an analysis of the results obtained for Serbia. Concluding remarks are provided at the end.

2 Overview of literature

Many central banks estimate the neutral interest rate. As previously noted, interest in this topic has increased markedly over the past three years, a period during which inflationary pressures intensified significantly in almost all countries worldwide, prompting central banks to respond by tightening monetary policy. The structural models used to estimate the neutral interest rate can be divided into two main groups: general equilibrium models, which include DSGE models, which estimate the neutral rate as the return on capital when savings and investments are in equilibrium; and semi-structural models, typically New Keynesian models, which are based on relationships between core macroeconomic variables estimated using econometric techniques. The Holston Laubach and Williams (HLW) model falls into the latter category.

As mentioned earlier, the majority of empirical analyses are based on the Laubach-Williams (LW) model, which was initially used to estimate the neutral interest rate and potential output for the United States for the 1960–2000 period. Application of the Kalman filter determined that the neutral rate fluctuated considerably over that period. Subsequently, Holston, Laubach and Williams (2017) re-estimated this model and extended the analysis to Canada, the euro area and the United Kingdom. Their results indicated a decline in the neutral interest rate during 1990–2016 and highlighted the significant role of global factors in its movements.

The HLW method has also been applied in numerous other empirical analyses [for example, Berger and Kempa (2014); Armelius et al. (2018)]. According to an IMF assessment (WEO 2023), which is based on the HLW and the Platzer and Peruffo (2022) methods, the neutral interest rate has declined substantially over the past four decades in most major economies (the United States, the United Kingdom, Japan, Germany, France, Brazil, China and India). Furthermore, projections suggest that in advanced economies, the neutral rate will converge towards its pre-pandemic levels, but how close it gets to those levels will depend on the trajectory of fiscal policy. This is because a high level of public debt and fiscal expenditure leads to higher interest rates and simultaneously increases the need for fiscal consolidation. The IMF projects that population ageing will contribute to a decline in the neutral interest rate in emerging economies, and that over the next 30 years, China's neutral rate will fall by 1.5 pp, hovering around zero by 2050. Brand, Lisack and Mazelis (2025) estimated the ECB's real neutral interest rate using various methods, including three variants of the HLW approach, and found that estimates vary significantly depending on the estimation method used. According to these estimates, the real neutral interest rate is in a range of -0.5% to 0.5%, implying a nominal neutral rate of 1.75% to 2.25%. This is lower than a previous estimate, which placed it in a range of 1.75% to 3%. Carvalho (2023) also estimated the neutral interest rate for the euro area over the last 50 years using an HLW method adapted for the pandemic period and modified to incorporate inflation expectations into the neutral rate estimate. The results of this analysis indicate that the neutral rate declined from around 3% in the early 1970s to approximately 0.5% in 2022. The neutral rate fell particularly sharply following the 2008 global financial crisis, influenced by a decline in potential output and reduced total factor productivity, as well as adverse demographic factors and increased risk aversion, especially after the public debt crisis in some euro area countries.

Several empirical studies have employed VAR models to estimate the neutral interest rate. For instance, Del Negro et al. (2017) estimated the neutral rate for the United States from the 1960s to the 2010s and found that its decline was driven by a slowdown in economic activity and increased convergence in the returns on safe and liquid assets. Subsequently, the analysis by Del Negro et al. (2019) was extended to seven advanced economies, concluding that since the 1970s, interest rates in these countries followed a similar trend to those in the US. Cesa-Bianchi et al. (2022) further expanded the analysis to a panel of 31 countries for the 1950–2015 period. They estimated that the average equilibrium real interest rate rose from 1.25% in the mid-1950s to 2.75% in the mid-1970s, and has since declined significantly, to 0.25% by 2015.

Regarding analyses of the neutral interest rate that include CSEE countries, the study by Bulíř and Vlček (2024) on twelve open economies is particularly noteworthy. For this estimation, the authors adjusted the HLW model by incorporating the equilibrium real exchange rate into their assessment of the real neutral interest rate (the so-called Penn effect, which indicates a positive correlation between economic growth and real exchange rate appreciation). Their premise was that in small open economies, the economic structure changes significantly under the influence of capital inflows from abroad, resulting in real appreciation. Generally, countries experiencing real appreciation will have a lower neutral interest rate, as investors require lower yields since they gain part of their yields from real appreciation. Conversely, in countries with real depreciation, investors demand a higher yields, leading to a higher neutral interest rate. The authors compared their results for the sample countries with those obtained using the HLW approach and concluded that their model estimates the neutral rate to be approximately 1 pp higher. In other words, according to their assessment, real interest rates were below neutral in many of the analysed countries, suggesting that excessively expansionary monetary policy also contributed to inflation in these economies during the 2021–2023 period. Serbia was included in this analysis, and the results indicated that Serbia's real interest rate was at or above the level of the neutral rate in the pre-pandemic period under review.

Previously, Hlédik and Vlček (2018) estimated the neutral interest rate for the Czech Republic for the period 2000–2017 using a small structural model with rational expectations. In their model, the neutral rate is a function of potential output adjusted for the equilibrium real exchange rate (the real exchange rate trend). According to their estimates, the neutral interest rate in the Czech Republic was around 1% in 2017, and its decline relative to 2015 was largely a result of real exchange rate appreciation amid strong economic growth.

Stefanski (2018) estimated the neutral interest rate for the Czech Republic, Poland, Hungary and the euro area for 1996–2017 using both a New Keynesian model, as recommended by Gali and Monacelli (2005), and a version of the HLW method. It was found that the neutral rate in the observed countries declined significantly following the global financial crisis, recovered somewhat after 2012, but remained substantially lower in 2017 than it was before 2008.

Bielecki et al. (2023), applying the methodology used by Del Negro et al. (2017), followed by Brand and Mazelis (2019) and Holston, Laubach and Williams (2017), estimated the neutral interest rate for Poland and compared it to the estimate for the euro area. The conclusion of this analysis was that the neutral rate had declined significantly over the past two decades in both Poland and the euro area, driven by demographic factors and declining productivity. The neutral interest rate in Poland was consistently higher than in the euro area by an average of about 2–3 pp. The future trend of the neutral rate is less clear-cut – demographic factors will exert downward pressure, but artificial intelligence could boost productivity and act in the opposite direction.

3 Methodology of neutral interest rate estimate

3.1 Estimate of the neutral interest rate using the HLW approach

One of the most commonly used methods for estimating the neutral interest rate is the Laubach and Williams (LW), or Holston, Laubach and Williams (HLW) approach, based on a small structural New Keynesian model, which posits a relationship between aggregate supply, demand, interest rates and inflation. According to this concept, the neutral interest rate is defined as the interest rate that returns GDP to the level of potential output once the effects of short-term supply- and demand-side shocks have dissipated, and which also returns inflation to its target level over the medium term.

The authors begin with a version of the New Keynesian model for open economies, where the relationship between inflation and GDP is represented by a Phillips curve:

$$\pi_{H,t} = \beta E_t[\pi_{H,t+1}] + k\widetilde{y}_t, \quad (1)$$

where $\pi_{H,t}$ is inflation, and a $\widetilde{y}_t$ is the output gap, $\widetilde{y}_t = 100(y_t - y_t^*)$, and where cy y_t and y_t^* are the logarithms of real GDP and estimated potential output, respectively.

The IS curve is given in the following form:

$$\tilde{y}_t = E_t[\tilde{y}_{t+1}] - \sigma^{-1}\left(i_t - E_t\left[\pi_{H,t+1}\right] - r_t^n\right). \quad (2)$$

In the previous equation, i_t is the nominal risk-free interest rate, and r_t^n is the equilibrium real interest rate, which depends not only on expected domestic economic growth but also on global economic growth. The parameters k and σ denote consumption preferences and the technological factor, respectively. When the real interest rate gap $(i_t - E_t\left[\pi_{H,t+1}\right] - r_t^n)$ closes, inflation and the level of output stabilise.

In addition to these equilibrium equations, further equations are defined to estimate the neutral interest rate:

$$\pi_t = b_\pi \pi_{t-1} + (1 - b_\pi)\pi_{t-2,4} + b_y \tilde{y}_{t-1} + \varepsilon_{\pi,t}, \quad (3)$$

$$\tilde{y}_t = a_{y,1}\tilde{y}_{t-1} + a_{y,2}\tilde{y}_{t-2} + \frac{a_r}{2}\sum_{j=1}^{2}\left(r_{t-j} - r_{t-j}^*\right) + \epsilon_{y,t} \quad (4)$$

In equation (3), $\pi_{t-2,4}$ represents average inflation from the second to the fourth preceding period, r_t in equation (4) represents the real short-term interest rate, and r_t^* *ex-post* the natural interest rate. From the previous equations, it follows that shocks affecting inflation and the level of output need not affect the neutral interest rate, which reflects long-term changes in the relationship between the interest rate and the output gap.

The HLW model is estimated using the Kalman filter, where transition equations are defined as follows:

$$r_t^* = c g_t + z_t \quad (5)$$

$$y_t^* = y_{t-1}^* + g_{t-1} + \varepsilon_{y^*,t} \quad (6)$$

$$g_t = g_{t-1} + \varepsilon_{g,t} \quad (7)$$

$$z_t = z_{t-1} + \varepsilon_{z,t} \quad (8)$$

where g is the potential output growth rate, and z represents other determinants that may influence the natural interest rate, with these variables following a random walk process, while y_t^* denotes a random walk process with drift.

The authors of this concept propose that, for the pandemic period, the level of potential output should be adjusted by incorporating a stringency index, constructed by the University of Oxford for the period of the pandemic's most severe effects, such that:

$$y_t^{*\prime} = \begin{cases} y_t^* + \rho d_t & t \geq 2020T1 \\ y_t^* \end{cases} \quad (9)$$

where d_t is the level of the stringency index, representing the three-month average of daily data for quarter t.

In this way, equation (4) can be expressed as:

$$(y_t - y_t^{*\prime}) = a_{y,1}(y_{t-1} - y_{t-1}^{*\prime}) + a_{y,2}(y_{t-2} - y_{t-2}^{*\prime}) + \frac{a_r}{2}\sum_{j=1}^{2}\left(r_{t-j} - r_{t-j}^*\right) + \epsilon_{y,t} \quad (10)$$

Equation (3) can be modified so that instead of adaptive expectations, future inflation expectations are incorporated, giving it the following form:

$$\pi_t = b_\pi \pi_{t-1} + (1 - b_\pi)\mathrm{E}_t[\pi_{t+H}] + b_y \tilde{y}_{t-1} + \varepsilon_{\pi,t}, \quad (11)$$

where *H* is the horizon to which expectations refer.

Under the assumption of anchored expectations around the target, the previous equation takes the form:

$$\pi_t = b_\pi \pi_{t-1} + (1 - b_\pi)\pi^* + b_y \tilde{y}_{t-1} + \varepsilon_{\pi,t}, \qquad (12)$$

where π^* is inflation target.

Furthermore, equation (12) can also be presented as follows:

$$\tilde{\pi}_t = b_\pi \tilde{\pi}_{t-1} + b_y \tilde{y}_{t-1} + \varepsilon_{\pi,t}, \qquad (13)$$

where $\tilde{\pi}_t = \pi_t - \pi^*$, which indicates that the neutral interest rate depends not only on the inflation level, but also on inflation's deviation from target.

3.2 Estimate of the neutral interest rate using the modified HLW approach (Bulíř and Vlček)

Bulíř and Vlček (2024) modified the HLW approach and incorporated the change in the equilibrium level of the real exchange rate (Δz_t^*) into the neutral interest rate equation, based on the assumption that the appreciation of the real exchange rate is associated with FDI inflows and productivity growth:

$$r_t^* = \rho r_{t-1}^* + (1 - \rho)[2c_1(c_2 g_t^* + (1 - c_2)\Delta z_t^*)] \qquad (14)$$

Another key assumption of this model is that there is no stochastic component in the neutral interest rate equation and that the sum of the coefficients on potential output growth and the appreciation of the real exchange rate trend is equal to one.

Like any classic model used by central banks (so-called quarterly projection models), the model estimated by Bulíř and Vlček (2024) essentially consists of four key equations: a Phillips curve equation, an aggregate demand equation, an uncovered interest rate parity equation, and a monetary policy reaction equation.

The Phillips curve equation is expressed in the following form:

$$\pi_t = \mathrm{a}_1 \pi_{t-1} + (1 - \mathrm{a}_1)\pi_{t+1} + \mathrm{a}_2 RMC_t + \varepsilon_{\pi,t}, \qquad (15)$$

where RMC denotes real marginal costs defining the output gap and the real exchange rate gap:

$$RMC_t = \mathrm{a}_3 \tilde{y}_t + (1 - \mathrm{a}_3)\tilde{z}_t \qquad (16)$$

The aggregate demand equation takes the following form:

$$\tilde{y}_t = b_1 \tilde{y}_{t-1} - b_2 MCI_t + b_3 \tilde{y}_t^F + \varepsilon_{y,t}, \qquad (17)$$

where $\tilde{y}_t$ is the output gap, and the Monetary Conditions Index MCI is the combination of the real interest rate gap ($\tilde{r}_t$) and the real exchange rate gap ($\tilde{z}_t$):

$$MCI_t = b_4 \tilde{r}_t - (1 - b_4)(\tilde{z}_t) \qquad (18)$$

$\tilde{y}_t^F$ denotes foreign output gap.

The uncovered interest rate parity equation is defined as follows:

$$s_t = h_2(s_{t-1} + \Delta s^*) + (1 - h_2)[(1 - e_1)s_{t+1}^e + \pi_{t-1} + e_1(s_{t-1} + 2(\pi^* - \pi^{*,f} + \Delta z^*)) + (-i_t + i_t^f + prem_t)/4] + \varepsilon_{s,t} \qquad (19)$$

where s_t is the nominal exchange rate, Δs^* is the targeted level of exchange rate change, which enables model's adaptation to various exchange rate regimes, and π^* is the targeted inflation rate.

The fourth, monetary policy reaction equation, takes the form:

$$i_t = h_1(4(s_{t+1} - s_t) + i_t^f + prem_t) + (1 - h_1)[g_1 i_t + (1 - g_1)((r_t^* + \Delta_4\pi_{t+3}) + g_2(\Delta_4\pi_{t+3} - \pi^*) + g_3\,\tilde{y}_t)] + \varepsilon_{i,t} \quad (20)$$

This model, as defined, can be applied both to countries that target inflation exclusively ($h_1 = 0$), and to those that combine inflation and exchange rate stability.

3.3 Estimate of the neutral interest rate using the Taylor rule

Some central banks (e.g. the Reserve Bank of New Zealand) estimate the neutral interest rate by applying the Taylor rule, which considers the relationship between the nominal interest rate and a time-varying neutral real interest rate, expected inflation, inflation's deviation from target, and the output gap. This relationship can be expressed by the following formula:

$$i_t = r_t^* + \pi_{t+1}^e + \beta_t(\pi_t - \pi^*) + \varphi_t\tilde{y}_t + \varepsilon_{1,t} \quad (21)$$

Under the assumption of no arbitrage, a relationship is established between short-term and long-term interest rates, such that the long-term nominal rate R_t is equal to the short-term nominal interest rate ($r_t^* + \pi_{t+1}^e$), plus a term premium, α:

$$R_t = r_t^* + \pi_{t+1}^e + \alpha + \varepsilon_{2,t} \quad (22)$$

The real neutral interest rate is obtained as:

$$r_t^* = r_{t-1}^* + g_{t-1} \quad (23)$$

where the potential output growth rate follows a random walk process:

$$g_t = g_{t-1} + \varepsilon_{g,t} \quad (24)$$

The parameters β_t and $\varphi_t$are time-varying. The implied neutral interest rate is derived under the assumption that the medium-term neutral rate serves as the basis for decision-making. By adjusting for inflation expectations, the short-term, medium-term, and long-term real neutral interest rates are obtained [Castaing et al. (2024)].

3.4 Modified uncovered interest rate parity rule

In open economies characterised by substantial capital inflows, domestic and foreign interest rates are linked by the rule of uncovered interest rate parity. The uncovered interest rate parity rule posits that the returns on two currencies, adjusted for risk premium, tend to equalise:

$$z_t = z_{t+1}^e + \frac{r_t - r_t^f + \rho_t^*}{4} + e_t^z \quad (25)$$

According to the previous equation, the real exchange rate will tend to depreciate ($z_t - z_{t+1}^e$) as the difference between domestic and foreign market returns ($r_t - r_t^f$) narrows. In this case, the domestic neutral real interest rate is obtained as the sum of the foreign neutral interest rate and the estimated risk premium.

4 Estimate of the neutral interest rate for Serbia

4.1 Description of the variables used in the analysis and the analysis period

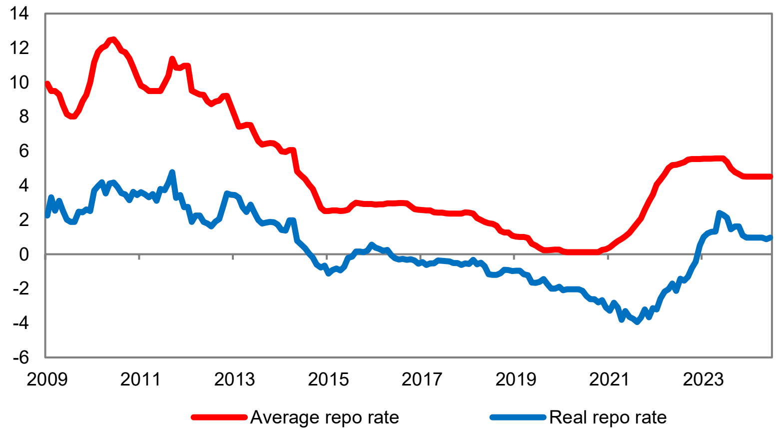
The analysis of the neutral interest rate estimate was conducted for the period from Q1 2008 to Q4 2024. Table 1 provides an overview of the variables used in the analysis.

In most part of the observed period, the NBS pursued an accommodative monetary policy. From late 2015, amid low and stable inflation, with inflation running below the target midpoint, the real interest rate was negative. Furthermore, since the end of 2012, the NBS has employed variable-rate auctions in its reverse repo transactions. This means that the key policy rate represents the maximum acceptable interest rate at auction. Due to the structural liquidity surplus, the average repo rate at which repo transactions are conducted becomes the benchmark for money market rates and trends below the key policy rate.

Table 1 **Overview of variables**

Designation	Description	Data source
π_t	quarterly inflation rate observed at annual level, s-a	SORS, authors' calculation
π^*	inflation target	NBS
$\widetilde{y}_t$	output gap	NBS, authors' calculation
$\widetilde{z}_t$	real exchange rate gap	NBS, authors' calculation
g_t^*	potential output growth rate	NBS, authors' calculation
Δz_t^*	change in real exhange rate trend	NBS, authors' calculation
$\widetilde{y_t^F}$	euro area output gap	NBS, authors' calculation
$\widetilde{r}_t$	real interest rate gap	NBS, authors' calculation
r_t^*	neutral interest (real interest rate trend)	NBS, authors' calculation
s_t	nominal exchange rate	SORS, authors' calculation
π^{*f}	euro area inflation target	ECB
i_t	one-week nominal repo interest rate	NBS
i_t^n	neutral nominal interest rate	NBS, authors' calculation
i_t^f	ECB key interest rate	ECB
RMC_t	real marginal costs	NBS, authors' calculation
MCI_t	monetary restrictiveness index	NBS, authors' calculation
$prem_t$	risk premium	NBS, authors' calculation

Chart 1 **Average repo interest rate (nominal and real)**



Following the outbreak of the coronavirus pandemic, amid rising global inflationary pressures, a monetary policy tightening cycle was initiated – first with an increase in the amount of liquidity withdrawn through repo auctions, which contributed to a rise in the average repo rate from around 0.1% in October 2021 to nearly 1% in April 2022. The rate thus practically aligned with the key policy rate. The key policy rate was subsequently increased in a series of steps until August 2023, reaching a level of 6.75%. Thereafter, as inflationary pressures eased, the need for further monetary tightening diminished, supported by a decline in inflation expectations. This allowed the real interest rate to return to positive territory, resulting in restrictive monetary conditions without additional key policy rate hikes. Inflation peaked at 16.2% y-o-y in March 2023 during this period of heightened inflationary pressures, before moderating and returning within the target band in May 2024. This enabled the NBS to commence an easing cycle in June 2024, reducing the key policy rate by a cumulative 75 bp by September 2024. Since then and up to the time of writing this working paper, the rate has remained unchanged (standing at 5.75%). Over this period, the nominal average repo rate stabilised at 4.5%, with the one-week BELIBOR rate – the interbank money market rate – also settling at a similar level.

4.2 Estimate results

Our analysis, covering the period from Q1 2008 to the end of 2024, is based on the estimation of various models and estimation methods outlined in Section 3, drawing on the papers of Laubach and Williams (2003), Bulíř and Vlček (2024), and Hlédik and Vlček (2018).

4.2.1 QPM results

The estimation of the neutral interest rate for Serbia, or the real interest rate trend, based on the QPM was conducted using two versions of this model type. In the first step, we modified the model we typically use for medium-term inflation projections to some extent, implementing this adjustment specifically in the part estimating the neutral interest rate. Rather than calculating it based on the uncovered interest rate parity equation, we followed the approach presented in Hlédik and Vlček (2018), where the neutral interest rate is proportional to potential GDP growth adjusted for changes in the equilibrium real exchange rate (i.e. change in the real exchange rate trend). In the second step, we employed the small structural QPM proposed by Bulíř and Vlček (2024), where the neutral interest rate is also determined based on equilibrium economic growth and real appreciation. The results from both models are presented below.

As previously highlighted, in the model proposed by Laubach and Williams (2003), the neutral interest rate is estimated based on a constraint derived from the Euler equation. According to this constraint, the neutral interest rate, r_t^*, is a function of potential GDP growth, Δy_t^*:

$$r_t^* = c\Delta y_t^* + \varepsilon_t, \tag{26}$$

where coefficient $c > 0$.

However, this equation is not entirely appropriate for estimating the neutral interest rate in the case of a small open economy with free capital movement, as the process of rapid economic growth and convergence typically results in real appreciation. Potential GDP growth only captures the yield on capital, while foreign investors also earn yield from changes in the real exchange rate. Therefore, according to Hlédik and Vlček (2018) and Bulíř and Vlček (2024), the estimation of the neutral rate must also incorporate changes in the equilibrium real exchange rate:

$$r_t^* = c(\Delta y_t^* + \Delta z_t^*) + \varepsilon_t, \tag{27}$$

where $\Delta z_t^* > 0$ denotes real depreciation, and $\Delta z_t^* < 0$ real appreciation, and where $\Delta y_t^* = g_t^*$ and Δz_t^* denote changes in equilibrium levels (trends).

As a reminder, according to Laubach and Williams (2003), the scaling parameter c is equal to 1. The specification of these equations differs from Laubach and Williams (2003) in that the neutral interest rate is not defined as the sum of two non-stationary random walk processes, but rather as a combination of two stationary variables, Δy_t^* и Δz_t^*. Equations were specified in a similar manner by Mesonnier and Renne (2007).

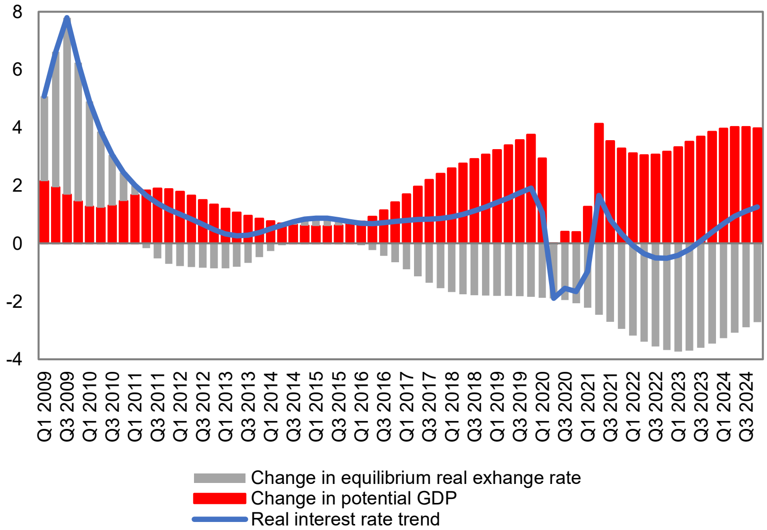
Chart 2 presents the contributions of potential GDP growth and real appreciation to the real interest rate trend in the absence of inertia in its movement, i.e. the estimate is based on equation (27). This Chart shows that the equilibrium real interest rate was relatively low and stable until the outbreak of the coronavirus pandemic, as relatively high potential GDP growth and an appreciating trend of the real exchange rate acted simultaneously. During the pandemic, the real interest rate trend decreased, primarily as a consequence of reduced potential output, but a gradual increase has been recorded thereafter, as the effect of higher potential GDP growth has outweighed that of real appreciation.

However, Hlédik and Vlček (2018) and Bulíř and Vlček (2024) in their empirical papers assumed that the neutral interest rate converges to potential GDP growth adjusted for the equilibrium real appreciation, with a certain degree of inertia in the movement of the neutral rate. They removed the stochastic component, as previously shown in equation 14, which we repeat here:

$$r_t^* = \rho r_{t-1}^* + (1-\rho)[2c_1(c_2 g_t^* + (1-c_2)\Delta z_t^*)], \tag{28}$$

where the change in potential GDP and the change in the equilibrium real exchange rate are defined as y-o-y changes.

Chart 2 **Decomposition of the real interest rate trend**



Furthermore, it can be noted that in the case where $c_2 = 0.5$, equation (28) is practically identical to equation (27).

Taking all of the above into account, we have incorporated equation (28) into the model used at the NBS for its medium-term inflation projection [for more details see Đukić, Momčilović and Trajčev (2011)], which was subsequently extended by including labour market equations [for details, see Momčilović and Miletić (2024)]. Previously, in these models, the real interest rate trend was estimated according to real uncovered interest parity:

$$r_t^* = \Delta z_t^* + prem_t^* + r\_ez_t^*, \tag{29}$$

where the real interest rate trend, r_t^*, as an approximation of the neutral interest rate, was obtained as the sum of the change in the estimated trend of the real exchange rate (Δz_t^*), an estimated risk premium ($prem_t^*$), and the trend of the real interest rate of the euro area ($r\_ez_t^*$), which was estimated using the Hodrick-Prescott (HP) filter.

We note that the coefficients in the model were calibrated in line with estimates obtained from other models or papers for other countries, but also based on the standard error of the Kalman filter to achieve economically intuitive relationships consistent with economic movements in Serbia (for more on the values of individual coefficients for estimating the neutral rate, see the Table 2).

The results of the neutral interest rate estimate obtained via the Kalman filter (Model 1), as well as potential GDP growth and the change in the equilibrium real exchange rate based on equation (28), are shown in Chart 3. Estimates from the same model calculated on the basis of uncovered interest parity, i.e. equation (29), are given in Chart 3.1. The analysis indicates that the real interest rate trend, as in other countries, was on a strong downward trajectory in the period following the 2008 global financial crisis. This can be linked to a reduced potential output in the initial years of the post-crisis period, caused by both low growth in the euro area

– our most important trading partner – and, consequently, low investment into Serbia, as well as an increased risk premium due to the risk of a public debt crisis erupting in certain euro area countries. Subsequently, according to this estimate, from 2014 to 2019 the real interest rate trend was relatively stable and low, at around 1%. After the real interest rate trend was further reduced following the outbreak of the coronavirus pandemic, a gradual increase has been observed in the post-pandemic period, and it is currently, according to this estimate, slightly below 1%. When observing the movement of the real repo rate and comparing it to the estimate of the real interest rate trend, it is evident that monetary policy had a restrictive character until the beginning of 2015. Then, in an environment of low inflationary pressures and inflation moving below the midpoint, monetary policy was expansionary. Since late 2023, according to this estimate, monetary policy has again had a restrictive character, but this is diminishing as inflationary pressures ease. Similar estimates were obtained using the uncovered interest parity equation, although according to that estimate, the trend of our real interest rate is at a lower level, around 0.5%.

Chart 3 **Estimate of the real interest rate trend by equation (28)**

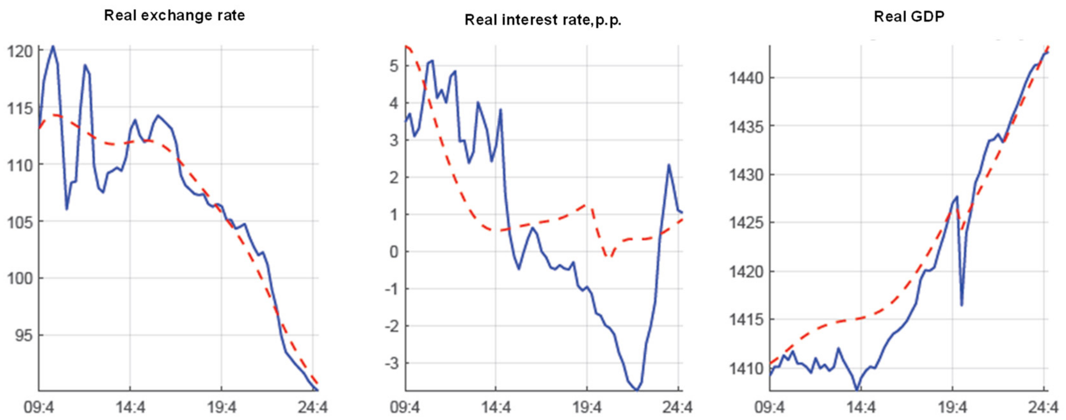
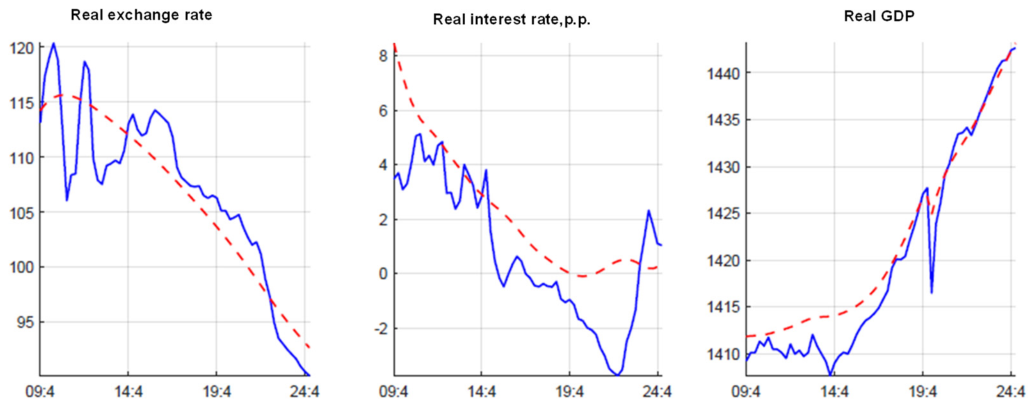


Chart 3.1 **Estimate of the real interest rate trend by UIP equation (27)**



The estimate of the neutral interest rate depends to a large extent on the estimates of potential GDP and the real exchange rate trend. The trends are based on the country's fundamentals and are not influenced by monetary policy. In contrast to the trend, the gap represents the cyclical component of a variable and is consistent with the country's business cycle. The estimate of the neutral interest rate also depends on the parameters in equation (28), namely on c_1, ρ and c_2. With this in mind, we conducted a sensitivity analysis of the obtained estimates to changes in the parameters of this equation, varying the values for the parameters: c_1 for $+0.25/-0.15, \rho$ for $\pm 0.17, c_2$ for ± 0.1 (see Charts 3.2, 3.3 and 3.4). The analysis shows that the resulting estimate of the real interest rate trend is most sensitive to changes in parameter c_2. The highest level of the interest rate is suggested by a coefficient value of $c_2 = 0.6$, as in this case the real interest rate trend is most dependent on potential output growth and less on real appreciation. In that scenario, the real interest rate trend is closer to a level of 2%.

Chart 3.2 **Estimate of the neutral interest rate depending on change in coefficient c_1**

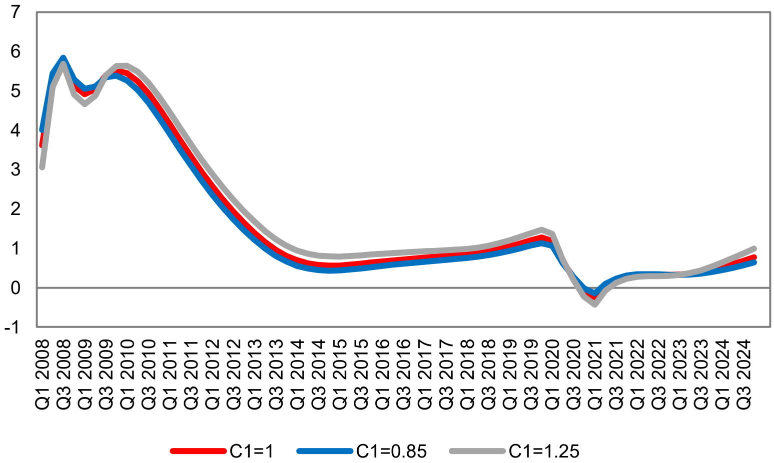


Chart 3.3 **Estimate of the neutral interest rate depending on change in coefficient ρ**

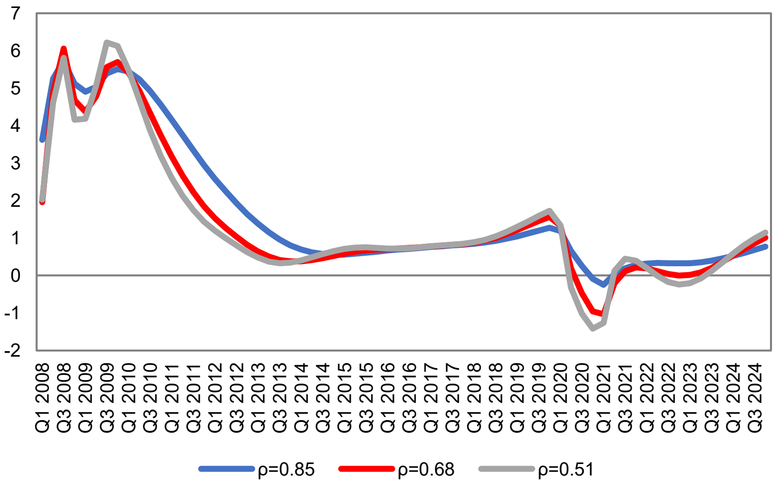
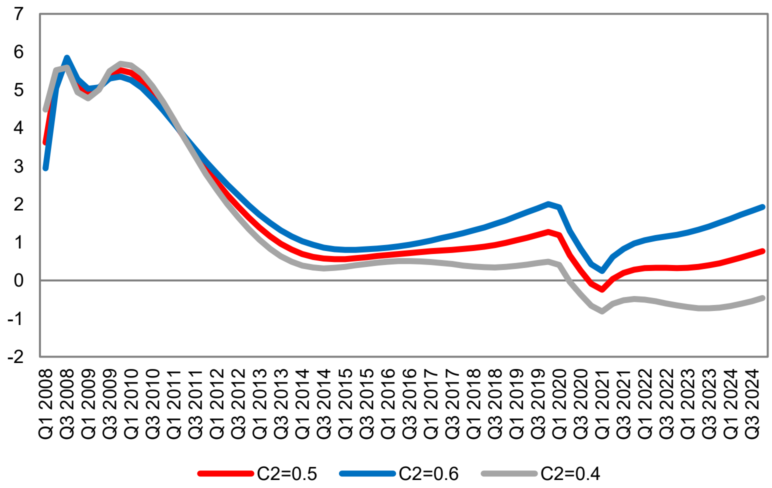


Chart 3.4 **Estimate of neutral interest rate depending on change in coefficient c_2** (in %)



The second model we estimated (Model 2) – QPM is proposed by Bulíř and Vlček (2024). The model is similar to the one we use for our medium-term inflation projection, with the difference that some equations are simplified (for instance, the Phillips curve for inflation) and the estimation was conducted using a Bayesian method. In addition to the Phillips curve, the model includes an IS curve, as well as a monetary policy rule. For further details, see Table 2, which provides an overview of all the equations in this model alongside the calibrated coefficients, as well as the prior distributions of the model's parameters.

Table 2 **Overview of equations, parameter values and standard deviations of estimated models**

Equations	Prior distribution		
	Type	Mean	Standard deviation
Phillips curve $\pi_t = a_1\pi_{t-1} + (1-a_1)\pi_{t+1} + a_2 RMC_t + \varepsilon_{\pi,t}$ $RMC_t = a_3\tilde{y}_t + (1-a_3)\tilde{z}_t$			
a_1	-	0.4	
a_2	Inv. γ	0.3	0.3
a_3	β	0.5	½*0.5
$\varepsilon_{\pi,t}$	Inv. γ	$^1/_4\,\mathrm{std}(\tilde{\pi}^{obs})$	Standard deviation during the coronavirus period (Q1 2021 – Q4 2022) was six times higher than in the pre-pandemic period.
IS curve $\tilde{y}_t = b_1\tilde{y}_{t-1} - b_2 MCI_t + b_3\tilde{y}_t^F + \varepsilon_{y,t}$ $MCI_t = b_4\tilde{r}_t - (1-b_4)(\tilde{z}_t)$			
b_1	β	0.4	¼*0.4
b_2	γ	0.2	¼*0.2
b_3	γ	0.6	¼*0.6
b_4	β	0.6	¼*0.6
$\varepsilon_{y,t}$	Inv. γ	$^1/_2\,\mathrm{std}(\widetilde{\Delta y}^{obs})$	
Neutral interest $r_t^* = \rho r_{t-1}^* + (1-\rho)(2c_1(c_2 g_t^* + (1-c_2)\Delta z_t^*))$			

Equations	Prior distribution		
	Type	Mean	Standard deviation
ρ	-	0.85	
c_1	γ	1	1/15*1
c_2	β	0.5	1/15*0.5
UIP $s_t = h_2(s_{t-1} + \Delta s^*) + (1 - h_2)((1 - e_1)s^e_{t+1} + \pi_{t-1} + e_1(s_{t-1} + 2(\pi^* - \pi^{*,f} + \Delta z^*)) + (-i_t + i^f_t + prem_t)/4) + \varepsilon_{s,t}$			
h_2	-	0	-
e_1	-	0.6	-
$\varepsilon_{s,t}$	-	$1/2\ \mathrm{std}(\widetilde{\Delta s}^{\mathrm{obs}})$	-
Monetary policy reaction function $i_t = h_1(4(s_{t+1} - s_t) + i^f_t + prem_t) + (1 - h_1)[g_1 i_t + (1 - g_1)((r^*_t + \Delta_4\pi_{t+3}) + g_2(\Delta_4\pi_{t+3} - \pi^*)] + g_3\,\tilde{y}_t + \varepsilon_{i,t}$ $prem_t = \rho_{prem} prem_{t-1} + (1 - \rho_{prem})(-\Delta z^*_t + r^*_t + r^{*f}_t) + \varepsilon_{prem,t}$			
h_1	-	0	-
g_1	-	0.7	-
g_2	-	2	-
g_3	-	0.2	-
ρ_{prem}	-	0.85	-
$\varepsilon_{i,t}$	-	$2 * \mathrm{std}(\tilde{\imath}^{\mathrm{obs}})$	Standard deviation is twice higher after 2010 and four times higher during 2008–2010.

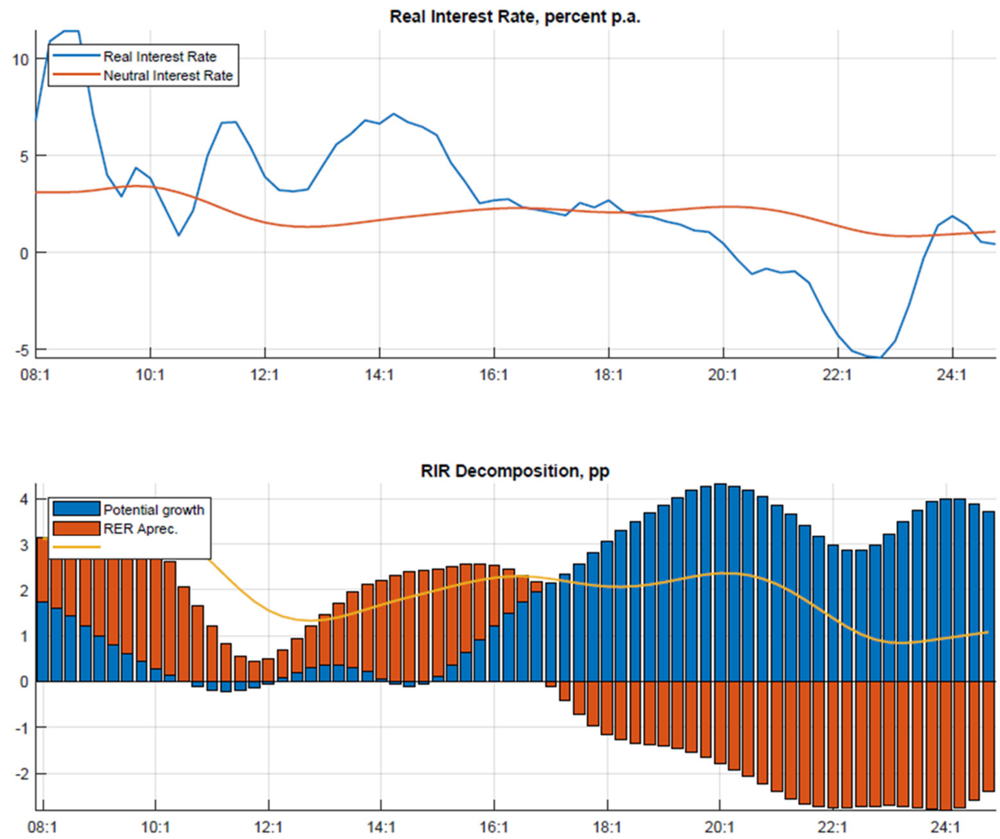
We adapted the model used by Bulíř and Vlček (2024) by calibrating its coefficients to match those from our medium-term inflation projection model and estimated it for the period Q1 2008 – Q4 2024. Specifically, the parameter denoting inflation inertia in the Phillips curve, a_1, was calibrated to 0.4, consistent with our medium-term inflation projection model, as opposed to the value of 0.5 used by Bulíř and Vlček (2024). This parameter reflects the assumed Calvo mechanism and is not estimated because it cannot be identified along with parameter a_2 due to their observational equivalence. The data for estimating the trend of real GDP of the euro area and the trend of the real interest rate of the euro area were obtained using an HP filter. Other trends and deviations, including the inflation target, are identified within the overall model framework using the Kalman filter, and the coefficients are estimated via the Bayesian method.

The prior distributions (priors) for parameters c_1 and c_2 were taken from the work of Bulíř and Vlček (2024) as 1 and 0.5, respectively, along with the standard deviations for these parameters suggested by the authors (provided in Table 2), given that these parameters are key for determining the neutral interest rate (r^*). In cases where a parameter was not estimated, only the mean of its calibrated value is shown. The prior distributions for the standard deviations of the supply shock, $std(\hat{\pi}\_obs)$, and demand shock, $std(\Delta\hat{y}\_obs)$, are set in line with the variability of the specific variable. Thus, $std(\hat{\pi}\_obs)$ denotes the standard deviation of the core inflation series from which the trend has been previously removed, and $std(\Delta\hat{y}\_obs)$ denotes the standard deviation of the real GDP growth rate series, from which the trend has also been removed (using an HP filter).

It is noteworthy that Bulíř and Vlček (2024), in their estimation for most countries, found the ratio of parameters c_1 and c_2 to be approximately ½, which together establish the proportional relationship between r* and potential growth g^*, known as the HLW relationship.

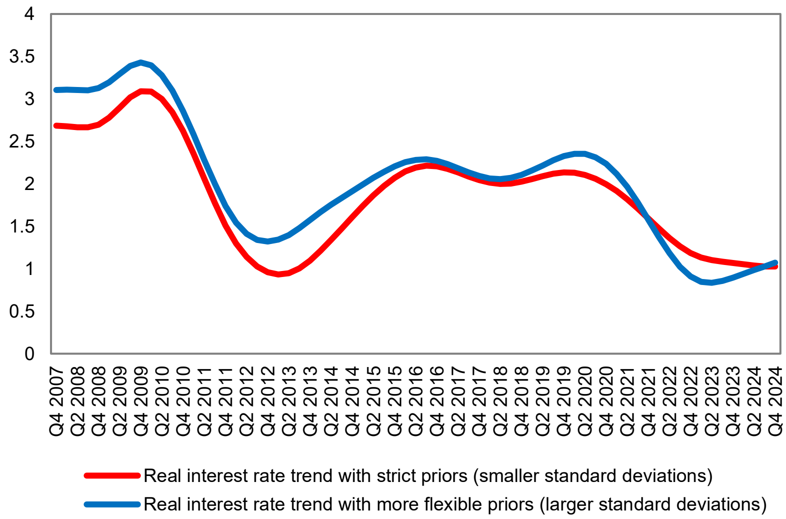
Chart 4 presents the estimate of the neutral rate, i.e. the real interest rate trend, and the estimates of its components derived from applying the QPM proposed by Bulíř and Vlček (2024). A decomposition of the neutral interest rate equation is also provided.

Chart 4 **Estimate of the neutral rate using the model proposed by Bulíř and Vlček (2024) and its decomposition**



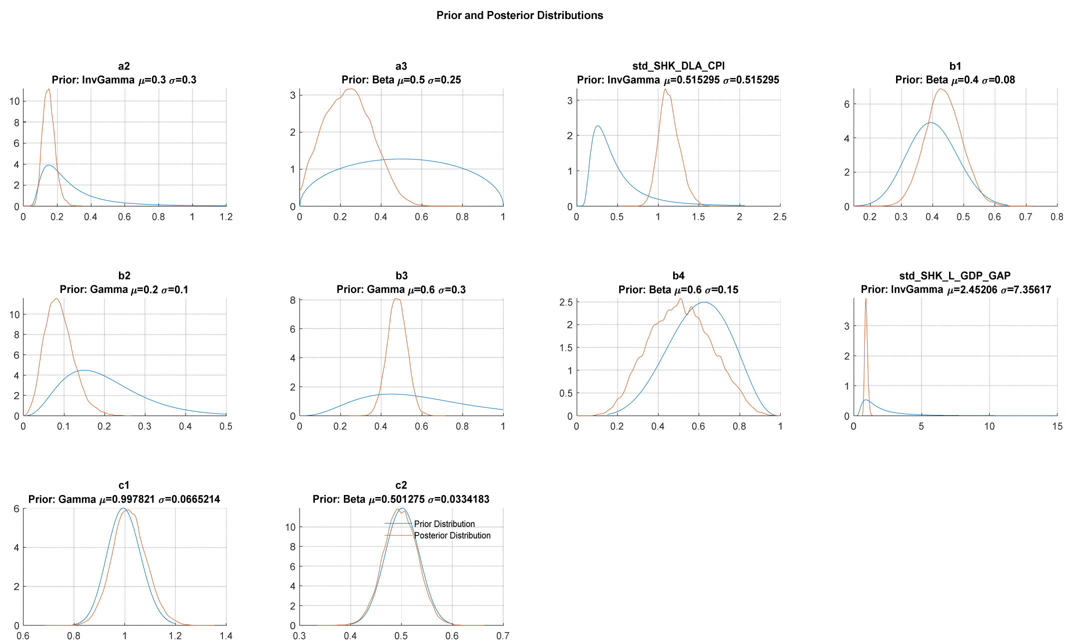
The authors analysed how changes in parameters c_1 and c_2 affect the estimate of the neutral interest rate (r*). The conclusion of the analysis is that, in the case of Serbia, the estimate of the neutral interest rate is sensitive to changes in the priors for c_1 and c_2. The estimate is conducted under an assumption of tight priors and less tight priors, by increasing the standard deviations of the estimated coefficients fivefold. In the case of Serbia, under the loosened priors, the estimate of the neutral interest rate was on average 30 bp lower over the period Q4 2007 – Q2 2021. When we extend the analysis period and incorporate the above model modifications, we find that for the period Q3 2021 – Q4 2024, the neutral rate estimate under the loosened priors is somewhat higher – by approximately 10 bp – but that the estimates nearly converge by the end of the analysed period (see Chart 5).

Chart 5 **Estimate of the neutral interest rate depending on changes in standard deviations used for estimating coefficients c_1 and c_2** (in %)



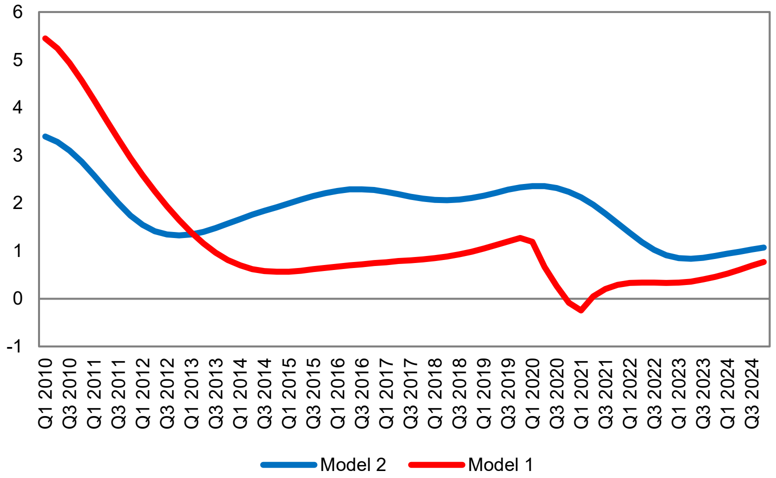
The posterior distribution of the model's estimated parameters was constructed using a Metropolis–Hastings simulation with 100,000 draws and is presented in Chart 6.

Chart 6 **Prior and posterior distributions of the coefficients estimated in Model 2**



In Chart 7, we present a comparison of neutral interest rate estimates derived from our medium-term projection model, where we replaced the UIP equation with a new equation incorporating potential GDP growth and the change in the real exchange rate trend for estimating the real interest rate trend (Model 1), and the QPM proposed by Bulíř and Vlček (2024), estimated via the Bayesian method (Model 2). A comparison of these models shows that the neutral interest rate estimate was lower for the majority of the observed periods according to Model 1. However, these differences are not significant, and by the end of the estimated period, the neutral rate estimates based on both models are very close.

Chart 7 **Comparison of neutral interest rate estimates based on Model 1 and Model 2** (in %)



Finally, bearing in mind that we adjusted the trend of potential GDP in our medium-term inflation projection model for the period Q1 2020 – Q4 2020 to account for a structural break, we also estimated Model 2 by incorporating this same break. The estimate of the neutral interest rate from a model that includes this break in the GDP growth trend – which is structurally identical to Model 2 and is estimated using the Bayesian method – is shown in Chart 8. The resulting estimate of the neutral interest rate is at a higher level than in the case of Model 1. This confirms findings from other countries that the estimate differs based on the underlying assumptions and analysis methods employed, and that estimates can vary significantly.

Chart 8 **Estimate of the neutral interest rate in Model 2 with a structural break**

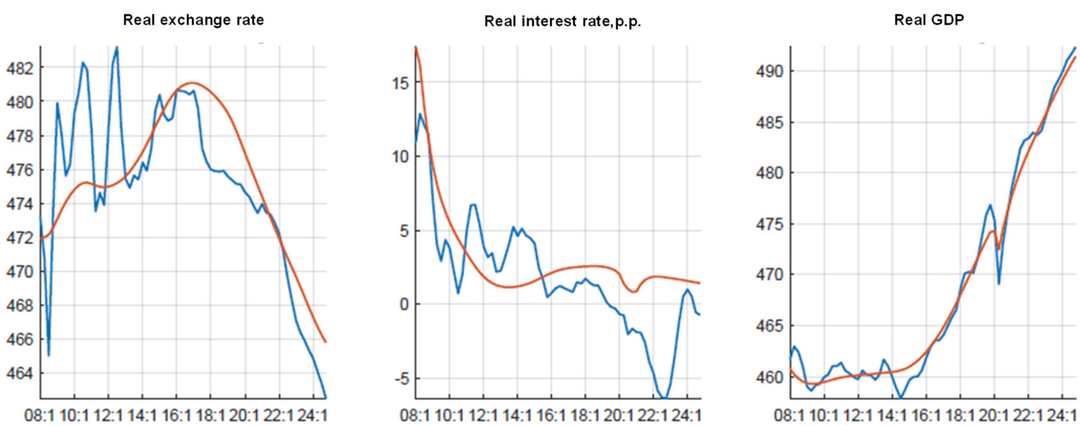


Chart 8.1 **Prior and posterior distributions of the parameters**

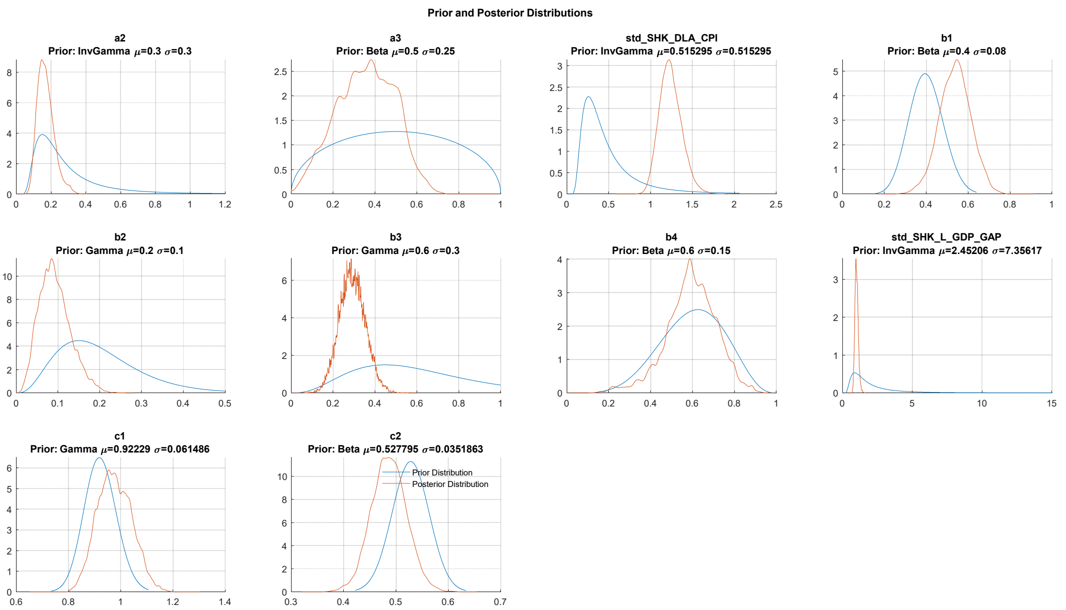
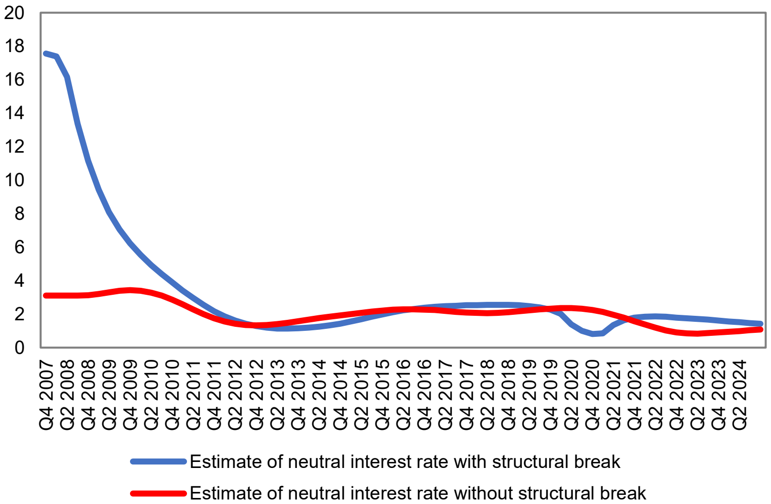


Chart 9 **Comparison of neutral interest rate estimates in Model 2 with and without a structural break** (in %)

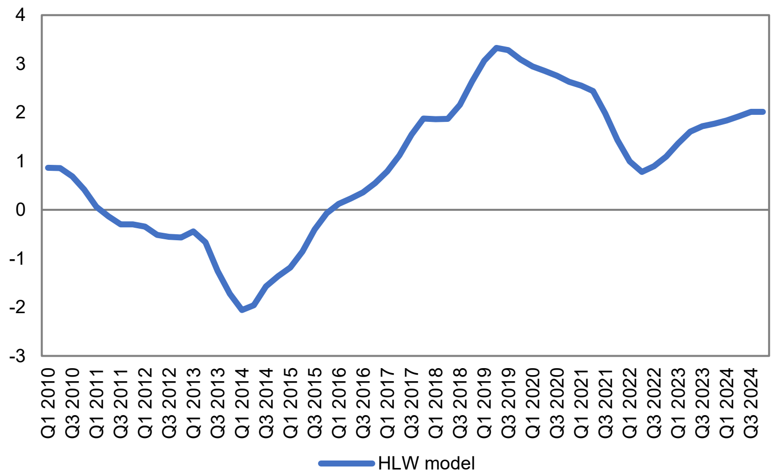


4.2.2 Results of the HLW model

In the estimation of the HLW model, presented by the equations in Section 3.1, we used the following variables: real s-a GDP, y-o-y inflation, the real money market interest rate (one-week BELIBOR) calculated based on one-year-ahead inflation expectations of the financial sector, according to a Bloomberg survey, and a stringency index constructed by the University of Oxford, which is available up to end-2022. Given that its last available values were low, this index was approximated using a linear downward trend. This indicator was included to account for the effects of the coronavirus pandemic.

Chart 10 presents the estimate of the neutral interest rate for Serbia using the HLW model. The estimation employed the smoothed state estimate obtained from the Kalman filter.

Chart 10 **Estimate of the neutral interest rate obtained using the HLW model**



According to the results of this estimate, the neutral interest rate was on a downward trajectory in the period following the 2008 global financial crisis until the beginning of 2014. This can be linked to a reduced potential output in the initial post-crisis years, caused by both low growth in the euro area – our most important trading partner – and the consequently low investment into Serbia, as well as an increased risk premium due to the risk of a public debt crisis erupting in certain euro area countries, and the negative contribution of other determinants captured by the component z. Subsequently, according to this estimate, a trend of a rising neutral interest rate was present from 2014 to 2019, which can be associated with growth in potential output. By the period immediately preceding the outbreak of the coronavirus pandemic, it had approached a level of around 4%, only to enter a downward path again until mid-2022. In the most recent analysed period, the neutral rate, according to this estimate, is again on an upward trend and stood at close to 2% by the end of 2024. The estimate results obtained using the HLW model indicate considerable volatility in the neutral interest rate, with its movement ranging between -4% and 4% over the entire analysed period. For this reason, we consider an estimate that also accounts for the effects of real exchange rate changes when assessing the neutral interest rate to be more adequate for the case of Serbia.

4.2.3 Results of the TVP-VAR model

In the final step of the analysis, we estimated a time-varying parameter vector autoregression (TVP-VAR) model. Unlike the previously presented structural models, which have a theoretical foundation and assume strong economic relationships between variables, the TVP-VAR model represents a more flexible framework with fewer restrictions.

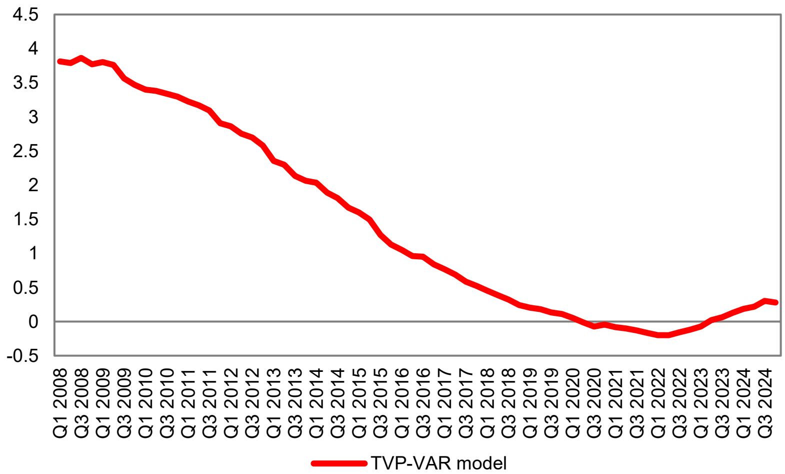
It should be noted that this is a specific class of VAR models, which differ from standard VAR models in that the model's parameters (the constant term, the coefficients on the lags of the variables included in the model, and the variances of economic shocks) are allowed to change over time. This accounts for the fact that the relationships between macroeconomic time series are characterised by a certain form of non-linearity, i.e. that the strength of their connection varies over time. All parameters follow a pure random walk process (first order), which allows for both temporary and permanent changes in parameter values, thereby enabling this class of models to adapt to changing economic relationships that occur over time. Estimating the TVP-VAR model involves the application of the Bayesian methodology, and the Gibbs sampler method was used, which is intended to simplify the computation of multi-dimensional probability densities (Lubik and Matthes, 2015). The priors for the model parameters, which are random variables, were determined based on the Primiceri (2005) procedure. This involves estimating a constant-parameter VAR model on a specific training dataset to obtain the mean and the variance matrix for the priors using a linear regression model.

Our model includes three variables: real GDP growth, quarterly s-a inflation (converted to an annual rate), and the real BELIBOR interest rate, calculated in the same manner as in the HLW model. The model was estimated for the period Q1 2004 – Q4 2024 with two lags, with the first four years (Q1 2004 – Q4 2007) used to establish the priors.

The neutral interest rate was obtained from a conditional forecast of the observed real interest rate. According to Lubik and Matthes (2015), the forecast horizon is set to five years ($r_t^* = r_{t+20}$) and is calculated for each period starting from Q1 2008. The assumption is that by forecasting over a longer period, the effect of temporary shocks is eliminated, allowing the short-term real interest rate to converge to its neutral level.

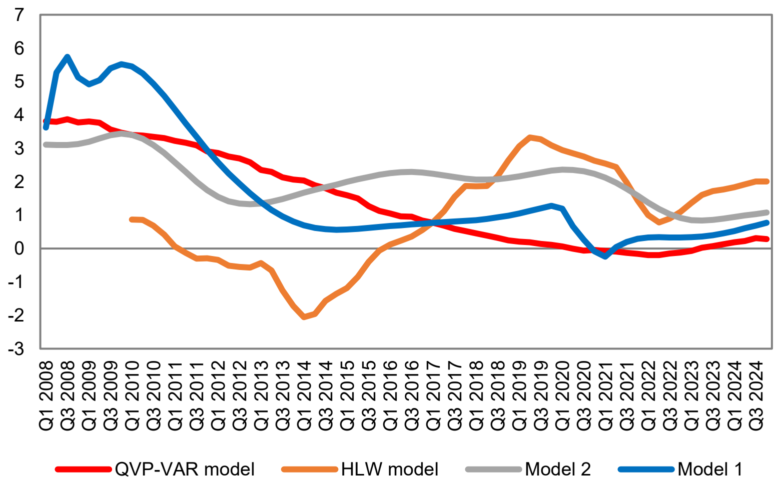
Chart 11 shows the estimate of the neutral interest rate obtained from the TVP-VAR model for the period Q1 2008 – Q4 2024. According to this estimate, the neutral interest rate was in decline for most of the observed period, though it began to rise towards the end. During 2008 and 2009, it moved in a range of 3.5–3.9%, then, following a downward path, reached around -0.2% by mid-2022. Thereafter, the neutral interest rate increased and stood at around 0.3% in 2024. The rise in the real interest rate is a consequence first of the increase in the nominal

Chart 11 **Estimate of the neutral interest rate obtained using the TVP-VAR model** (in %)



interest rate, and subsequently of lower inflation expectations, which the model identified as a likelihood that the neutral rate r* is rising.

Chart 12 **Comparison of different neutral interest rate estimates** (in %)



5 Conclusion

A crucial guide in assessing the monetary policy stance is the concept of the neutral interest rate, r*, which represents the equilibrium interest rate, i.e. the rate that will ensure the targeted level of inflation and a closed output gap in the medium term, and will thus exert neither inflationary nor disinflationary pressure.

Its future path depends on the influence of numerous factors, the direction and contribution of which cannot be predicted with certainty at this moment. Consequently, it is not possible to definitively determine the level at which real interest rates will settle in the medium term. The prevailing view among central bankers and analysts is that there is little probability that the neutral interest rate, r*, will fall below its pre-pandemic level in the coming period, although some factors that contributed to its decline in the previous period will continue to exert influence in the next decade, primarily demographic factors. The possibility that the real interest rate could rise in the future is not excluded; factors that could lead to this include growth in the supply of safe assets relative to demand, the weakening of some drivers of inequality, and increased investment necessary for the transition to a green economy.

Given the significance of the neutral interest rate for the monetary policy conduct process, we have estimated its level for Serbia using various methods: two versions of small structural models with quarterly data that account for the effect of real exchange rate appreciation on the level of the neutral interest rate, the HLW model, and a time-varying parameter vector autoregression (TVP-VAR) model. To our knowledge, this is the first paper to estimate the level of the neutral interest rate for Serbia using a TVP-VAR model.

Based on the estimated models, several key conclusions can be drawn:

- According to all estimated models, as has been the case for other countries, the neutral interest rate in Serbia had a downward trend in the initial years following the global economic crisis until the beginning of 2014. Thereafter, models that incorporate the real exchange rate for estimating the neutral interest rate, as well as the TVP-VAR model, indicate a relatively low neutral interest rate or even a continuation of its downward trajectory.
- The estimate obtained from the HLW model deviates the most from the other estimates and is the most volatile over the observed analysis period. As it does not account for the effects of real exchange rate appreciation, which characterised our economy in previous years, and given high FDI inflows, we consider this estimate to be the least relevant.
- As with other countries, the level of the estimated neutral interest rate changes depending on the model used, and assumptions about the priors of the model's parameters can also influence the level of the estimate.

A common characteristic of all the estimated models is that the neutral rate has had an upward trend in the last two years. However, for most models (except for the HLW model), the estimate of the neutral rate is below 1%, with the majority indicating that the monetary policy stance remains restrictive.

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ANALYSIS OF ASYMMETRICAL EFFECTS OF FISCAL POLICY IN SERBIA

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Available at www.nbs.rs

The views expressed in the papers constituting this series are those of the author and do not necessarily represent the official view of the National Bank of Serbia.

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Analysis of asymmetrical effects of fiscal policy in Serbia

Andrea Jović

Abstract: The research focuses on analysing the impact of fiscal policy on economic activity in Serbia, with a particular emphasis on the asymmetry of effects in the short and long run. Using data from the first quarter of 2007 to the first quarter of 2025, we applied a Nonlinear Autoregressive Distributed Lag (NARDL) model, which enabled the separation of positive and negative fiscal shocks and the examination of their impact on real GDP. Control variables were included in the model: the real effective exchange rate, the consumer price index, and the key policy rate, to more precisely assess the impact of fiscal policy. The results show that fiscal policy in Serbia has almost symmetrical effects in both the short and long term, with a 1% increase in public expenditure leading to a 0.55% growth in GDP in the long run, while a reduction in public expenditure of the same magnitude contributes to a 0.47% decrease in GDP. The effects of fiscal policy on aggregate demand suggest that a countercyclical approach – increasing government spending during recessions and rationalization (austerity measures) during periods of expansion – can contribute to more stable economic growth while maintaining fiscal sustainability. The recommendations include the consistent and responsible use of fiscal instruments, coordination with monetary policy, and the planning of a long-term fiscal strategy aimed at sustainable growth and economic stability.

Keywords: fiscal policy, current public expenditure, GDP, Non-linear ARDL model
[JEL Code]: H30, H50, O47

Non-technical summary

Fiscal policy is one of the key economic policy tools for managing macroeconomic performance and entails the use of public revenues and public expenditures to prevent excessive fluctuations in economic activity. The role and significance of fiscal policy have changed in line with shifts in the macroeconomic paradigm, and according to the current consensus, fiscal policy should have a countercyclical character – stimulating economic activity during recessions, and vice versa. In accordance with this, this research empirically examines the effects of the degree of fiscal policy expansiveness on economic activity, with a particular focus on analysing their asymmetry.

Fiscal policy in Serbia over the past almost two decades has gone through various phases, in line with challenges from the domestic and international environment. The initial years of the observation period were marked by a rising primary fiscal deficit and an increase in public debt, to which the global economic crisis significantly contributed. In response to the rising level of public debt, the Serbian Government began implementing fiscal consolidation measures at the end of 2012, initially focused on the revenue side of the budget. However, from 2014, measures on the expenditure side were also introduced, the most significant of which were the reductions in public sector wages and pensions. These measures, along with accelerated economic activity in the country driven by private investment and exports, yielded results in the subsequent period, with a primary fiscal surplus achieved for four consecutive years in the period 2016–2019, alongside a simultaneous decrease in total public debt both in relative terms (share of GDP) and in absolute amount. These favourable trends were interrupted in 2020 due to the coronavirus pandemic, when a high fiscal deficit was recorded alongside an increase in public debt to support economic activity affected by the pandemic; however, from 2021, a downward trajectory for the deficit and a declining path for public debt were resumed.

For the purposes of the paper, we conducted an empirical analysis of the effects of fiscal policy on Serbia's economic activity from Q1 2007 to Q1 2025, using an econometric model (NARDL) that allows for the separate examination of the effects of positive and negative changes in government consumption, i.e. its increase and decrease. Control variables were also included in the model – the real effective exchange rate of the dinar, the consumer price index, and the key policy rate of the National Bank of Serbia – to obtain a more complete picture of the impact of fiscal policy. The results show that expansionary and restrictive fiscal policy in Serbia have symmetrical effects both in the short and long term, meaning economic activity reacts equally to increases and decreases in public expenditure, only in opposite directions, with the effects of fiscal policy on economic activity being significantly more pronounced in the long run. Specifically, a 1% increase in public expenditure leads to a rise in GDP of approximately 0.55%, while a decrease by the same amount reduces GDP by approximately 0.47%, when viewed in the long term.

Contents:

1 Introduction

Fiscal policy, alongside monetary policy, is a key lever of a state's economic policy, with its most important instruments being public revenues and public expenditures. Approaches and attitudes regarding the significance of fiscal policy have evolved throughout history – from classical economists, who emphasized the limited role of the state, to Keynes and the concept of active intervention, then monetarists and representatives of new classical macroeconomics, who again limited the state's role, and finally to New Keynesians, who advocate for an active approach in coordination with monetary policy. In the previous period, fiscal policy in Serbia played a significant role in stimulating economic activity, following a successfully implemented fiscal consolidation aimed at stabilising public finances, particularly through measures supporting the economy and the population during external shocks.

Numerous previous studies have dealt with analysing the effects of fiscal policy on economic activity, which forms the basis of this paper. To measure fiscal policy, we used current public expenditures, which accurately approximate fiscal policy and are often used as a regressor in similar empirical studies. In doing so, we included appropriate control variables in the model – the real effective exchange rate, the consumer price index, and the key policy rate of the National Bank of Serbia – to better observe the impact of fiscal policy on economic activity. The research first conducted unit root tests, which showed that the time series are of different orders of integration – I(0) or I(1) – which is why we used the Non-linear Autoregressive Distributed Lag (NARDL) model. The constructed model is well-specified, stable, and meets all assumptions, as shown by the relevant tests, and the obtained results are in line with expectations.

The aim of this paper is to examine whether fiscal policy contributes to economic growth in Serbia, as well as to determine whether the effects of expansionary and restrictive fiscal policy are asymmetric, as suggested by some literature. The empirical results show that fiscal policy significantly determines the rate of economic growth in Serbia, with the effects of expansionary and restrictive fiscal policy being symmetrical.

The paper is structured as follows. The first part presents the role and significance of fiscal policy, along with a review of the relevant literature. In the second part, we reflect on the movements of fiscal policy in Serbia in the previous period. The third part is dedicated to the methodology and description of the data used in the empirical research. The fourth part encompasses the research results and their analysis, while the final part contains concluding considerations.

2 Theoretical framework and literature overview

Fiscal policy represents a set of measures implemented by the state through the use of public revenues and expenditures to influence macroeconomic variables, primarily with the aim of mitigating excessive fluctuations in economic growth (Fabris, Jandrić & Ješić, 2023). In this regard, during periods of recession, an expansionary fiscal policy is recommended, which entails increasing government spending – thereby directly stimulating aggregate demand – and/or reducing taxes, which results in an increase in disposable income.

Conversely, during periods of expansion and under conditions of so-called overheated demand, a restrictive fiscal policy should be pursued to curb inflationary pressures. Beyond this stabilisation objective, fiscal policy has two other primary objectives – allocative and redistributive – which are not the focus of this paper.

Fiscal policy gained significance in economic theory following the Great Depression in the United States in the 1930s, after representatives of classical theory failed to provide adequate solutions for the prevailing decline in economic activity and rising unemployment. In this context, an interventionist approach based on Keynesian theory took primacy as an effective instrument of economic stabilisation. The dominance of the Keynesian paradigm lasted until the period of the oil crisis and stagflation, after which fiscal policy declined in importance due to the rise of the monetarist school and the real business cycle theory (Hall, 1992). However, the Great Recession considerably shook the foundations of the new consensus (Mihajlović & Marjanović, 2019), leading to fiscal policy once again becoming a focus for economic policymakers, in line with New Keynesian theory. Bearing this in mind, it is clear that the shocks which have severely impacted the global economy in recent years – including the coronavirus pandemic, the energy crisis, as well as geopolitical tensions and trade protectionism – have resulted in significant state interventions. This was particularly evident during the pandemic, under conditions of a sharp decline in economic activity, when the majority of countries responded with substantial aid packages.

According to economic theory, there are several factors due to which fiscal policy can have asymmetric effects on economic growth, with the most commonly cited being the crowding-out effect and nominal rigidities (Kandil, 2001; Branichon, Matthes & Price, 2017; Xu & Wu, 2023). These factors influence the size of the fiscal multiplier, which represents the measure of change in GDP resulting from a change in fiscal expenditure. Regarding nominal rigidities, primarily sticky prices and wages, the focus is on the New Keynesian interpretation of the slower downward adjustment of prices and wages compared to a significantly more flexible upward adjustment. This results in stronger effects from a negative fiscal shock. In other words, during restrictive fiscal policy, the economy will reduce quantities rather than prices, whereas during expansionary fiscal policy, it will adjust both quantities and prices. Similarly, the crowding-out effect also suggests potentially stronger effects from restrictive fiscal policy compared to expansionary policy. Specifically, when the state increases expenditure financed by borrowing, interest rates rise, which limits private investment and consumption, thereby reducing the overall effect of expansionary policy.

The literature in this field contains a large number of papers that have empirically investigated the effects of fiscal policy on economic growth. However, most of these papers start from the assumption that these effects are linear, and that fiscal policy has symmetrical effects on economic activity, regardless of the direction of the response (Shevchuk & Roman, 2018; Deskar-Škrbić & Šimović, 2017; Klyuev & Snudden, 2011; Mirdala, 2009; Ocran, 2011; Quashigah, Grace & Pickson, 2016). Conversely, Yusuf and Mohd (2021) showed that the effects of fiscal policy in Nigeria during the period 1980–2018 were asymmetric in both the short and long term, with the variables approximating fiscal policy and GDP growth being cointegrated. Similarly, Ali, Mohamed, and Mohamed (2024) demonstrated the cointegration of the used time series and the asymmetry of fiscal policy effects in Somalia during 1970–

2019, where the long-term effect of restrictive fiscal policy was more pronounced, while the opposite was true in the short term. In contrast, Donkor et al. (2022) showed that in the long run, a positive fiscal impulse has a stronger effect on economic growth than a negative one in Ghana. Using the example of Turkey, Kocman (2022) investigated the asymmetry of the effects of fiscal and monetary policy during 2005–2019, proving that economic activity reacts more to restrictive fiscal policy. Regarding developing European countries, Asandului et al. (2021) analysed the asymmetric effects of fiscal policy on inflation and economic activity in twelve former socialist countries. They state that fiscal expansion can even have negative effects on economic activity in the long run, as the inflationary effect of fiscal stimulus outweighs the fiscal multiplier effect.

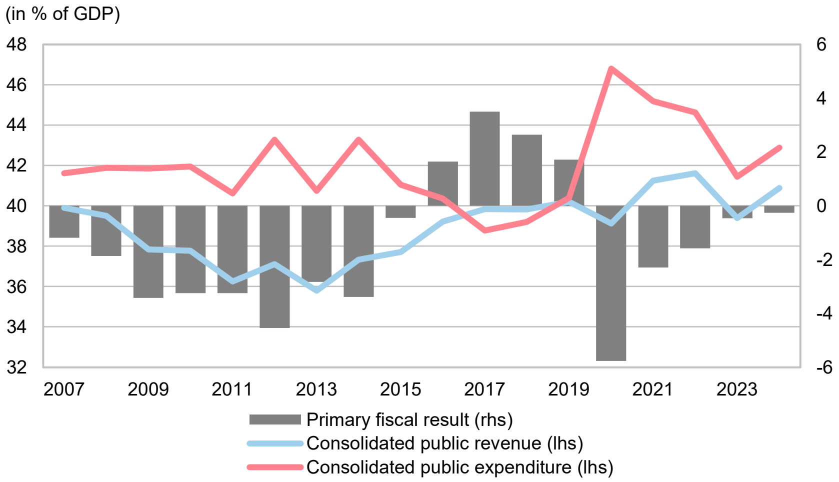
Regarding research in developed countries, Sosvilla-Rivero and Rubio-Guerrero (2022) demonstrated, using the example of Spain, that an increase in public consumption and a decrease in taxes positively affects economic growth in both the short and long term, and vice versa, with the effects of a positive fiscal shock being more pronounced. They used linear and non-linear autoregressive distributed lag models in their research for the period 1980–2020. Baum and Koester (2011) examined the asymmetric effects of fiscal policy on economic activity in Germany, depending on the phase of the business cycle, showing that fiscal policy has significantly stronger effects during crisis periods, i.e., when the output gap is negative. According to research conducted by Gogas and Pragidis (2013, 2015), fiscal policy in the USA during the period 1967–2011 had asymmetric effects on GDP, with expansionary fiscal policy having a stronger influence. In contrast, a greater impact of restrictive fiscal policy on US GDP was also confirmed by Xu and Wu (2023). Despite the numerous studies conducted, on the whole, it can be said that there is no unanimous conclusion regarding the symmetry of fiscal policy effects, indicating that they depend on the specificities of each individual country, the period covered by the analysis, and the phase of the cycle and structure of public finances.

3 Fiscal policy in Serbia

Fiscal policy in Serbia over the past nearly two decades has gone through various phases, in line with challenges from both the domestic and international environment. During the first years of the observation period, the global economic crisis adversely affected fiscal trends (Kisin, Mašović & Ignjatović, 2021). In this regard, the primary fiscal deficit (the fiscal deficit excluding interest costs) increased from 1.2% of GDP in 2007 to 4.5% in 2012, which also impacted the rising trajectory of public debt, expressed as a share of GDP, which reached 50.8%. In response to the rising level of debt, the Government began implementing fiscal consolidation measures in October 2012, which were primarily focused on the revenue side of the budget, most significantly through an increase in the VAT rate from 18% to 20%. However, although the primary deficit was reduced, total public debt continued to rise, reaching 63.4% of GDP by the end of 2014. This led to the adoption of new fiscal consolidation measures to halt the growth of public debt and ensure the sustainability of public finances. The three-year fiscal consolidation programme included reductions in public sector wages and pensions, while on the revenue side, the key focus was on reducing the grey economy and tax evasion.

The fiscal consolidation yielded positive results in the subsequent period, with the primary deficit already reduced to just 0.5% of GDP by 2015, while a surplus was achieved in the following four years. Such developments had a positive impact on the movement of public debt, which was reduced to 49.7% of GDP by the end of 2019. This was not exclusively the result of real GDP growth, but also of a decrease in the total debt in absolute terms by approximately EUR 1 bn compared to 2015.

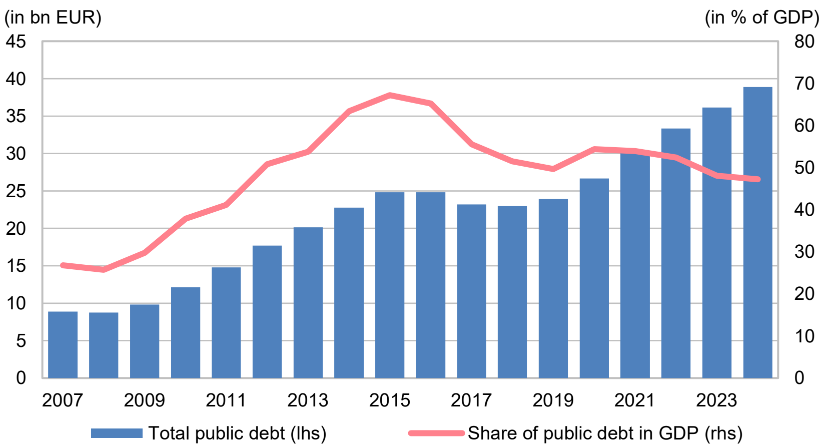
Chart 1 **Primary fiscal result of general government budget**



Source: Ministry of Finance.

The favourable fiscal trends were interrupted in 2020 under the influence of the coronavirus pandemic, which required a strong state response through a package of economic support for the economy, alongside a simultaneous increase in citizens' healthcare costs (Kisin, Ignjatović, 2020). Consequently, in 2020, a primary fiscal deficit of 5.8% of GDP was recorded, with public debt rising to 54.4% of GDP. However, according to the World Bank, this significantly mitigated the effects of the pandemic, primarily on the labour market (2021). While the Fiscal Council emphasized that the economic aid package in Serbia was relatively more extensive compared to comparable countries in Central and Eastern Europe, with some

Chart 2 **Serbia's public debt – central government level**



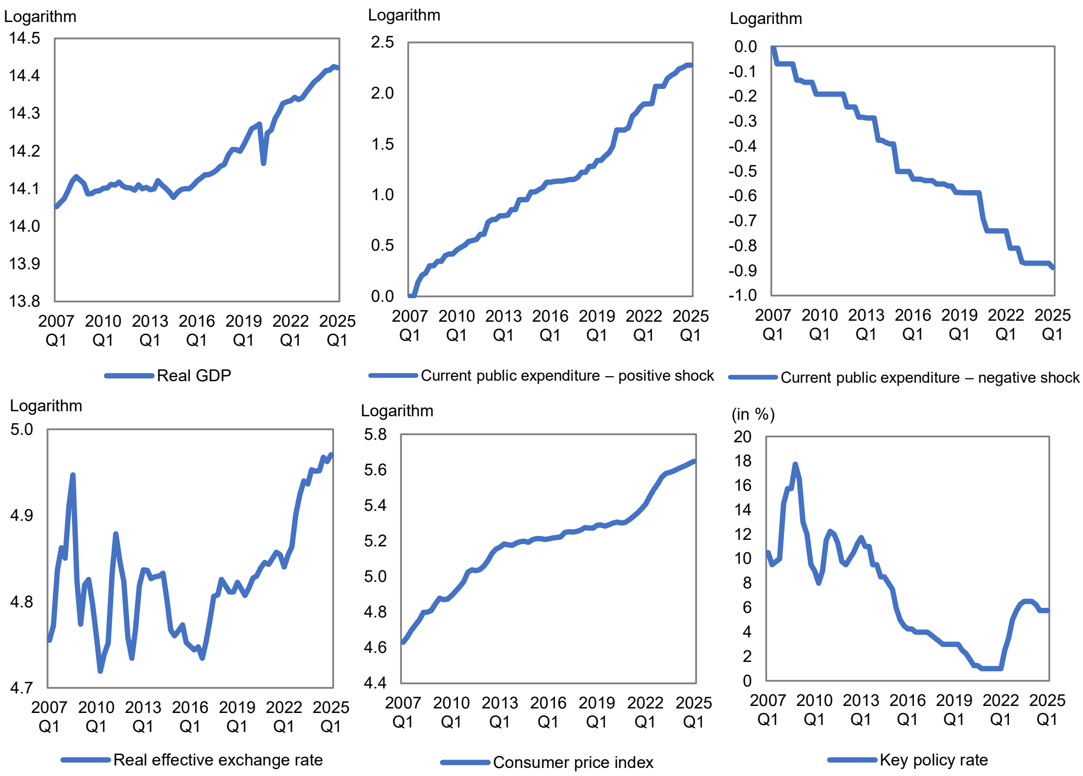
Source: Ministry of Finance.

measures being non-selective and therefore showing limited effectiveness (2022), the World Bank's view was that the scale of the aid package in Serbia was made possible thanks to the successfully implemented fiscal consolidation in the years preceding the crisis, which provided stable fiscal space for response (2021). Despite numerous challenges from the international environment (energy crisis, geopolitical tensions, trade protectionism), through the continued pursuit of responsible fiscal policy, the primary fiscal deficit was consequently reduced to just -0.3% of GDP by 2024, with a simultaneous fall in public debt to 47.2%, which is significantly below the Maastricht criterion.

4 Research data and methodology

For the empirical research, quarterly data from the Serbian Statistical Office, the National Bank of Serbia, and the Ministry of Finance were used, covering the period from Q1 2007 to Q1 2025. In accordance with previous literature dealing with similar research, current government expenditures at the consolidated level were used as an approximation of fiscal policy. The dependent variable in the model is real GDP, with both variables being seasonally adjusted using the ARIMA X-13 Census method. Furthermore, the real effective exchange rate, the consumer price index, and the key policy rate were included in the model as control variables. All variables were transformed into logarithmic forms to reduce heteroscedasticity and allow for the interpretation of coefficients as elasticities, with the exception of the key policy rate, which was used in its original form, as it can have zero or negative values.

Chart 3 **Time series of variables that are the subject of the empirical analysis**



Sources: SORS, NBS and Ministry of Finance.

The selection of an appropriate methodology for time series analysis is the most crucial step in research, which is why we used an algorithm for methodology selection developed by Shrestha and Bhatta (2018). After gathering the aforementioned data, we conducted unit root tests, determining that the variables are of different orders of integration – I(0) or I(1) – which is why the NARDL model was selected for the investigation. To ensure the robustness of the results in determining the stationarity of the time series, Augmented Dickey–Fuller (ADF) and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) unit root tests were conducted in the study.

The NARDL model was developed by Shin, Yu, and Greenwood-Nimmo (2014) and represents an extension of the linear Autoregressive Distributed Lag (ARDL) model constructed by Pesaran, Shin, and Smith (2001). For its application, all variables must be integrated of order zero or one. The advantage of this model is that it better captures the dynamics of the relationship between variables and avoids residual autocorrelation problems, given that lagged values of the dependent variable and independent variables are included as regressors (Mihajlović, 2020). Furthermore, this model allows for the decomposition of changes in the independent variables into positive and negative shocks, which provides the possibility to examine their asymmetric effects on the dependent variable.

The first equation shows the general form of the NARDL model, where y_t is the dependent variable, while $x^{+}_{\tau-j}$ and $x^{-}_{\tau-j}$ are the decomposed positive and negative changes of the independent variable, and ε_τ is the stochastic error term.

$$y_t = \sum_{j=1}^{p} \phi y_{\tau-1} \sum_{j=0}^{g} \left(\theta_j^{+} x^{+}_{\tau-j} + \theta_j^{-} x^{-}_{\tau-j}\right) + \varepsilon_\tau \qquad (1)$$

In this process, the partial sums of the positive and negative changes in the independent variable were obtained in the following manner:

$$x_\tau^{+} = \sum_{j=0}^{t} \Delta x_j^{+} = \sum_{j=0}^{t} max(\Delta x_j, o)$$

$$x_\tau^{-} = \sum_{j=0}^{t} \Delta x_j^{-} = \sum_{j=0}^{t} min(\Delta x_j, o) \qquad (2)$$

Following the determination of the time series' stationarity and the construction of partial sums of positive and negative changes in the series approximating fiscal policy, a bounds test was conducted to examine the cointegration of the variables. To answer the research questions, a Wald test for long-run and short-run asymmetry was performed, after which the stability of the model was tested.

5 Empirical analysis of the impact of fiscal policy on economic activity in Serbia

The third equation shows the model to be estimated, where the dependent variable is the logarithm of real GDP (lny), β is the constant in the model, and λ is the short-term coefficient of the model's autoregressive component. The parameters δ_i^{+} and δ_i^{-} represent the short-term coefficients of the partial sums of positive ($\ln e\_pos$) and negative ($\ln e\_neg$) changes in fiscal expenditure, respectively. In accordance with economic theory, we expect positive values for both parameters, as an increase in fiscal expenditure has a stimulating effect on economic activity, and vice versa. The parameters $\gamma_i^{(1)}, \gamma_i^{(2)}$ *and* $\gamma_i^{(3)}$ represent the short-term coefficients of the control variables in the model: the real effective exchange rate (*lnex*), the consumer price index (*lnp*), and the reference interest rate (*int*), respectively. A negative sign is expected for the real effective exchange rate because a real appreciation reduces the competitiveness of the domestic economy, which diminishes exports and overall economic activity. A negative sign is also expected for the coefficient of the consumer price index, considering that a rise in prices reduces real disposable income and aggregate demand. A negative sign is likewise expected for the coefficient of the reference interest rate, as an increase leads to a reduction in investment and consumption.

Simultaneously, ρ represents the coefficient of the model's autoregressive component in the long run, while Φ^+ and Φ^- represent the coefficients for the long-term effects of positive and negative fiscal shocks respectively, whereby we also expect positive signs in this case. The coefficients for the long-term effects of the model's control variables are θ_1, θ_2 and θ_3. In the long run, we expect a positive relationship between the real effective exchange rate and economic activity, which can be explained by the Balassa-Samuelson effect (*Amstad & Mauro*, 2017). This effect implies a real currency appreciation resulting from productivity growth in the tradable sectors of the economy (*Bussiere, Lopez & Tille*, 2014). Furthermore, there is evidence that a real exchange rate appreciation, through cheaper imports, can contribute to higher economic growth and lower inflation in both developed and developing countries (*Kandil*, 2015). The coefficient θ_2 relates to the long-term effect of the consumer price index, for which a negative sign is expected, as is the case for θ_3, which represents the long-term effect of the key policy rate. V_t denotes the model's random error.

$$\Delta \ln y_\tau = \beta + \sum_{j=1}^{p-1} \lambda_j \Delta lny_{t-i} + \sum_{i=0}^{q} \delta_i^+ \Delta \ln e\_pos_{t-i} + \sum_{i=0}^{q} \delta_i^- \Delta \ln e\_neg_{t-i} + \sum_{i=0}^{q} \gamma_i^{(1)} \Delta \ln ex_{\tau-i} + \sum_{i=0}^{q} \gamma_i^{(2)} \Delta \ln p_{\tau-i} + \sum_{i=0}^{q} \gamma_i^{(3)} \Delta int_{t-i} + \rho lny_{\tau-1} + \Phi^+ \ln e\_pos_{t-1} + \Phi^- \ln e\_neg_{t-1} + \theta_1 \ln ex_{\tau-1} + \theta_2 \ln P_{\tau-1} + \theta_3\, int_{\tau-1} + v_t \quad (3)$$

However, the aforementioned coefficients (Φ^+, Φ^-) reflect the long-term effects conditioned by the immediate and short-term changes in the model. In other words, they are not entirely "pure" indicators of the long-term relationship between the regressor and the dependent variable, as they also take into account dynamic short-term adjustments. For this reason, we have constructed cointegration coefficients, which represent the long-term relationship among the variables without the influence of short-term fluctuations; these are shown in the fourth equation, where L^+ denotes the coefficient for the long-term effects of positive changes in fiscal expenditure, and L^- denotes the coefficient for the long-term effects of negative changes in fiscal expenditure.

$$L^+ = \frac{-\Phi^+}{\rho};\ L^- = \frac{-\Phi^-}{\rho} \quad (4)$$

The initial research hypotheses concerning the asymmetric effects of fiscal policy on economic activity are presented in Table 1. The first hypothesis pertains to the long-term effects of fiscal policy, while the second hypothesis concerns the short-term effects. In both cases, the null hypotheses imply that the effects of positive and negative fiscal policy shocks on economic activity are symmetric. Conversely, the alternative hypotheses assume an asymmetry of these effects.

Table 1 **The initial research hypotheses**

H_0	H_1
$L^+ = L^-$	$L^+ \neq L^-$
$\sum_{i=0}^{q} \delta_i^+ = \sum_{i=0}^{q} \delta_i^-$	$\sum_{i=0}^{q} \delta_i^+ \neq \sum_{i=0}^{q} \delta_i^-$

Source: drafted by the author.

The first step in the empirical analysis was to conduct appropriate unit root tests to verify the stationarity of the used time series. For greater robustness of the results, the analysis employed both the **ADF** and **KPSS** tests. In cases where the results of these tests were not concordant, i.e. when one test indicated the presence of a unit root in the level series while the other suggested stationarity, the stricter criterion for determining the order of integration was used.

The **Stock–Watson procedure** was used to determine the deterministic components in the model, which enabled the correct specification of the unit root tests. The results of the conducted tests showed that the series of negative changes in fiscal expenditures is stationary at level – I(0), while all other observed series were stationary at first difference – I(1) (Table 2). These results justify the application of the **NARDL** model in the further empirical analysis.

Table 2 **Unit root tests**

Variables	Unit root testing	ADF (k) test	Presence of unit root	KPSS test	Presence of unit root	Determinist component
lny	Level	-1.06 (1)	Yes	0.28	Yes	Constant and trend
	I difference	-10.45 (0) ***	**No**	0.11*	**No**	
ln e_pos	Level	-1.97 (0)	Yes	0.19***	**No**	Constant and trend
	I difference	-10.23 (0)***	**No**	-		
ln e_neg	**Level**	-3.20 (0)*	**No**	0.06*	**No**	Constant and trend
	I difference	-		-		
lnex	Level	-1.25 (2)	Yes	0.53***	**No**	Constant
	I difference	-5.20 (2)***	**No**	-		
lnp	Level	-2.28 (1)	Yes	0.16***	**No**	Constant and trend
	I difference	-4.52 (0)***	**No**	-		
int	Level	-1.61 (1)	Yes	0.84	Yes	Constant
	I difference	-4.10 (0)***	**No**	0.09*	**No**	

Source: the author’s calculation using EViews 13.

Note: Designation *k* with the ADF test pertains to the number of correction factors added in order to eliminate autocorrelation in residuals. Designation *** means 1% of statistical significance, ** means 5% of statistical significance, and * means 10% of statistical significance.

To determine the optimal number of lags, an auxiliary VAR model was first constructed, and the decision was made based on information criteria, primarily the SC (Schwarz) criterion. Based on the obtained results, a NARDL (1,1,1,1,1,1) specification model was estimated. Following this, an F-bound test for restrictions was conducted to verify the existence of a cointegrating relationship between the observed variables. The obtained F-statistic value was 8.86, which is significantly above the upper critical value bound for all significance levels; accordingly, we reject the null hypothesis of no cointegration, and the existence of a long-run equilibrium between the variables is confirmed.

Table 3 presents the short-run results of the NARDL model, based on which **we conclude that an increase in fiscal expenditure in Serbia, measured by current public expenditure at the consolidated level, stimulates an increase in overall economic activity, and vice versa**. An increase in fiscal expenditure has a statistically significant positive effect on GDP growth, whereby a 1% increase in expenditure in the short run contributes to a 0.07% increase in GDP. In contrast, although the coefficient for a negative shock to fiscal expenditure is somewhat more pronounced, it is not statistically significant. The coefficient for the first lag of the dependent variable is positive and statistically significant, indicating a high degree of inertia in economic activity growth; specifically, a 1% growth in the previous quarter leads to a 0.76% growth in the current quarter.

Regarding the model's control variables, an appreciation of the real effective exchange rate also has a statistically significant positive effect on economic activity in the short run. This is explained by the fact that a real appreciation of the domestic currency reduces the level of public debt denominated in foreign currency, which creates room for an increase in government consumption and total investment, thereby positively affecting economic activity. GDP growth in the short run is negatively affected by an increase in the price level, measured by the consumer price index. A 1% increase in the index compared to the previous quarter slows the growth of real GDP by 0.22%, and this effect is statistically significant. Conversely, the key policy rate does not have a statistically significant impact on economic activity in the short run, which is unsurprising given that the effects of monetary policy typically manifest with a certain lag, after three to four quarters. Furthermore, a dummy variable, V2020Q2, was included in the model. It takes the value of 1 in the Q2 of 2020 and 0 in all other observed periods to capture the specific effect of the shock caused by the coronavirus pandemic. The effect of this variable proved to be statistically significant, justifying its inclusion in the model. The coefficient suggests the pandemic had a pronounced negative shock on economic activity – real GDP was approximately 13% lower than would be expected under normal conditions.

The estimated speed of adjustment coefficient (*CointEq(-1)*) indicates the rate at which deviations from the long-run equilibrium are corrected in subsequent periods. The coefficient is statistically significant, and its negative sign indicates convergence towards the long-run equilibrium; specifically, approximately 24% of the deviation of GDP from its long-run relationship with the real exchange rate, consumer prices, the key policy rate, and the character of fiscal policy is corrected each quarter.

Table 3 **Estimated NARDL model in the short run**

Variable	Coefficient	*t* statistics
Dependent variable: change in real s-a GDP – ($\Delta\ ln\ y$)		
$\Delta\ ln\ y_{t-1}$	0.76	13.54***
Δlne_pos_t	0.07	2.16**
Δlne_neg_t	0.09	1.57
$\Delta lnex_t$	0.15	3.55***
Δlnp_t	-0.22	-2.80***
Δint_t	0.0016	1.33
$\Delta V2020Q2$	-0.13	-12.03***
c	3.67	4.66***
Coeff. of speed of adjustment *CointEq(-1)*	-0.24	-8.27***
R^2	0.77	
Corrected R^2	0.75	
Period	Q1 2007 – Q1 2025	

Source: the author's calculation using EViews 13.

Note: *** means 1% of statistical significance, ** means 5% of statistical significance, and * means 10% of statistical significance.

In the long run, an increase in fiscal expenditure also contributes positively to the growth of real GDP, and vice versa, with the effects of a positive shock being moderately more pronounced (Table 4). Specifically, a 1% increase in fiscal expenditure leads to a 0.55% growth in economic activity, while a 1% decrease in fiscal expenditure negatively impacts GDP by 0.47%, with both coefficients being statistically significant. These results indicate that fiscal impulses are a persistently significant factor for economic growth in Serbia.

The coefficient for the real effective exchange rate is statistically significant and shows that a 1% appreciation in the long run leads to a 0.37% increase in GDP growth, which is in line with expectations. Specifically, in accordance with the Balassa–Samuelson effect, an appreciation of the domestic currency indicates a stronger economy, as it contributes to lowering the price of imported capital and energy, resulting in lower inflationary pressures and more favourable conditions for economic growth. Conversely, a rise in the price level in the long run undermines purchasing power and the investment environment, which is confirmed by a statistically significant negative coefficient indicating that a 1% increase in prices in the long run reduces economic activity by 0.6%. In contrast to the short run, the key policy rate proved to be statistically significant in the long run. Its coefficient indicates that a 1 pp increase in the interest rate reduces real GDP by approximately 0.79%, which is consistent with expectations.

Table 4 **Estimated NARDL model in the long run**

Variable	Coefficient	*t* statistics
Dependent variable: real GDP – logarithmic value of real s-a GDP ($ln\, y$)		
lne_pos_t	0.55	4.72***
lne_neg_t	0.47	2.40**
$lnex_t$	0.37	1.97*
lnp_t	-0.60	-4.09***
int_t	-0.0079	-2.08**
c	15.21	10.80***
F-Bounds **test statistics**	8.86***	
Period	Q1 2007 – Q1 2025	

Source: the author's calculation using EViews 13.

Note: *** means 1% of statistical significance, ** means 5% of statistical significance, and * means 10% of statistical significance.

To examine whether the model is stable and well-specified, we conducted appropriate tests, the results of which are presented in Table 5. Using the Jarque–Bera test, we showed that the model's error terms are normally distributed, as indicated by the high *p*-value leading us not to reject the test's null hypothesis. To demonstrate the absence of autocorrelation in the error terms, the Breusch–Godfrey test for autocorrelation was applied; based on the *p*-value, we accepted the test's null hypothesis. The Glejser test was used to determine the homoscedasticity of the error terms, showing that the model does not suffer from heteroscedasticity. The Ramsey RESET test was employed to check for specification errors, and the CUSUM and CUSUM of squares tests confirmed that the model is stable and well-specified.

Table 5 **Stability and model specificity tests**

Assumption	Test	*p* value
Normality	Jarque–Bera	0.93
Autocorrelation	Breusch–Godfrey	0.14
Heteroscedasticity	Glejser	0.11
Model specification	Ramsey RESET	0.31
Model stability	CUSUM и CUSUM SQ.	Stable

Source: the author's calculation using EViews 13.

Finally, to examine whether the effects of fiscal policy in Serbia are asymmetric, a Wald test was conducted, the results of which are presented in Table 6. The obtained results do not allow for the rejection of the null hypotheses, leading us to **conclude that the effects of fiscal policy on domestic economic activity are symmetric in both the long and short run**.

Specifically, although the effects of a positive shock are somewhat more pronounced in the long run compared to those of a negative shock, there is no statistically significant difference to confirm asymmetry. We therefore conclude that expansionary and restrictive fiscal policies have nearly equal effects on GDP.

Table 6 **Wald test results**

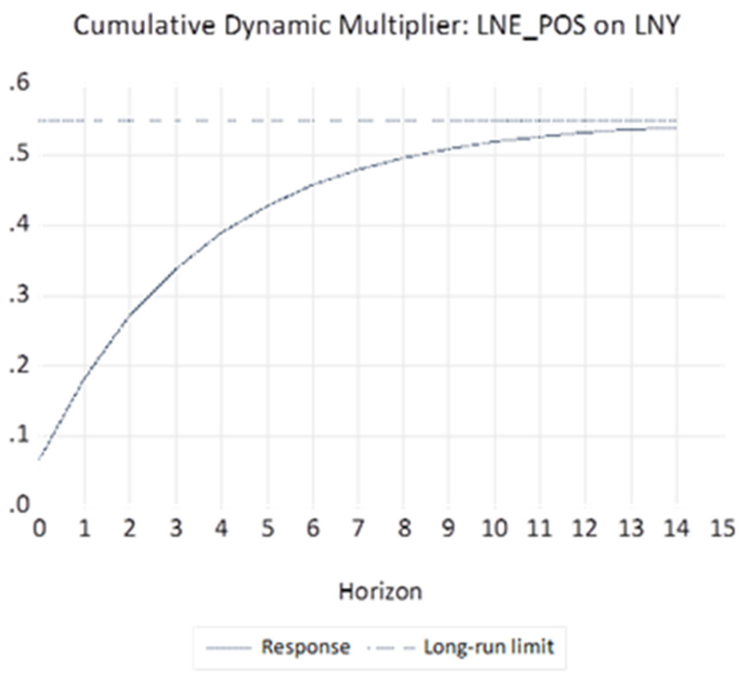
$\mathbf{H_0}$	$\mathbf{H_1}$	**Wald test *p* value**
$\boldsymbol{L^+ = L^-}$	$L^+ \neq L^-$	0.55
$\sum_{i=0}^{q} \boldsymbol{\delta_i^+} = \sum_{i=0}^{q} \boldsymbol{\delta_i^-}$	$\sum_{i=0}^{q} \delta_i^+ \neq \sum_{i=0}^{q} \delta_i^-$	0.80

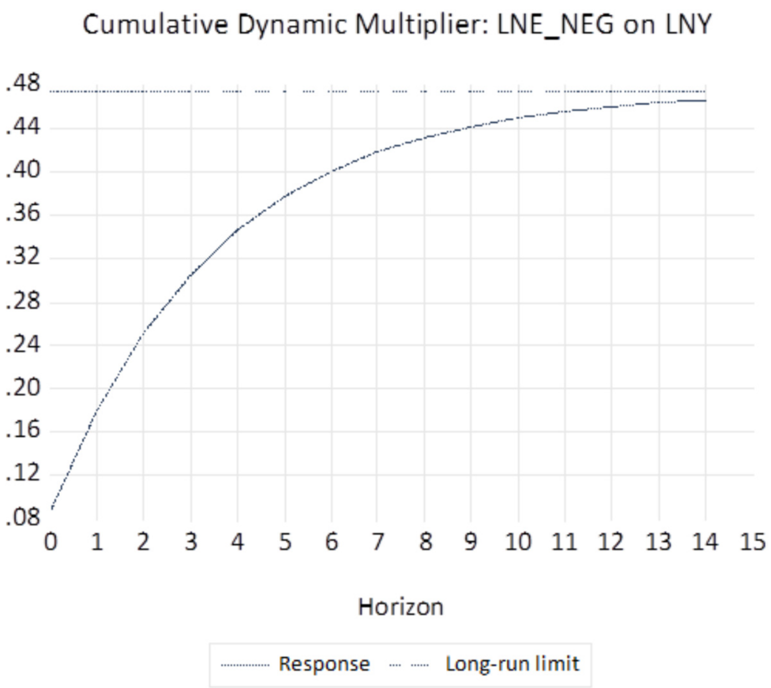
Source: the author's calculation using EViews 13.

The effects of positive and negative fiscal expenditure shocks, as well as the tendency to re-establish long-run equilibrium following an initial shock, can be illustrated using dynamic multipliers (Shin, Yu & Greenwood-Nimmo, 2014). The dynamic multiplier chart for a positive fiscal shock (Chart 4, left) shows that the short-run effect of an increase in fiscal expenditure on GDP growth is relatively small, amounting to approximately 0.07% in Q1. In the subsequent quarters, the effect grows rapidly – reaching about 0.4% after one year and approaching 0.5% after two years. This pattern indicates **an efficient transmission of the fiscal shock, which gradually converges to the long-run effect on economic activity of 0.55%, suggesting that fiscal policy has a pronounced and stable influence on economic growth in the long run**.

The dynamic multiplier for a negative fiscal shock (Chart 4, right) shows that the initial effect is somewhat more pronounced than that of a positive shock, at approximately 0.09%, but the growth of the effect occurs more slowly – reaching roughly 0.35% after one year and about 0.43% after two years, converging in the long run to 0.47%.

Chart 4 **Dinamic multiplier of curant public expenditures**





6 Conclusion

Based on the conducted research and the obtained results, we can conclude that fiscal policy in Serbia has symmetric effects on economic activity in both the short and long run. This suggests that expansionary and restrictive fiscal policies influence GDP almost equally. Therefore, it is recommended that fiscal instruments be used consistently and responsibly, particularly during periods of economic fluctuation, to avoid excessive inflationary pressure during expansions and to prevent further constraints on growth during recessions. Also, maintaining fiscal responsibility represents a significant factor for fostering sustainable long-term economic growth (Ješić, 2023).

The short-term effect of fiscal shocks on economic activity is relatively small – a 1% increase in public expenditure leads to a 0.07% growth in GDP, while the effect of a 1% decrease in expenditure is approximately 0.09%. The long-term effect of fiscal shocks is considerably more pronounced, with a 0.55% increase in GDP following an increase in expenditure and a 0.47% decrease in GDP following a decrease in expenditure, indicating a stable and sustainable influence of fiscal policy on economic activity.

Consequently, fiscal policy should be countercyclical in nature, meaning that public expenditure should be increased during recessions to stimulate aggregate demand (taking into account the high long-term multiplier of 0.55%), while carefully managing the trajectory of public debt and sustainable economic growth. Conversely, during periods of expansion, the volume of fiscal expenditure should be reduced.

The effect of monetary policy in the long run also proves to be significant, as a 1 pp increase in the key policy rate reduces real GDP by approximately 0.79%. The other control variables – the real effective exchange rate and the consumer price index – also show statistically significant long-run effects, and the directions of their influence are in line with expectations.

Given the demonstrated strong effect of monetary policy on long-term economic activity, the coordination of fiscal and monetary policy is a necessary condition for the effectiveness of economic policies in achieving macroeconomic stability. This is particularly important since a single policy maker rarely has full controllability over a specific target (Ješić, 2019).

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