STRUCTURAL CHANGES TO QUARTERLY PROJECTION MODEL

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Structural changes to quarterly projection model

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Abstract: In this paper we present structural changes to the macroeconomic model used in the National Bank of Serbia for medium-term inflation forecasting, made in the period since inflation targeting was first introduced as the monetary policy regime. We describe in detail three changes related to inflation determinants. The first change has to do with the aggregation of overall inflation components, with the goal of linking them more directly to the underlying factors driving inflation. The second change is an extension of the model to explicitly include the effect of private sector wages on inflation. The third change is the inclusion of the effect of fiscal policy on aggregate demand, which has increased in significance in the period since the breakout of the COVID-19 pandemic in 2020. From the perspective of a reduced forecast error, the changes are justified by performing historical simulations.

Keywords: inflation, model, prices, labour market, wages, fiscal impulse
[JEL Code]: C53, E17, E58

Non-technical summary

With the introduction of inflation targeting as a monetary policy regime in 2008, the quarterly model for medium-term inflation forecasting was developed at the National Bank of Serbia (NBS). The rationale for relying on the medium-term inflation forecast in making monetary policy decisions has to do with the fact that monetary policy instruments are transmitted to inflation with a time lag. For this reason, monetary policy decisions are made based on future inflation developments.

In addition to its main role in supporting monetary policy decisions, the medium-term projection has a significant role in public communication. By transparently communicating our forecast of inflation and its driving factors to the public, the NBS influences the formation of market participants' expectations, which is one of the key inflation determinants in the medium run. With that in mind, we describe some of the key changes in the medium-term inflation forecasting model, which have been implemented after 2010, with the goal of better informing the public about the structure of the macroeconomic model used for forecasting. We also present the results of a simulation exercise which confirms that the changes contribute to a reduction in the forecast error.

The first change, with respect to the aggregation of CPI components, has been implemented with the goal of better connecting the factors which determine prices with the CPI components they influence. The prices of products predominantly determined by weather changes (fruits and vegetables), government decisions (regulated prices) and movements in global commodity markets (processed food) have been separated from prices of non-food products and services which are strongly influenced by monetary policy measures. In addition to improving the accuracy of the forecast, the separation has allowed us to separate inflation factors under the control of monetary policy, from cost factors which are by nature transitory.

The second change is an extension of the model to explicitly include the effect of private sector wages on inflation. After an extended period of wage growth lower than productivity and the absence of associated wage pressures, in the past several years the growth of wages relative to productivity has accelerated. Bearing in mind the central theoretical role of wages in the formation of inflationary pressures, their inclusion in the model contributes to forecast accuracy and supports monetary policy decisions.

The third change pertains to modelling the impact of fiscal policy on aggregate demand, which has gained in importance since the outbreak of the COVID-19 pandemic in 2020. After several years of contractionary fiscal policy during the period of fiscal consolidation, followed by the period of relatively stable policy, the impact of fiscal policy strongly increased with the pandemic (in the direction of expansion), whilst the gradual phase-out of the measures had a contractionary effect.

Contents

1 Introduction

In agreement with the Government of the Republic of Serbia, the NBS officially adopted inflation targeting as its monetary policy regime at the end of 2008. Considering that monetary policy instruments are transmitted to inflation with a time lag, the decision on the interest rate and other policy instruments is based on future macroeconomic developments. This is why the medium-term forecast of inflation and factors that influence inflation has been developed. Bearing this in mind, the NBS focused its efforts since 2007 on understanding the transmission mechanism of monetary policy and developing a consistent analytical framework and process for medium-term forecasting of key macroeconomic indicators. In addition, the inflation forecast has an external role – it provides an important tool for communicating to the public. Realisation of the forecast or understanding the reasons behind its deviation are important for strengthening credibility of the NBS, which contributes to the anchoring of inflation expectations – one of the key determinants of successful inflation targeting.

With this goal in mind, a model for medium-term inflation forecasting has been developed at the NBS, described in detail in the NBS working paper *Medium-term projection model of the National Bank of Serbia* (Đukić et al. 2010). It should be noted that the model is a tool, not a source of final answers. A well-structured macroeconomic model provides an analytical approach to the forecasting process and can therefore be useful for monetary policy makers. The model-based forecasts of inflation, consistent with achieving the targeted level of inflation, provide support for monetary policymakers in making decisions on the key policy rate. In line with the inflation targeting regime, the main goal in developing the model was to take into account the key factors which influence price formation, as well as channels through which a central bank decision affects inflation. In addition, analytical support to monetary policy decision making has continuously been strengthened by working on improvements to the model.

Improvements to the model may refer to the periodic recalibration of equation coefficients, usually based on econometric estimates as new data flows in, as well as to the analysis of previous forecast errors. However, in this paper we present three significant structural changes regarding inflation determinants made since the introduction of the model. The first change is related to the disaggregation of CPI components for modelling purposes, with the goal of better connecting factors that determine prices with inflation components, and improving forecast accuracy. The second change is an extension of the model to include the effect of private sector wages on inflation, whereas the third change represents the inclusion of the impact of fiscal policy on aggregate demand, which has gained in importance in the period since the outbreak of the COVID-19 pandemic.

2 Headline inflation decomposition

Initially, the goal was to maintain a simple structure of the equations, in order to make interpretation of the model straightforward. CPI inflation was disaggregated into three groups of prices based on the mechanism of price formation and the potential of monetary policy to influence them:

– core inflation,

– non-core inflation excluding oil derivatives, and

– prices of oil derivatives.

Core inflation[1] constituted more than a half of the Consumer Price Index (CPI). As defined at the time, core inflation consisted of total inflation excl. administered prices, prices of agricultural products (fruits, vegetables, eggs) and prices of oil derivatives. As these prices are formed in the market, monetary policy can affect them.

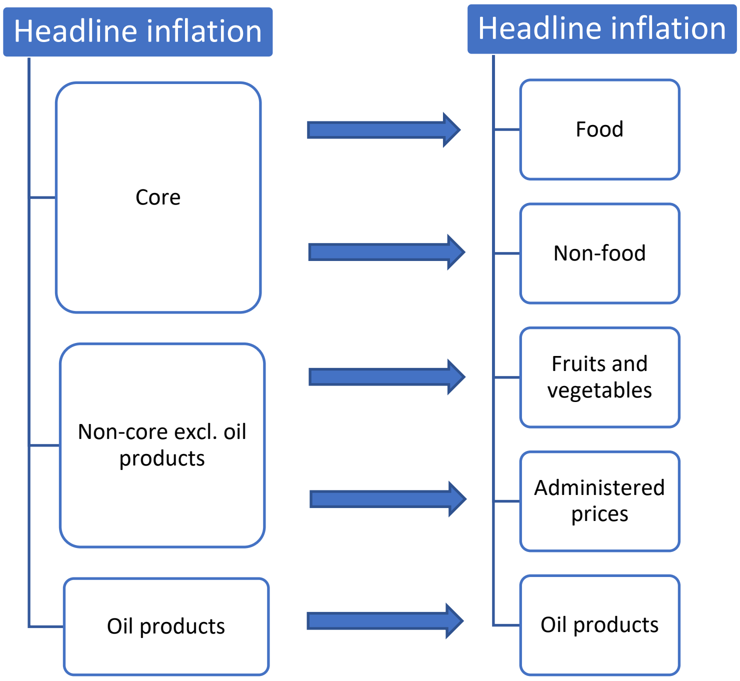
In the original model structure, even though the prices of agricultural products included in the CPI (fruits, vegetables, eggs) are formed in the market, they were classified as *non-core prices excluding oil derivatives*. Given that they are mostly determined by weather conditions, the influence of monetary policy on prices of these products is negligible. In addition to agricultural products, *non-core prices* also include *administered prices excluding oil derivatives*, i.e. prices that are influenced by the government (electricity prices, cigarettes, utility services, etc.).

The third component of inflation consists of the prices of *oil derivatives*, which depend on excise taxes and other state appropriations, as well as on the crude oil price expressed in dinars. Therefore, monetary policy can affect this component of inflation through the exchange rate channel.

In the meantime, in order to improve the forecast accuracy, taking into account the structure of the domestic economy (primarily the volatility of food prices), we further disaggregated the CPI. The changes refer to the separation of *processed food* prices from *core inflation*, as well as the division of *non-core inflation* (excluding oil derivatives) into two separate groups – *fruits and vegetables* and *administered prices*. In the rest of this chapter, the detailed description of methods used for forecasting each of these components separately is presented, as well as the equations currently used for our medium-term forecast.

[1] The formal definition of core inflation that the NBS used at the moment of introduction of the model for medium-term projections is different from the one used now: core inflation represents the CPI from which food, energy, alcohol and tobacco prices are excluded. The current definition of core inflation is closest to the non-food category.

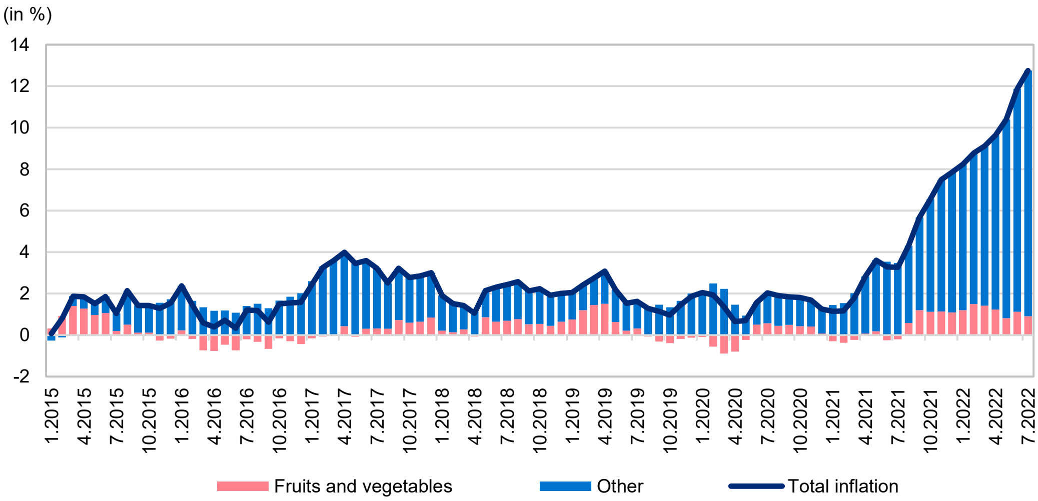
Chart 1 **Disaggregation of total inflation from three to five components (original setup compared to the current model setup)**



Fruits and vegetables

Even though the fruits and vegetables component has only a moderate share in total CPI (5.6% in 2022), this component often contributes the most to the change in the annual inflation rate (Chart 2) due to its volatility (fruits and vegetables are the most volatile component of CPI).

Chart 2. **Fruits and vegetables share in total y-o-y. monthly inflation**



Source: SORS and NBS calculation.

The forecast of these prices is the least predictable due to their high volatility and dependence on weather conditions. Initially, the prices of fruits and vegetables were forecast exogenously – based on expert judgement, their current levels, seasonal factors, under the assumption of an average agricultural season. Later, fruits and vegetables were included into the model as a separate component with its own equation:

$$\pi_t^{fvg} = c_1\pi_{t-1}^{fvg} + (1 - c_1)E_t\pi 4_{t+4} - c_2\,(lfvg_{t-1} - lcorexfood_{t-1} + wedge) + \varepsilon_t^{fvg}$$

The interpretation of this equation is as follows: at the end of a weak agricultural season, fruit and vegetable prices are high. If the following season proves to be average, a decrease in these prices (compared to other prices) can be expected. Therefore, fruit and vegetable prices are influenced by weather conditions affecting yields, as well as their initial levels at the beginning of the season. While the weather is difficult to predict, an estimate of the level of prices relative to their equilibrium level can be made. As a basis for determining the equilibrium price level of fruits and vegetables, market *non-food* prices are used, for two reasons. First, these prices are also formed in the market, so it is expected that they will have an approximately equal growth rate in the long term. Second, unlike the prices of processed foods, the prices of non-food market products are not dependent on the prices of fruits and vegetables, and therefore provide a more stable and independent basis for comparison.

The equation shows the change in the prices of fruits and vegetables from the previous quarter (π_{t-1}^{fvg}), which reflects a certain degree of inertia in the movement of these prices, as well as one-year-ahead inflation expectations. In terms of the model, inflation expectations are determined by current year-on-year inflation, rational expectations and the inflation target. The term in parentheses determines the degree of over(under)-valuation of fruit and vegetable prices, represented by the level difference between fruit and vegetable prices (lfvg) and *non-food* prices (lnonfood) in relation to a constant trend (wedge). When the prices of fruits and vegetables are relatively high (the term in parentheses is positive), their growth in the following period is expected to be slower, and vice versa; therefore, the sign in front of the coefficient is negative.

OLS estimates of the coefficients for the fruits and vegetables equation (sample period: Q1 2008 – Q1 2022) are presented in the table below:

Table 1 **Estimated coefficients for the fruits and vegetables equation**

	Estimate	p-value
c1	0.295	0.037
c2	1,451	0.002
wedge	-35,504	0

Source: NBS calculation.

Separation of core inflation into food and non-food

As already mentioned, core inflation (the largest component of total inflation) reflects the growth of prices that are formed freely in the market and that are influenced by monetary policy.

As processed food prices are influenced heavily by the prices of agricultural commodities (corn, wheat, soybeans), the next step in CPI disaggregation was to extract these prices from core inflation as a separate component with its own equation that includes the gap in real marginal costs of food production.

$$\pi_t^{food} = a_1\pi_{t-1}^{food} + a_2\pi_t^M + (1 - a_1 - a_2)E_t\pi 4_{t+4} + a_3 RMCPgap_t + a_4 zgap_{t-1} + a_5 ygap_{t-1} + a_6 wagegap_t + \varepsilon_t^{food}$$

The remaining part of core inflation, as previously defined, refers to the prices of non-food products and services. This component is described by a similar equation, omitting the producer marginal cost gap arising from the prices of primary agricultural products (RMCPgap).

$$\pi_t^{nonfood} = b_1\pi_{t-1}^{nonfood} + b_2\pi_t^M + (1 - b_1 - b_2)E_t\pi 4_{t+4} + +b_3 zgap_{t-1} + b_4 ygap_{t-1} + b_5 wagegap_t + \varepsilon_t^{nonfood}$$

Table 2 **Comparison of the coefficients in the equations**

Variable		Core	Food (π_t^{food})	Non-food ($\pi_t^{nonfood}$)
Inertia	π_{t-1}	0.30	0.30	0.35
Imported inflation	π_t^M	0.30	0.20	0.15
Expected inflation	$E_t\pi 4_{t+4}$	0.40	0.50	0.50
RMCP	$RMCPgap$	0.20	0.15	-
Real exchange rate gap	$zgap$	0.20	0.25	0.10
Demand	$ygap$	0.10	0.35	0.20
Real wage gap	$wagegap$	-	0.10	0.10

Source: NBS calculation.

Forecasting food prices

Bearing in mind that food prices are dominantly determined by costs, which are highly volatile compared to other inflation factors, we forecast this component with a separate equation.

RMCP – real marginal costs of food producers represent the ratio of prices of agricultural products (P_t^{agr}), and prices of industrial-food products (P_t^{food}):

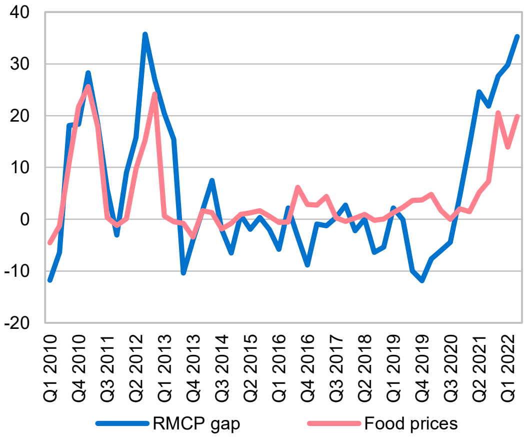
$$RMCP = \frac{P_t^{agr}}{P_t^{food}}$$

We call the deviation of this ratio from its long-term trend (RMCPtnd) the RMCP gap, which is an indicator of cost pressures on processed food prices:

$$RMCPgap = RMCP - RMCPtnd$$

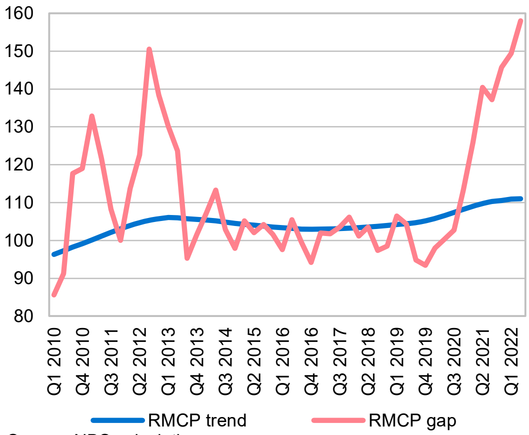
In Chart 3, the growth of this indicator (2010, 2012, 2020 and 2021) reflects increased cost pressures on food prices, and vice versa (2009 and 2011). A positive RMCP gap indicates that the costs of raw materials in food production are relatively high, i.e. the presence of cost pressures for food on that basis. In the 2013–2019 period this relationship was significantly weaker, which can be attributed to relatively small changes in the prices of primary agricultural products, which producers of final food products can absorb by adjusting their profit margins. However, when there is a significant increase in the prices of food-related commodities, the transmission to food inflation is strong. This is noticeable during previous inflationary episodes (2011 and 2012 in the case of food prices), and a strong connection is also observed since 2021.

Chart 3 **Real marginal costs in food production and food prices**



Source: SORS and NBS calculation.

Chart 4 **Real marginal costs in food production**

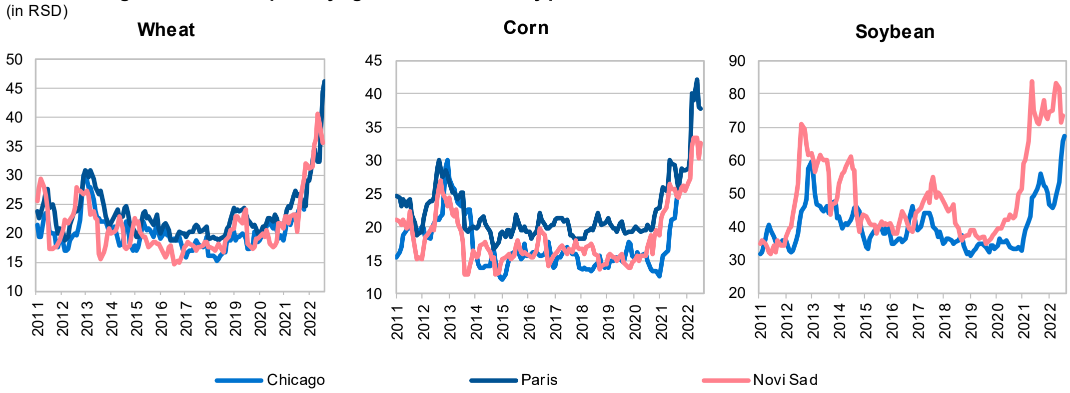


Source: NBS calculation.

We estimate the trend with the Kalman filter together with other unmeasured variables of the model (trends and gaps of other variables), such as the output gap and the real exchange rate gap, so that they are mutually consistent, but also consistent with the movement of inflation of industrial food products.

As a measure of the prices of agricultural products, we use a composite index, which consists of prices of the main inputs in food production: wheat, corn and soybeans, and the prices of fruits and vegetables. While the prices of fruits and vegetables are included in the quarterly projection model, we project the prices of wheat, corn and soybeans using a satellite model that links the domestic prices of these products with their world prices, as measured on the Chicago and Paris exchanges. Chart 5 shows a high correlation between domestic and foreign prices of these crops.

Chart 5 **Foreign and domestic primary agricultural commodity prices**
(in RSD)



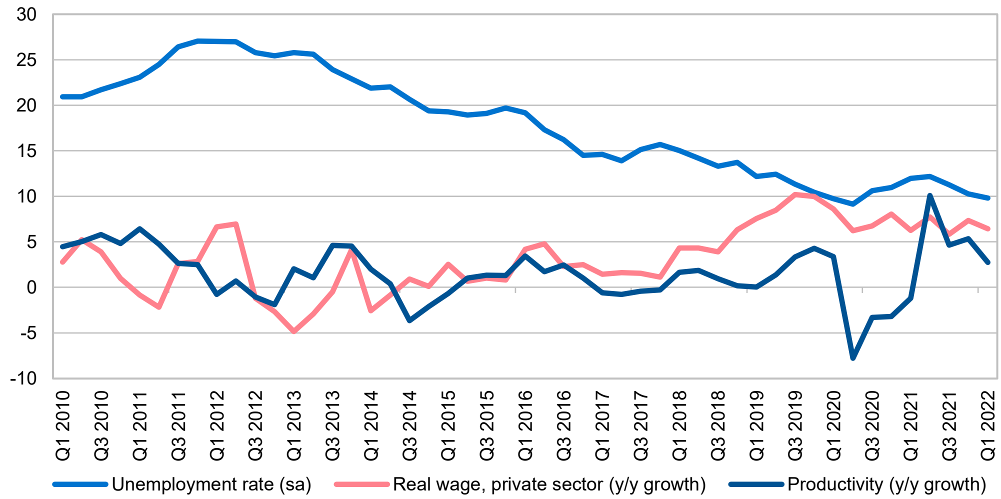
Source: Chicago Board of Trade, Commodity Exchange Novi Sad, Euronext Paris MATIF.

3 Labour market

Since the introduction of inflation targeting as a monetary policy regime (implicitly since 2007, formally as of 2009) and development of the model for medium-term inflation forecasting, the domestic economy has continued to develop and undergo structural changes within the transition process. These changes have also influenced the balance of factors affecting price formation. At the time of the introduction of inflation targeting, the labour market was characterised by high unemployment rates, even compared to other transition economies. With the outbreak of the global financial crisis of 2008, the contingent of employed persons declined further, and the unemployment rate (as measured through the labour force survey) reached 28% in 2012. In an environment of high unemployment, firms were able to respond to an increase in demand by hiring more labour without significantly increasing wages, which implies that wages did not generate significant cost pressures for employers. At the same time, a high rate of unemployment and negative output gap point to an absence of inflationary pressures on the demand side. For these reasons, but also due to the short data sample and frequent changes in the data collection methodology, the first setup of the model did not include labour markets as a factor driving inflation.

In the following period, with the recovery of external demand, implementation of fiscal consolidation and resolution of structural problems in the banking sector and SOEs, accompanied by a freeze in public sector employment, growth picked up while wage employment and wage growth remained subdued. This has led to slower growth in real wages than productivity growth, which indicates an absence of cost pressures from the labour side (the labour share in total costs declines). Developments in unemployment, real wages and productivity are shown in Chart 6.

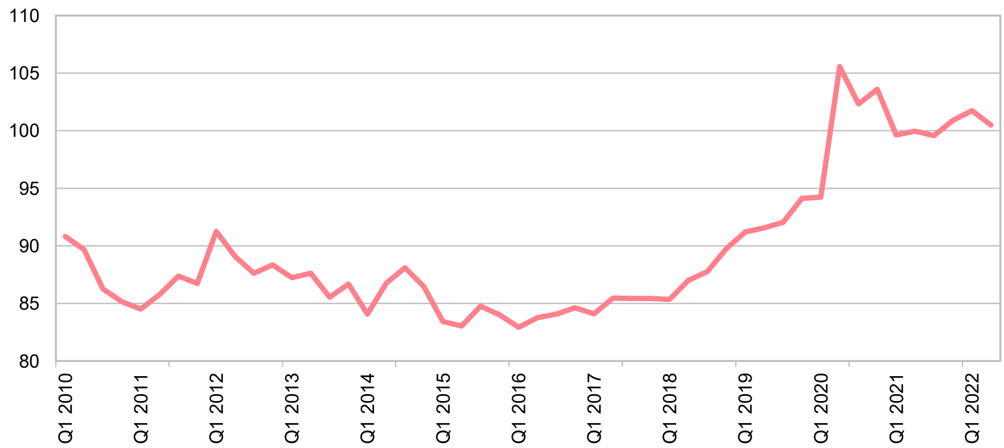
Chart 6 **Unemployment rate, real wage and productivity growth**



Source: SORS.

With the completion of fiscal consolidation and continued development of the economy, as of 2016, the growth rate in wages has started exceeding productivity growth, leading to an increase in unit labour costs (Chart 7) and gradual increase of cost pressures – despite very low inflation in the same period. This is supported by increasingly frequent reports on labour shortages in individual sectors, despite a relatively high (but falling) rate of unemployment. In

Chart 7 **Unit labour costs (whole economy**)
(sa, 2021 = 100)



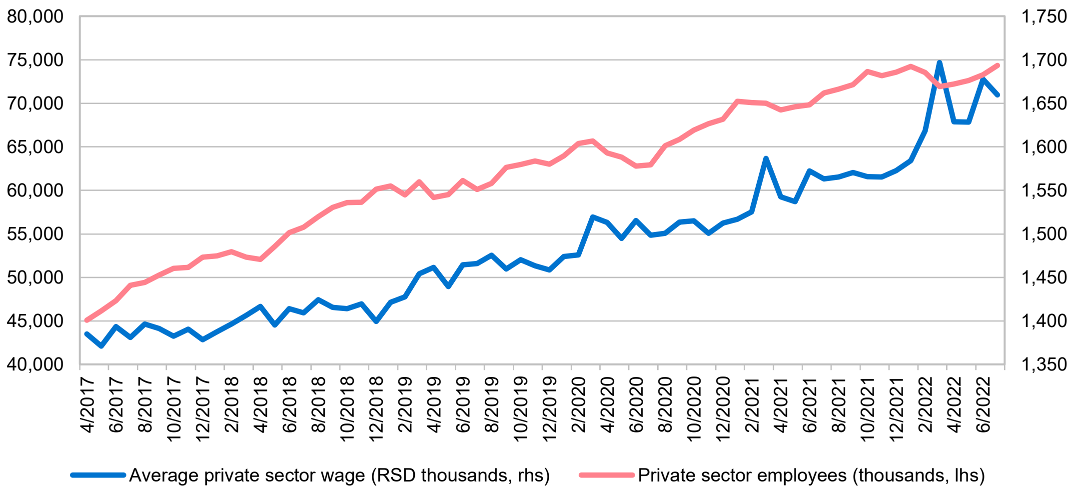
Source: SORS.

addition, the increase in market wages was supported by increases in public sector wages, as well as increases in the minimum wage. Between 2015 and 2022, the minimum wage has been increased by 66.3% (36.5% in real terms), which also spills over to wages higher in the distribution.

After several years of dynamic growth in the absence of inflation pressures, the pandemic has caused a sharp contraction in economic activity (GDP recorded a contraction of 6.3% in Q2 2020, and 0.9% in the year as a whole) – both due to the introduction of health measures, as well as due to a strong fall in external demand and capital outflows from developing economies. The response by policymakers involved significant measures to mitigate the consequences of the health measures and falling external demand on households and firms.

From the perspective of the labour market, the key fiscal policy measures implemented in Serbia include direct payments of a part of private sector wages by the government, postponing income tax and social security contribution payments (both of these measures were contingent on maintaining employment at pre-crisis levels). These measures, in combination with a relatively favourable growth outturn during the crisis period (a contraction of 0.9% in 2020 followed by 7.4% growth in 2021) helped prevent a long-term impact of lockdowns on private sector wages and employment (Chart 8).

Chart 8 **Private sector employment and wages**



Source: SORS.

The decline in output combined with a constant level of wages led to an increase in unit labour costs, creating cost pressures for employers, which eventually contributed to the growth in headline inflation. In light of this, the medium-term inflation model was expanded with a block for wages and their effect on inflation.

New Keynesian models and the wage Philips curve – theoretical concepts

The NBS quarterly projection model is based on the New Keynesian framework model, similar to the models used by central banks in other small and open economies. It provides a relatively simple tool for macroeconomic analyses and supports monetary policy decisions.

According to Gali (2008), important differences from the traditional macroeconometric models that preceded the New Keynesian models that are worth emphasising concern the importance of expectations and the natural levels of output (potential GDP) and the interest rate. For a central bank relying on the interest rate as its main instrument of monetary policy, private sector expectations of the future path of the central bank's policy rate are crucial. This is because current inflation (and aggregate output) depends not only on the current short-term interest rate, but also on agents' expectations of future movements of the rate. This is one of the reasons why the communication of inflation forecasts to the public has a key role in the inflation targeting regime.

The assessment of equilibrium levels of GDP and interest rates, i.e. their trends are very important reference points for monetary policy, in part because they reflect the constrained efficient level of economic activity, but also because monetary policy cannot create persistent departures from those natural values without triggering either inflationary or deflationary pressures. In New Keynesian models trends are estimated using the Kalman filter, taking into account all relevant economic factors that affect the assessment of equilibrium values – these trends correspond to values those variables would have in the absence of nominal rigidities.

In recent years, there is significant literature on macroeconomic analyses based on the use of New Keynesian models. Building on this literature, we have implemented elements of labour markets into the NBS forecasting model. The first step to this end is introducing the Phillips wage curve equation. Building on the basic New Keynesian model characterised by price rigidities, Jordi Gali (2011) analysed the introduction of unemployment in New Keynesian models. Preserving the paradigm of a representative household, through a combination of labour market rigidity and wage rigidity, Gali allows for determining the equilibrium level of the unemployment rate (NAIRU), the unemployment rate, as well as other important macro variables conditioned by the monetary policy rule.

In this chapter we provide a very brief overview of the derivation of the wage Philips curve (for more details see Gali, 2008) and introduce it into the existing model. As with the price Philips curve, the assumption that monopolistic firms are faced with the constraint of updating prices and wages is key to defining the Phillips curve, see Calvo (1983). The assumption is that not all firms (households) are able to adjust their prices (wages) in every observed period. That is why firms change prices with a certain probability in each period, which implies that a certain share of prices/wages is updated in each period.

Implementing wage equation into the QPM model

Considering the models of Đukić et al. (2010) and Gali (2008), the practice of using similar models in some other central banks, and limitations in the form of short time series on unemployment, we introduce the equation of nominal wages without unemployment. Wage equations are similarly introduced for the Central Bank of Belarus, see Musil, Pranovich & Vlcek (2018).

This equation states that the amount by which current wage inflation exceeds its steady-state value depends on the percentage by which the households' average marginal rate of substitution exceeds the real wage, taking the expected wage inflation next period as given.

Wage inflation is at its steady-state value only when the real wage and the marginal rate of substitution are equal and are expected to remain so. The percentage deviation of real wages from the average marginal rate of substitution, in the wage equation, represents the wage markup (Erceg et al. 2000).

To explain the Phillips curve by deriving the equations, we start with the GDP gap as the relevant variable, $\widehat{y_t} = y_t - y_t^n$, where y_t^n shows the potential level, i.e. equilibrium level of GDP. The equilibrium level of GDP is the level that can be achieved with the existing labour, capital, and productivity without inflationary pressures, i.e. without the price and wage rigidity. The same is true for real wages, the gap in real wages is $\widehat{\omega_t} = \omega_t - \omega_t^n$.

Wage inflation is driven by the average wage markup, which is defined as the difference between average real wages and the average marginal rate of substitution, and the Phillips curve is derived as the connection between wage inflation and the GDP and wage gaps. According to the assumption of the above-mentioned Calvo pricing (1983), the price and wage rigidity affects markup fluctuations, i.e. lead to inefficiency in the medium term as deviations of real variables from their equilibrium levels, which is shown in the Phillips curve through gaps.

Wage markup i.e. the deviation of the wage markup from the equilibrium level can be expressed through the gap between real wages and the GDP gap, considering that $\mu_t^\omega = \omega_t - mrs_t$, where the marginal rate of substitution is derived from the utility function of the household (they choose how much to spend and how much to work):

$$\widehat{\mu_t^\omega} = \widehat{\omega_t} - \widehat{mrs_t} = \widehat{\omega_t} - (\sigma\widehat{y_t} + \varphi\widehat{n_t}) = \widehat{\omega_t} - \left(\sigma + \frac{\varphi}{1-\alpha}\right)\widehat{y_t},$$

According to the derived equations, the wage Phillips wage curve:

$$\pi_t^\omega = \beta E_t\{\pi_{t+1}^\omega\} - \lambda_\omega \widehat{\mu_t^\omega},$$

i.e.

$$\pi_t^\omega = \beta E_t\{\pi_{t+1}^\omega\} + \lambda_\omega\left(\sigma + \frac{\varphi}{1-\alpha}\right)\widehat{y_t} - \lambda_\omega\widehat{\omega_t}.$$

describes wage inflation, which depends on the wage inflation in the previous period, the expected inflation, as well as on marginal costs (GDP gap and real wage gap).

$$\pi_t^{wage} = a_{11} \cdot \pi_{t-1}^{wage} + (1 - a_{11}) \cdot \pi_{t+1}^{wage} + a_{12}(a_{13} \cdot ygap_t - (1 - a_{13}) \cdot wagegap_t) + \varepsilon_t^{\pi wage}$$

A period of expansion implies growth in aggregate demand (positive GDP gap), i.e. growth in production leads to an increase in nominal wages. In addition, the growth in real wages above the growth in productivity (a positive wage gap) leads to an increase in the marginal costs of producers, which creates pressure to reduce labour costs, i.e. decrease nominal wages. When the GDP gap (aggregate demand) is greater than the wage gap (labour costs), employers are able to increase nominal wages and vice versa. Wage inflation, therefore, accelerates during expansions and slows down during crises.

In our model, real wages are obtained by adjusting nominal wages for the CPI.

$$real\_wage_t = wage_t - p_t$$

Real wages are decomposed into unobserved components, gaps and trends using the Kalman filter, see Đukić et al. (2010). The wage inflation, i.e. Phillips wage curve, as well as the rest of the wage equations, are the same as the ones that we use in the model for history.

We use the real wage gap as an approximation of real marginal labour costs. This gap represents the deviation of real wages from the level of marginal labour productivity (a proxy for the equilibrium level of wages).

$$wagegap_t = lreal\_wage_t - lrealwage\_tnd_t$$

We assume that in the long run (steady state), decreasing the working age population (which we assumed constant at 1.3% based on trends in the last ten years) will affect faster productivity growth by the same percentage ($ss\_dlreal_{wedge_{tnd}}{}_t = 1.3\%$) compared to the growth of potential GDP.

$$lrealwage_{tnd_t} = lreal\_wedge\_tnd_t + lgdp\_tnd,$$

$$dlreal\_wedge\_tnd_t = a_{31} \cdot dlreal\_wedge\_tnd_{t-1} + (1 - a_{31}) \cdot ss\_dlreal\_wedge\_tnd_t + \varepsilon_t^{wedge}.$$

Wage and price inflation

Similarly to the Phillips curve for wages, the equation for price growth is also derived, i.e. inflation equation. The average price markup is related to the GDP gap and the wage gap, considering the fact that$\mu_t^p = mpn_t - \omega_t$, and the gap in markup:

$$\widehat{\mu_t^p} = \widehat{mpn}_t - \widehat{\omega_t} = (\widehat{y_t} - \widehat{n_t}) - \widehat{\omega_t} = -\left(\frac{\alpha}{1-\alpha}\right)\widehat{y_t} - \widehat{\omega_t},$$

The Phillips curve is:

$$\pi_t^p = \beta E_t\{\pi_{t+1}^p\} - \lambda_p \widehat{\mu_t^p},$$

i.e. $$\pi_t^p = \beta E_t\{\pi_{t+1}^p\} + \left(\frac{\alpha\lambda_p}{1-\alpha}\right)\widehat{y_t} + \lambda_p \widehat{\omega_t}.$$

Inflation will be high when the average markup is below its steady state, in that case, firms that are able to change their prices will choose a price above the average level, in order to adjust their margin to the desired level (steady state).

Considering described equations that relate to non-food and food inflation, Musil et al. (2018) in the Belarusian model introduce the wage gap in addition to the other gaps related to real marginal costs. Increases in real wages result in inflationary pressures because the growth in wages affects the growth in the labour cost of producers.

Non-food inflation equation:

$$\pi_t^{nonfood} = b_1 \cdot \pi_{t-1}^{nonfood} + b_2\pi_t^M + (1 - b_1 - b_2)E_t\pi 4_{t+4} + b_3 \cdot zgap_{t-1} + b_4 \cdot ygap_{t-1} + b_5 \cdot wagegap_t + \varepsilon_t^{nonfood}$$

Food inflation equation:

$$\pi_t^{food} = a_1 \cdot \pi_{t-1}^{food} + a_2\pi_t^M + (1 - a_1 - a_2)E_t\pi4_{t+4} + a_3 \cdot RMCPgap_t + a_4 \cdot zgap_{t-1} + a_5 \cdot ygap_{t-1} + a_6 \cdot wagegap_t + \varepsilon_t^{food}$$

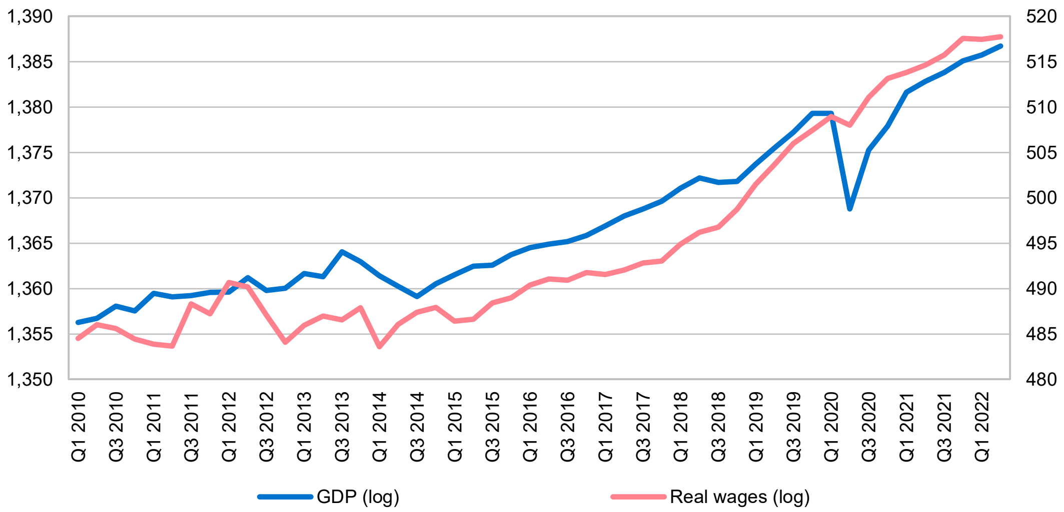
Wages and aggregate demand

Besides their effect on costs to firms, the growth in real wages above the steady state affects the growth in aggregate demand through the growth in household consumption.

$$ygap_t = a_{31} \cdot ygap_{t-1} - a_{32} \cdot rmci_t + a_{23} \cdot ygap_t^{ez} + a_{23} \cdot fi_t + a_{24} \cdot wagegap_{t-1} + \varepsilon_t^{ygap}$$

Musil et al. (2018) introduced the wage gap into the equation of aggregate demand and we were motivated to introduce the wage gap in the aggregate demand equation. In order to confirm the relation between real wages and GDP, we estimated the long-term relationship between the variables. The results showed that from 2008 to 2022, based on quarterly data, wages are adjusted by 0.28% each month to the equilibrium relationship. The impulse response function of the VEC model shows that after an initial increase of 1% in GDP, real wages in the private sector increased by 0.12% in the third quarter. The other way around an increase in wages of 1% results in an increase in GDP of 0.38% in the third quarter, see Chart 10.

Chart 9 **The impact of real wages on GDP growth**



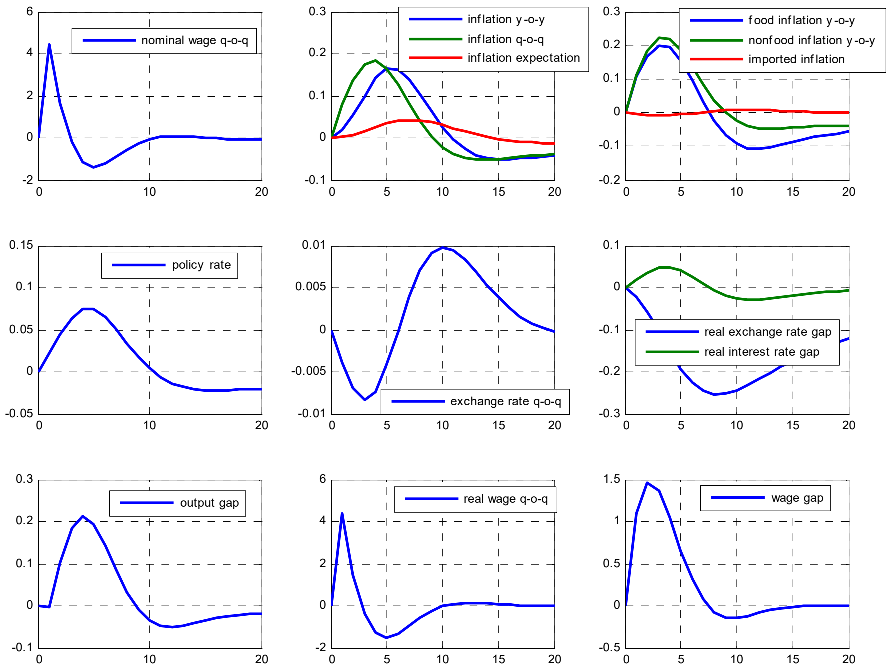
The shock in nominal wages

The properties of the model for medium-term projections are checked by using the impulse response function, which gives us the response of the most relevant macroeconomic variables to a shock in nominal wages. If we assume that there was (autonomous) growth in nominal wages by 10%, this generates an increase in annual inflation of about 1.7% during one quarter.

The assumption is an increase in nominal wages for the private sector by 1% in the first quarter. If nominal wages increase faster than inflation, real wages will rise and will result in a positive wage gap due to higher labour costs than productivity growth. Higher labour costs (a positive wage gap) give rise to inflationary pressures for food and non-food inflation components. The central bank reacts by raising the key policy rate, based on the projected annual inflation four periods ahead. Therefore, the bank does not react directly to the mentioned shock but only to its secondary effects, which are the result of inertia and higher inflationary expectations that affect the rise of the neutral interest rate.

Furthermore, a higher nominal interest rate results in a higher real interest rate and a positive real interest rate gap. Tight monetary policy, along with the reduction of real marginal costs of net importers, gives us disinflationary pressures. A positive output gap was initially opened due to higher real wages that affect higher consumption. Although prices continue to rise for some time as a result of inertia and the pressure on real wages, inflation will return to target due to the reaction of the central bank. This reduction of cost pressures contributes to the gradual opening of the negative production gap in the following period.

Chart 10 **Impulse response function (shock in nominal wages)**



Kalman filter

The Statistical Office of the Republic of Serbia is the main source of time series used in the model, including data on wages, whereby the wages of the IT sector were excluded from the total wages of the private sector.

The main reasons for excluding the IT sector are:

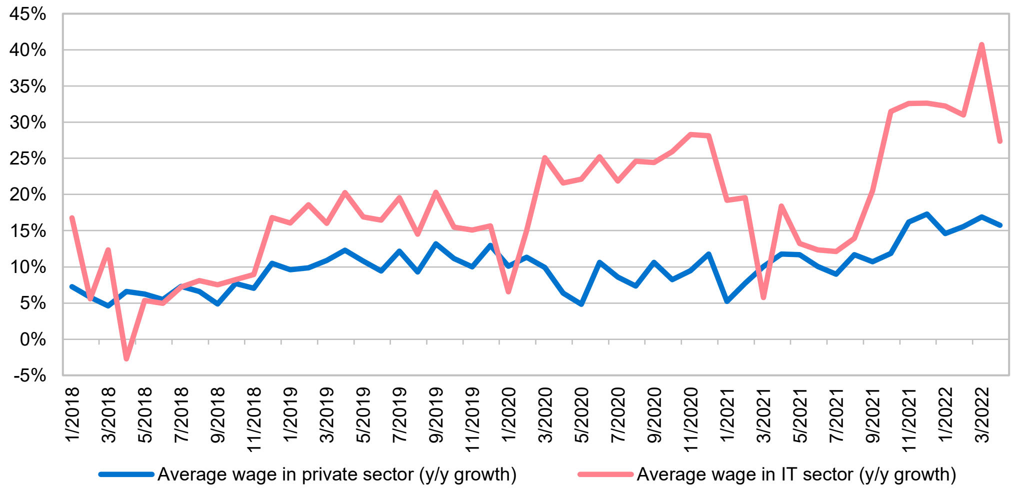
1 High wage growth in the IT sector and the wage fluctuation from 2020 deviate significantly from the rest of the private sector wages.

2 The measures were taken in order to suppress the grey economy – amendments to the Law on Income Tax, the introduction of IT freelancer controls, and tax incentives for

employment have had an impact on the increase of registered employment and wages in this sector, and it is assumed that this is about employees who have had these jobs before. These measures were introduced in 2019 and came into force at the beginning of 2020 (when the biggest deviation in the growth of wages compared to the average began).

3 The low participation of IT services in the consumer basket (taking into account that this branch mainly provides services abroad) implies a weak relationship between labour costs based on wages in this sector and headline inflation.

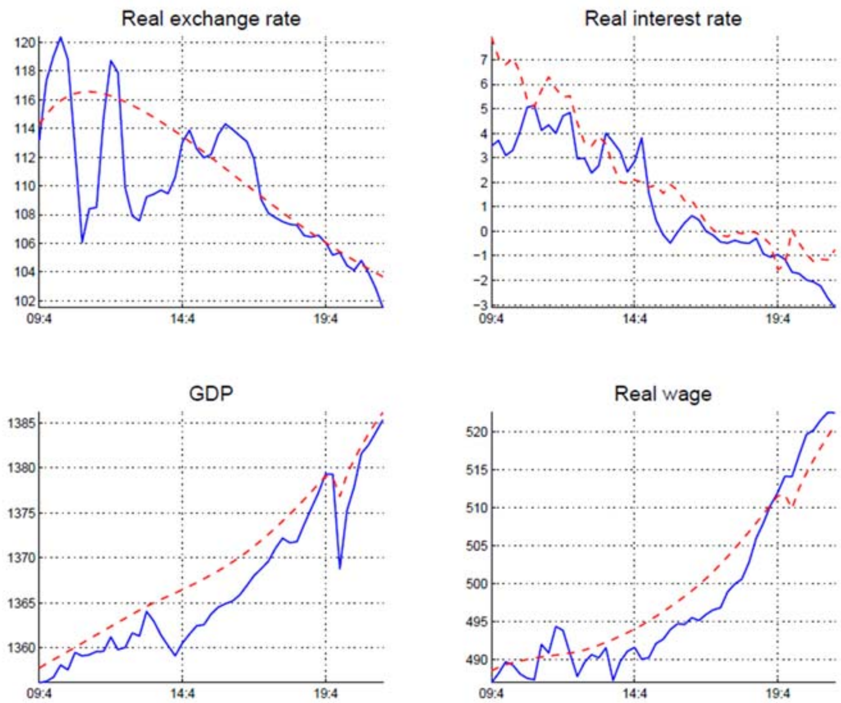
Chart 11 **Average wages in the ICT sector and entire private sector**



Source: SORS.

In the forecasting process, an important step is the estimation of unobservable components, gaps, and trends. These estimates are performed using the Kalman filter on historical data. The coefficients in the model are calibrated. The assessment of trends and gaps from 2009 to date shows us that certain co-integration relationships as described in the work of Mladenović (2020) are also confirmed in our model. According to that paper, the real appreciation of the exchange rate is driven by the drop in the real interest rate in the last ten years, affecting real wage growth, while real wage growth, in the long run, is related to potential growth

Chart 12 **Estimates of trends**



4 Fiscal impulse

As mentioned above, the outbreak of the COVID-19 pandemic elicited a strong fiscal policy response in order to mitigate the negative impact of the pandemic on economic growth and to support the health system, globally as well as in Serbia. In the period since the fiscal consolidation (2015–2017), Serbia's fiscal position has been stable, which did not generate significant effects on aggregate demand nor on inflation. Since there was a sudden fiscal policy expansion in 2020, the effect of fiscal policy through the aggregate demand channel has gained in importance and we have included it in the model for medium-term inflation projections.

A vast number of countries have promptly reacted to the COVID-19 outbreak by implementing fiscal measures in order to prevent lockdowns from affecting aggregate demand and labour markets. However, the size of fiscal packages has differed significantly among countries. According to the IMF's Fiscal Monitor, October 2021: Strengthening the Credibility of Public Finances, in advanced economies the size of fiscal support amounted to USD 15,884.7 bn (approximately 10% of GDP on average), of which 60% was directed to above-the-line measures, and the rest to below-the-line measures[2]. On the other hand, due to generally narrower fiscal space in emerging market economies, the response was on average more restrained (USD 2,326 bn, around 4.4% of GDP on average). No significant relationship has been found between the size of fiscal support and public debt levels before the pandemic

[2] Equity injections, loans, asset purchases etc.

globally, according to Lacey et al. (2021). However, we estimated the relationship between debt levels in percent of 2019 GDP and above-the-line fiscal measures for developing countries and found a statistically significant relationship – a 1 pp increase in debt levels leads to approximately 0.07 pp lower fiscal measures (regression output in Table 3). Our findings suggest that developing countries with lower debt levels had more space to implement fiscal support measures.

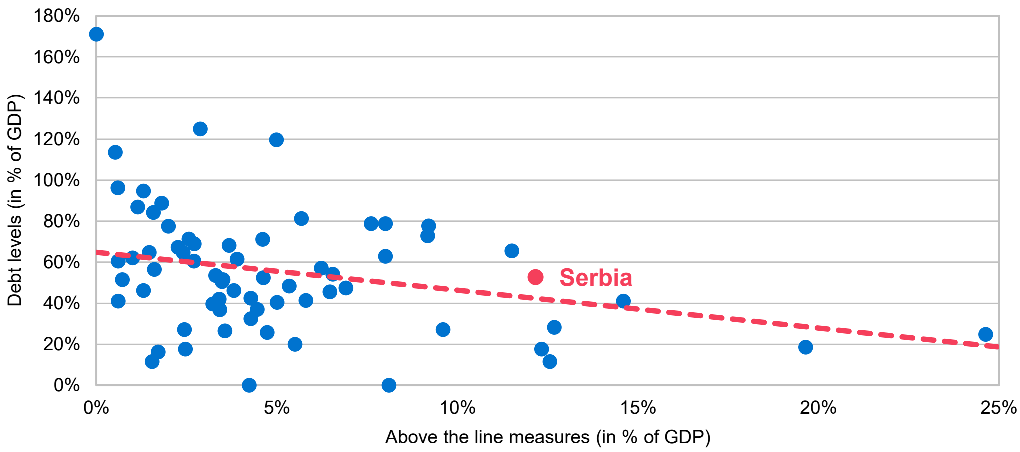
Table 3 **The estimate of a relationship between debt levels and "above the line" measures** (in % of GDP)

	Estimate	*p*-value
Constant	9.13	0.000
Debt	-0.066	0.004

Source: author calculation.

The effect is illustrated in Chart 13, where we can see that Serbia was among the countries able to respond to the pandemic to a greater extent, which was part of the motivation to include the fiscal impulse (as a proxy for character fiscal policy) in the model for medium-term inflation projections.

Chart 13 **The relationship between debt levels and "above the line" measures**
(in % of GDP)



Source: IMF.

Serbia's strong pre-pandemic fiscal position has provided space for delivering a substantial fiscal support package, which amounted to RSD 880.1 bn (15.6% of GDP).

The effect of fiscal policy on aggregate demand is captured by the fiscal impulse, a derived variable used to describe the discretionary stance of fiscal policy. The fiscal impulse is used because changes in the budget deficit (which is often used for describing the stance of fiscal policy) are not only a result of discretionary policy changes, but also cyclical factors. In order to capture only structural fiscal policy changes, we apply the following procedure for deriving the annual fiscal impulse:

(1) Social security contributions are excluded from public revenues, while interest payments, net lending and payment of called guarantees are excluded from public expenditures.

(2) Both revenues and expenditures are seasonally adjusted, and by subtracting adjusted expenditures from revenues, we obtain the adjusted budget balance.

(3) The cyclical primary balance represents the part of the budget balance that automatically reacts to the cycle movements, and it is computed as follows:

$$PB_{cyclical,year\ t} = elasticty * ygap_{year\ t}$$

Where:

- *elasticity* represents revenues elasticity to total GDP, and according to our OLS estimate (in the period 2008–2021) equals 0.45;
- *ygap* represents our estimate of output gap, obtained by implementing the *Hodrick-Prescott* filter.

(4) Structural balance is obtained by subtracting cyclical primary balance from adjusted budget balance:

$$PB_{structural,year\ t} = PB_{primary,year\ t} - PB_{cyclical,year\ t}$$

(5) The annual change in structural balance is the fiscal impulse (i.e. discretionary change in stance of fiscal policy):

$$fiscal\ impulse_{year\ t} = -\Delta PB_{structural,year\ t}$$

When the current structural balance exceeds previous year's structural balance, the fiscal impulse is positive and vice versa.

Aforementioned calculations of the fiscal impulse are presented in Table 4:

Table 4 **Top-down calculation of fiscal impulse**

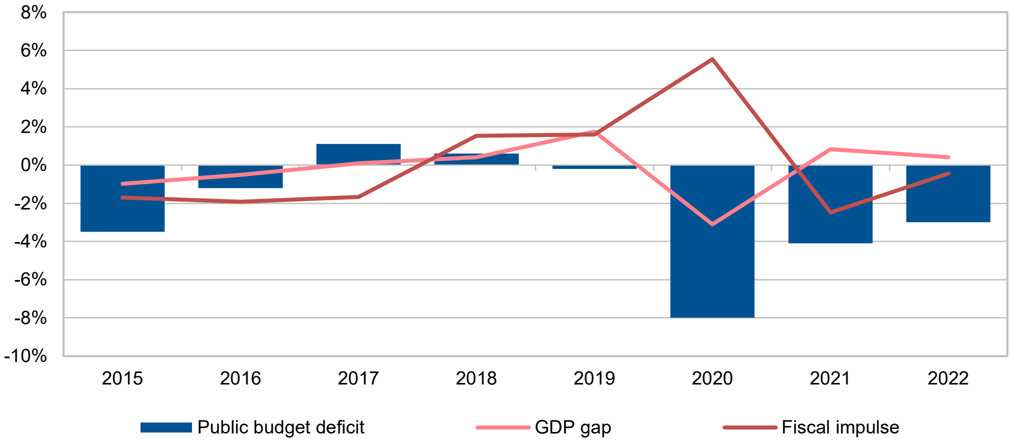
in % of GDP	2017	2018	2019	2020	2021	2022*
Public revenues	41.30	41.21	41.80	40.65	43.00	42.15
Public expenditure	36.83	38.11	39.71	46.20	44.45	43.22
of which interest payments	2.42	2.24	2.03	2.00	1.80	1.70
Fiscal balance	4.48	3.10	2.09	-5.55	-1.45	-1.07
of which: primary balance	6.90	5.33	4.12	-3.55	0.35	0.63
one-off measures	0.88	0.52	0.40	0.94	0.94	0.80
Adjusted budget balance	4.51	3.12	2.12	-5.62	-1.36	-1.10
Cyclical component	-0.04	-0.16	-0.71	1.27	-0.34	-0.17
Structural balance	-4.47	-2.93	-1.33	4.21	1.73	1.28
Fiscal impulse	-1.66	1.53	1.60	5.54	-2.48	-0.45

* Estimate from the Fiscal Strategy.

Source: NBS calculation, Ministry of Finance.

Comparison between the fiscal impulse and public budget deficit is illustrated in Chart 14:

Chart 14 **GDP gap, fiscal impulse and public budget deficit**
(in %)



Source: NBS calculation, Ministry of Finance.

From the equations presented above, we can identify several factors of divergence between the fiscal impulse and budget deficit: (1) the structural balance excludes income and expenditure components that have no effect on aggregate demand (interest payments, net lending, etc.) (2) the structural balance excludes the effects of the business cycle (3) the fiscal impulse depicts the annual change in the structural balance (which affects aggregate demand), while the public budget deficit depicts the level difference between public revenues and expenditures.

To illustrate the importance of excluding the cyclical component of fiscal policy when analysing its impact on the economy, we considered how the increase in economic activity can result in a decrease in the deficit, without any change in the character of fiscal policy, but rather because of cyclical movements. Furthermore, the sign of the fiscal impulse is also determined by deficit dynamics and the output gap sign. Therefore, there are cases (as in 2017) when the fiscal impulse is negative, while the deficit increases.

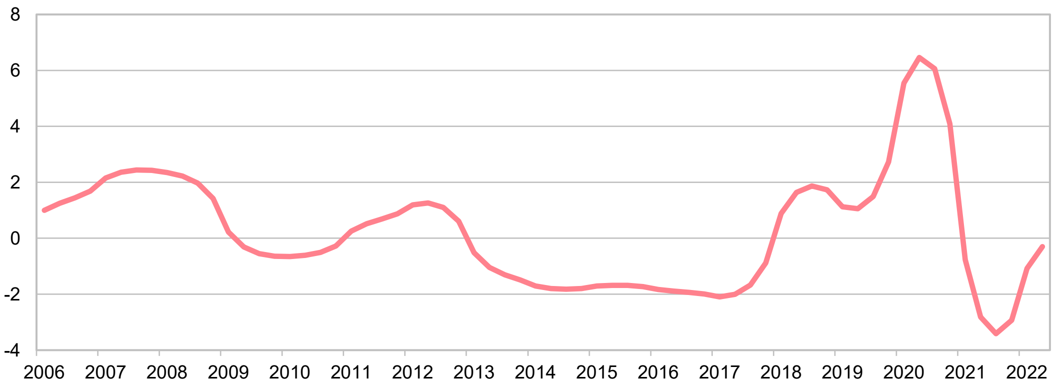
Taking everything into consideration, the fiscal impulse is a more appropriate indicator for the analysis of the fiscal policy impact on aggregate demand, and thus inflation, compared to the budget deficit.

We can assess the discretionary nature of fiscal policy by comparing the fiscal impulse sign to the output gap sign. Fiscal policy is procyclical when these two indicators are of the same sign, and countercyclical when they are of opposite signs. Chart 14 shows that fiscal policy was procyclical prior to the pandemic (with the exception of 2017); however it has been countercyclical following the epidemic's onset in an effort to lessen its effects on employment and economic activity.

The fiscal impulse is implemented in the aggregate demand equation as an expert-estimated residual, therefore it affects inflation through the output gap. Implementation of the fiscal impulse into the aggregate demand equation requires its disaggregation from annual to quarterly level, which we do by using the Chow-Lin statistical method, and furthermore, determination of its coefficient in the equation. The quarterly fiscal impulse (obtained by Chow-Lin procedure) is given in Chart 15:

The coefficient of the fiscal impulse can either be estimated or calibrated (i.e. theoretical values or values obtained from empirical studies for other countries can be used). Estimation of the effect of the fiscal impulse on aggregate demand yields a coefficient of 0.1, which is statistically significant. When it comes to estimates for other countries that can be employed

Chart 15 **Quarterly fiscal impulse**
(in %)



Source: NBS calculation.

in our model, we have taken into consideration estimates from (Salas, 2010) obtained by the Bayesian method for a small, open economy, where the fiscal impulse coefficient equals 0.25 (90% confidence interval 0.13–0.37). Taking into consideration the range of the confidence interval and the fact that both calibration and estimation are acceptable, we decided to use the coefficient of 0.15 for the fiscal impulse in the aggregate demand equation. The aggregate demand equation becomes:

$$ygap_t = 0{,}5 \cdot ygap_{t-1} - 0{,}2 \cdot rmci_t + 0{,}6 \cdot ygap_t^{ez} + \mathbf{0{,}15 \cdot fi_t} + 0{,}1 \cdot wagegap_{t-1} + \varepsilon_t^{ygap}$$

notation:

$ygap_t$ – domestic output gap in current period,

$ygap_{t-1}$ – domestic output gap in previous period,

$ygap_t^{ez}$ – euro area output gap,

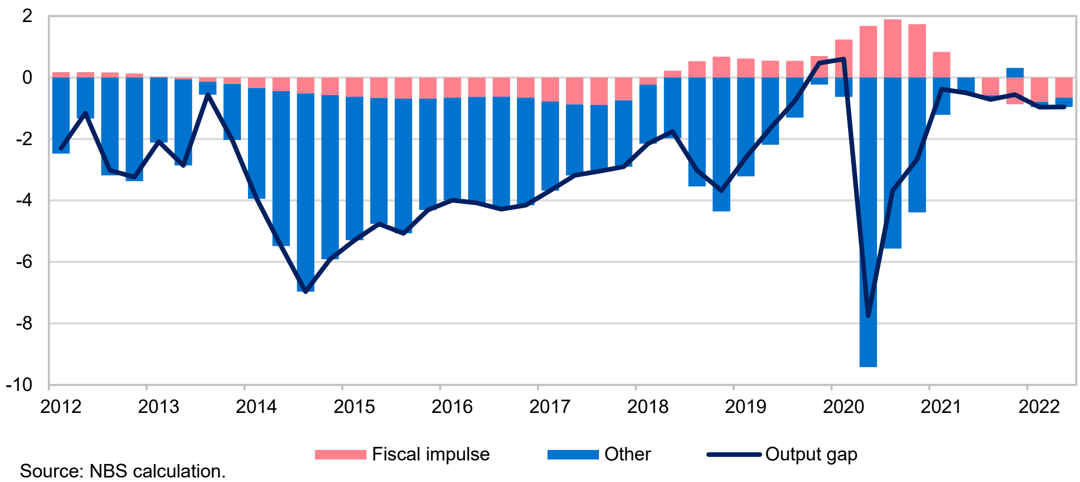
$rmci_t$ – monetary conditions index, i.e. linear combination of real interest rate gap and real exchange rate gap,

fi_t– fiscal impulse (positive in periods of expansionary fiscal policy), and

$wagegap_{t-1}$– real wage gap in previous period.

The decomposition of this equation on the historical period is in accordance with the character of fiscal policy in the observed period. For forecast assumptions, the announcement of revenues and expenditures (from the Fiscal Strategy) is employed for computation of the fiscal impulse, thus the accuracy of calculated contributions of the fiscal impulse to aggregate demand depends on the accuracy of these estimates.

Chart 16 **Fiscal impulse share in output gap**
(in %)



Source: NBS calculation.

The impact of the fiscal impulse on aggregate demand is depicted in Chart 16, where we can distinguish among several different periods:

(1) Restrictive fiscal policy in the period of fiscal consolidation.

(2) Moderately expansive fiscal policy in 2018 and 2019.

(3) Strong fiscal expansion in 2020, as a response to the pandemic outbreak, which prevented a more drastic fall in aggregate demand.

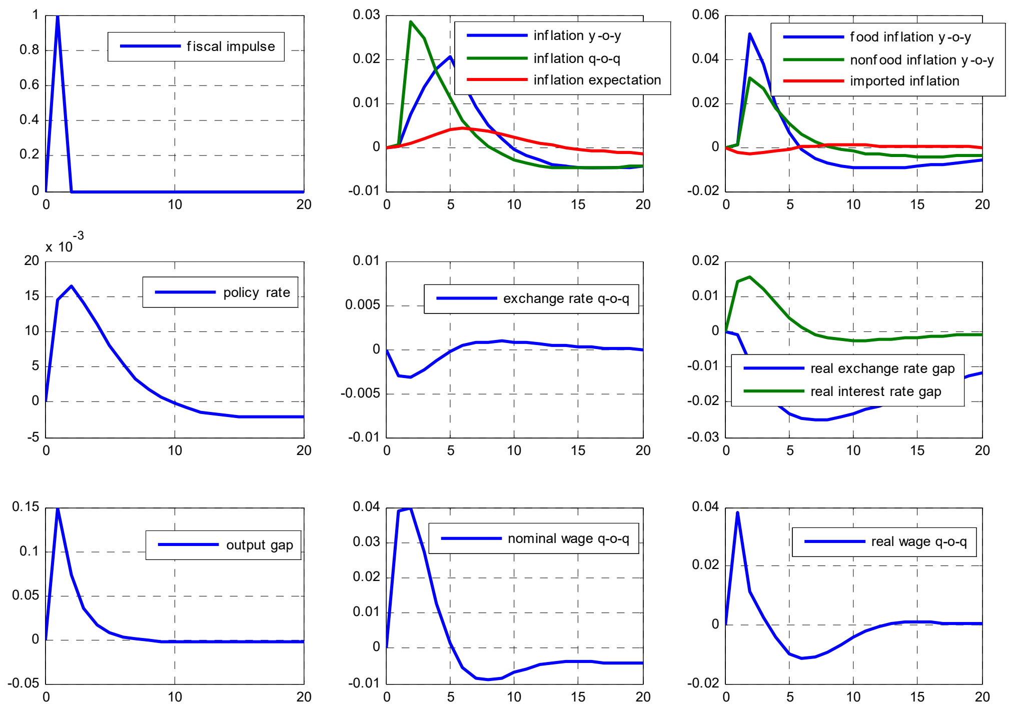
(4) Restrictive fiscal policy after expiration of anti-pandemic measures.

Fiscal policy shock

If we assume that there has been an increase in government consumption of 10%, aggregate demand will increase by 1.5%. Bearing in mind that demand affects inflation with a lag, this increase in demand will produce inflationary pressures in the next quarter. The central bank reacts to inflation four periods ahead by increasing the key policy rate, which due to its rigidity (persistence) in movement reaches its maximum after five quarters.

The key policy rate and domestic price level increases lead to an increase in the real interest rate and real appreciation of the exchange rate, respectively. Opening of the real appreciation gap implies that real marginal costs of net importers decline, which has a disinflationary effect in the following periods. Closing of the output gap, partly due to the restrictiveness of the central bank, also contributes to inflation gradually returning to the target.

Chart 17 **Impulse response function (fiscal policy shock)**



5 Simulation results

In this section we compare the results of a historical simulation of the current version of the model (M1) with a version that excludes changes described in the previous chapters (M2). We forecast y-o-y inflation up to one year ahead, for the period from Q1 2012 to Q1 2022.

In Chart 18, the red lines represent historical out-of-sample projections of inflation using model M1 (left) and model M2 (right), while actual inflation data are presented by the blue line. Mean forecast errors are greater when applying the M2 model. This is confirmed in Table 5, which shows statistical measures of the forecast error (root mean squared error) for forecast horizons of 2, 3 and 4 periods (quarters) ahead. RMSE values are smaller with the M1 model on all three horizons, which shows that the changes implemented improved forecast accuracy. Errors at the one-quarter-ahead horizon were not analysed, given that the short-term forecast is performed exogenously to the QPM model.

Chart 18 **Simulation of inflation forecast by applying M1 model (left) and M2 model (right)**

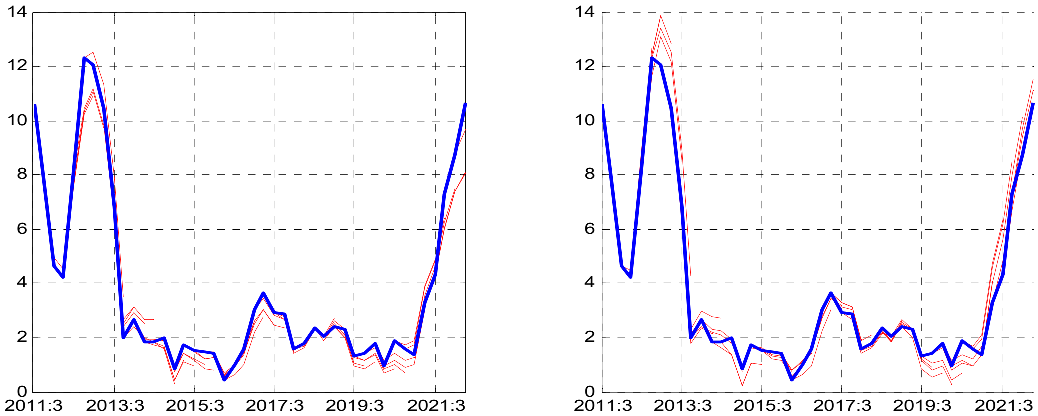


Table 5 **Forecast error statistics**

Quarters	**2**	**3**	**4**
RMSE			
M1	0.58	0.65	0.68
M2	0.59	0.77	0.90

6 Conclusion

The goal of this paper is to present changes in the structure of the macroeconomic model used at the NBS for forecasting inflation and understanding the factors which drive it. In addition to continuous improvements to the model, which relate to a periodic recalibration of coefficients, changes in sources of data or the use of satellite models, in the period since QPM was introduced some changes to its structure have been made. Considering the long period since the paper describing the original model structure was published (Đukić et al. 2010), in this paper we present the most important changes made in the meantime, which are related to factors driving inflation.

The first section presents changes to inflation components, i.e. disaggregation of CPI with the goal of separating sub-indices which correspond to individual factors driving inflation. For this reason, core inflation (as defined at the time) has been split into its food and non-food components, while con-core inflation has been split into fresh fruits and vegetables, and regulated prices. In addition to a reduction in the forecast error which has been confirmed through simulations in this paper, the disaggregation of inflation has an analytical purpose by making it easier to identify cost-push factors from demand-side factors under the influence of monetary policy.

In the literature on New Keynesian models (which form the core analytical instrument used by inflation targeting central banks), the assumption of nominal stickiness of wages and prices is central. It is only due to that stickiness that monetary policy has a short-run impact on real variables, and the ability to contribute to business cycle smoothing. At the time inflation targeting was introduced, in order to keep the model tractable, as well as due to the fact that wages in the period of transition and high unemployment had a little significant inflationary effect, labour market developments were approximated through the output gap. With the acceleration of wage growth above productivity growth in recent years (especially since the COVID-19 pandemic), this channel gained in importance. Wages are introduced into the model though the real wage gap (the deviation of wages from their trend level), which affects both the cost (a direct effect on prices in the equations for market price inflation) and on the demand side (included in the aggregate demand equation). In order to justify the inclusion of the real wage gap into the aggregate demand equation, we estimated a cointegrating relationship between real wages and real GDP, confirming their long-term relationship. In addition to contributing to a reduction in the forecast error, the explicit inclusion of wages in the model sheds more light on potential overheating of the labour market, which has a key role in the formation of sustained inflation pressures. The impact of an exogenous shock in wages on key macroeconomic variables and monetary policy reaction is described by impulse response functions at the end of Section 2.

The impact of fiscal policy on aggregate demand has gained in importance in the period since the outbreak of the COVID-19 pandemic in 2020. Modelling the policy impact through a new variable – the fiscal impulse – allows us to include assumptions on future developments in fiscal policy into the forecast and assess the contribution of fiscal policy to aggregate demand changes in the previous period. After a period of contractionary fiscal policy during fiscal consolidation, and several years of moderately expansive policy thereafter, the effect of fiscal policy strongly gained in importance (in the direction of expansion) with the outbreak of COVID-19, while the gradual abolition of support schemes had a contractionary effect.

In section 5 we present a comparison of historical forecast simulations of the original and updated versions of the model. Simulations of inflation and output gap were performed over the 2012 – Q1 2022 period for up to four quarters ahead. The results suggest improved forecast accuracy of the updated version of the model for both variables at all forecast horizons. The improvements are more significant at shorter forecast horizons. In the future we will continue to monitor performance of the model, and make adjustments to the calibration, data and other structural adjustments.

Appendix

Link between wages and GDP in the long run

Based on obtained results, we included the wage gap in the aggregate demand equation (GDP gap).

Estimate of cointegration link of GDP and real wages

Dependent	tau-statistic	Prob.*	z-statistic	Prob.*
L_GDP	-3.435022	0.0512	-19.27583	0.0420
L_REAL_WAGE	-3.484820	0.0457	-18.93592	0.0457

*MacKinnon (1996) p-values.

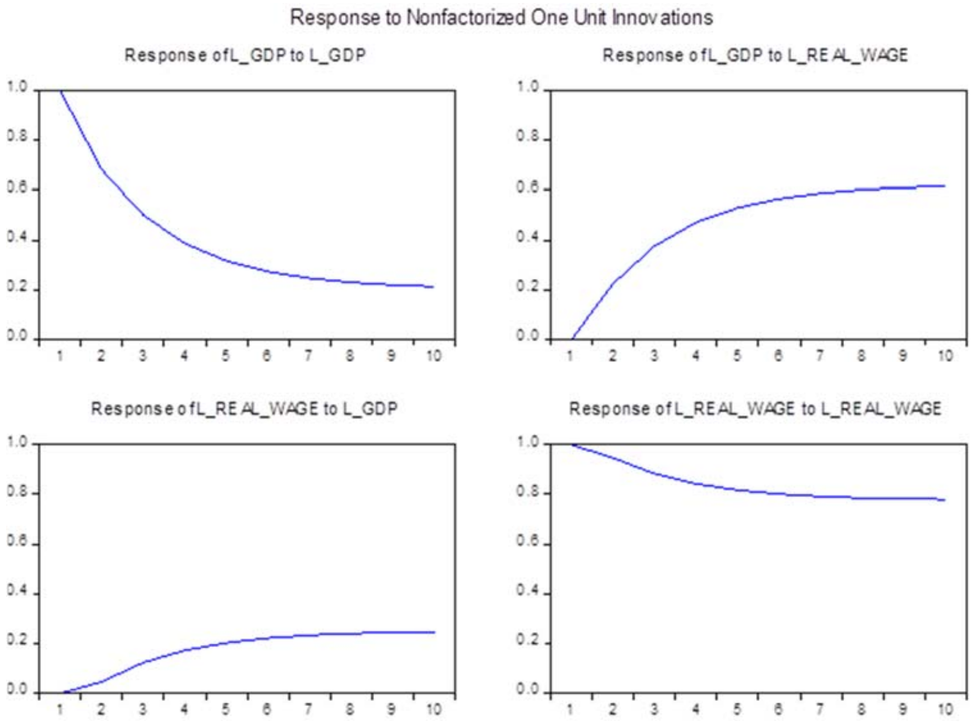
VAR Lag Order Selection Criteria
Endogenous variables: L_GDP L_REAL_WAGE
Exogenous variables: C
Date: 07/19/22 Time: 10:12
Sample: 2008Q1 2022Q2
Included observations: 53

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-324.8234	NA	778.3785	12.33296	12.40731	12.36155
1	-203.8651	228.2232*	9.430275*	7.919437*	8.142489*	8.005212*
2	-203.4840	0.690210	10.81974	8.056001	8.427754	8.198960
3	-200.9625	4.376988	11.46321	8.111793	8.632247	8.311934
4	-199.5412	2.359970	12.67955	8.209100	8.878256	8.466425
5	-198.1058	2.274935	14.04635	8.305879	9.123736	8.620387

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Vector Error Correction Estimates
Date: 07/19/22 Time: 10:15
Sample (adjusted): 2008Q3 2022Q2
Included observations: 56 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	
L_GDP(-1)	1.000000	
L_REAL_WAGE(-1)	-0.804506 (0.06684) [-12.0368]	
C	-969.4111	
Error Correction:	**D(L_GDP)**	**D(L_REAL...**
CointEq1	-0.293384 (0.11048) [-2.65548]	0.095245 (0.09091) [1.04765]
D(L_GDP(-1))	-0.024760 (0.14296) [-0.17319]	-0.049097 (0.11764) [-0.41735]
D(L_REAL_WAGE(-1))	-0.012644 (0.17915) [-0.07058]	0.022926 (0.14742) [0.15552]
C	0.509891 (0.28590) [1.78346]	0.712936 (0.23526) [3.03041]



Response of L_GDP:		
Period	L_GDP	L_REAL_WAGE
1	1.000000	0.000000
2	0.681857	0.223385
3	0.499997	0.376350
4	0.386144	0.471332
5	0.315904	0.529974
6	0.272560	0.566160
7	0.245816	0.588487
8	0.229314	0.602264
9	0.219132	0.610765
10	0.212850	0.616010
Response of L_REAL_WAGE:		
Period	L_GDP	L_REAL_WAGE
1	0.000000	1.000000
2	0.046148	0.946301
3	0.124233	0.882868
4	0.173055	0.842099
5	0.203282	0.816867
6	0.221936	0.801294
7	0.233446	0.791685
8	0.240547	0.785756
9	0.244929	0.782098
10	0.247633	0.779840
Nonfactorized One Unit		

Coefficients in the model are calibrated by using coefficients from the model from Belarus, Musil et al. (2018).

Table 1 **Calibrated coefficients in the medium-term projection model**

Coefficients	Values
Nominal wages	
a_{11}	0,5
a_{12}	0,5
a_{13}	0,5
Difference in growth in trend in real wages compared to the potential	
a_{31}	0,9
Core inflation (non-food)	
a_{25}	0,1
Non-core inflation (food)	
a_{56}	0,1
GDP gap	
a_{24}	0,1

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