National Bank of Serbia

WORKING PAPERS BULLETIN

September
2022

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Foreword by the Governor

The National Bank of Serbia releases the third issue of the Working Papers Bulletin, a semi-annual publication launched one year ago.

This issue is coming out at a time particularly challenging for monetary policy makers. Global inflationary pressures on account of economic bounce-back from the pandemic shock were further heightened this year by strong geopolitical tensions. Like many other countries, Serbia is also affected by such movements, facing mounting inflation and risks to economic growth.

It is undisputable that today's inflation derives from a complex mix of monetary policies, fiscal interventions, market psychology and consumer choices.

For that very reason, in economically unstable times such as the current ones, analyses and research may give a special contribution to quality conduct of economic policies. The papers presented in this issue serve not only academic purpose, but explain the analyses and methodologies applied at the National Bank of Serbia, with a view to supporting the maintenance of price and financial stability.

One of the papers deals with structural changes to the medium-term projection model which the National Bank of Serbia regularly uses to project inflation and other relevant macroeconomic variables. The changes concern de-composing the market component of inflation into food and non-food, singling out fruits and vegetables from the category of non-core prices as a separate group, and introducing the labour market and fiscal policy into the model. These changes have proved to be improving the model's forecasting performance, adding to the quality of decisions of monetary policy makers.

Apart from the basic model, in periods of heightened volatility, indicators that could timely signal inflation upturn gain in importance. The second paper uses newspaper article analysis to assess the strength of inflationary pressures in Serbia. Application to the period 2007–2022 showed that the frequency of the use of words connected to price hikes and drops in newspaper articles is a good indicator of inflationary pressures, especially in unstable times. The use of the so-called big data in economic forecasting, covered in this paper, is a relatively new area that is provoking more and more interest among central bankers.

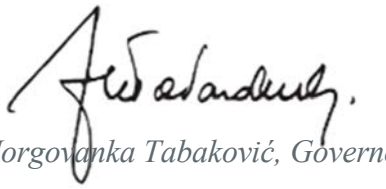
Since a large number of central banks, including the National Bank of Serbia, are joining the fight against climate change by purchasing the so-called green bonds, the next paper in the Bulletin looks into factors impacting their yields in European countries and the existence of green premium (lower yield on green bonds). The results of this paper suggest that higher values of VIX, six-month EURIBOR, longer remaining maturity and the lack of independent external opinion require higher yield on green

bonds, while higher credit rating enables lower required yield. At the same time, we found no greenium in the analysed European countries.

The increasing importance of digital payments imposed the need to somehow measure their movement. The next paper in the Bulletin presents the digital payments index developed at the National Bank of Serbia as a measure of use of digital payments over time. The index covers digital methods of payment by category: Payment services infrastructure; Degree of technological development; Payment performances and Consumer experience. This index has recorded continuous growth in the period observed, indicating an improvement in the field of digital payments in the Republic of Serbia year after year.

The Bulletin concludes with a detailed overview of the history of Basel Accords and their importance for banks' operation and preservation of financial stability. The National Bank of Serbia pays special attention to improving banking regulations, in accordance with the international standards and EU regulations, while accounting for the specificities of the domestic legal framework and the local market.

We hope the papers in the third issue of the Bulletin will help readers to better understand the aspects of analyses and research that are part of the decision-making process in the National Bank of Serbia aimed at preserving price and financial stability.



Dr Jorgovanka Tabaković, Governor

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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.

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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.

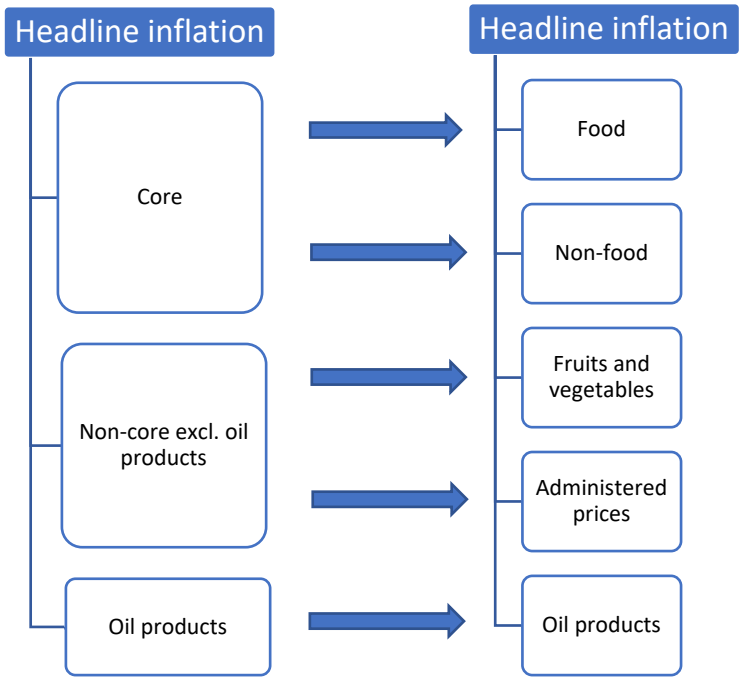
In the original model structure, even though the prices of agricultural products included in the CPI (fruits, vegetables, eggs) are formed in the market, they were classified as *non-core prices excluding oil derivatives*. Given that they are mostly determined by weather conditions, the influence of 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)**

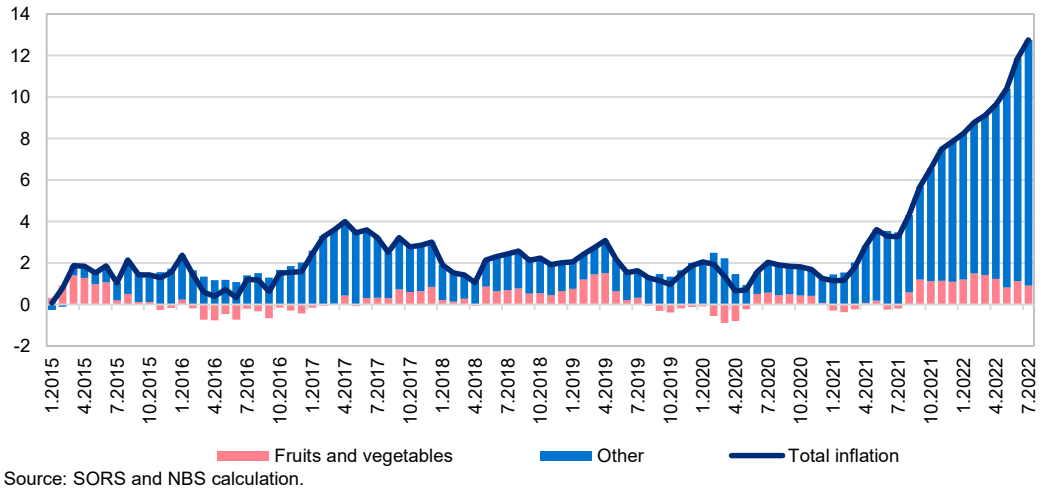


Fruits and vegetables

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**

(in %)



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}):

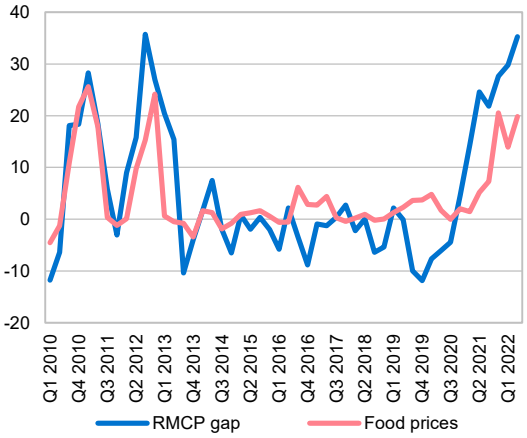
$$RMCP = \frac{P_t^{agr}}{P_t^{food}}$$

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:

$$RMCPgap = RMCP - RMCPtnd$$

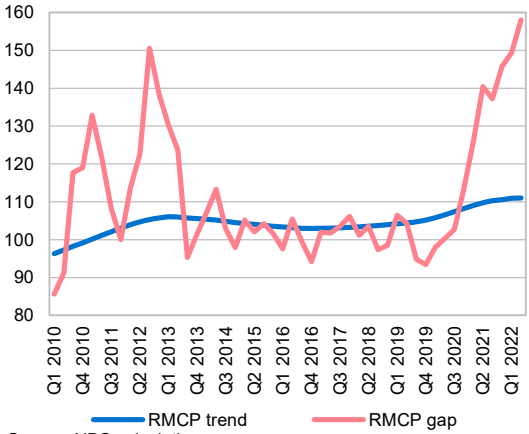
In Chart 3, the growth of this indicator (2010, 2012, 2020 and 2021) reflects increased cost pressures on food prices, and vice versa (2009 and 2011). A positive RMCP gap indicates that the costs of raw materials in food production are relatively high, i.e. the presence of cost pressures for food on 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**

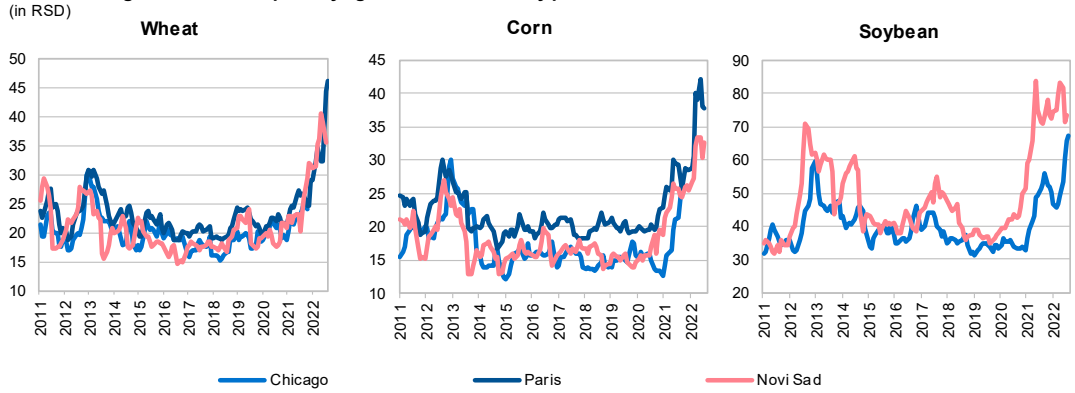


Source: NBS calculation.

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)



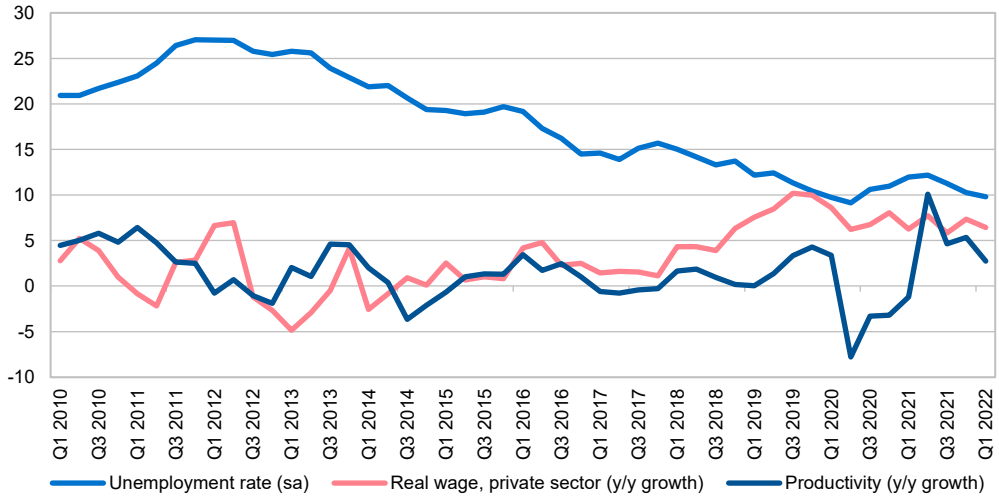
Source: Chicago Board of Trade, Commodity Exchange Novi Sad, Euronext Paris MATIF.

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.

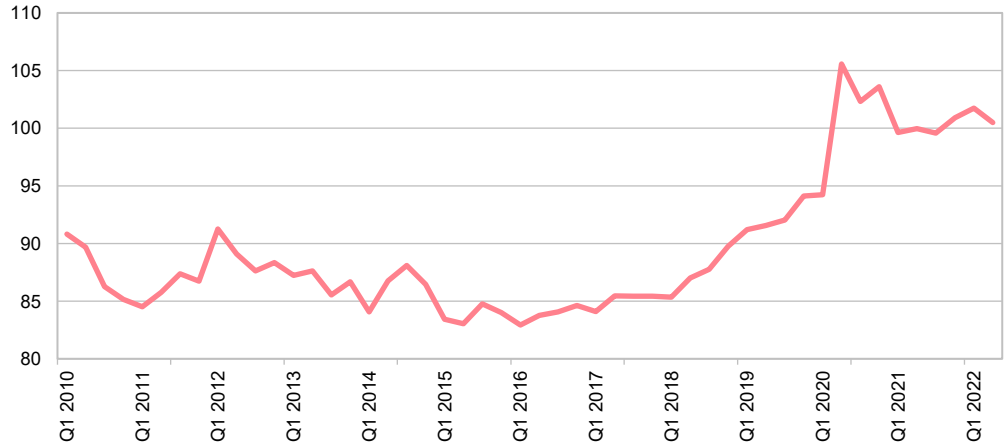
Chart 6 **Unemployment rate, real wage and productivity growth**



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)



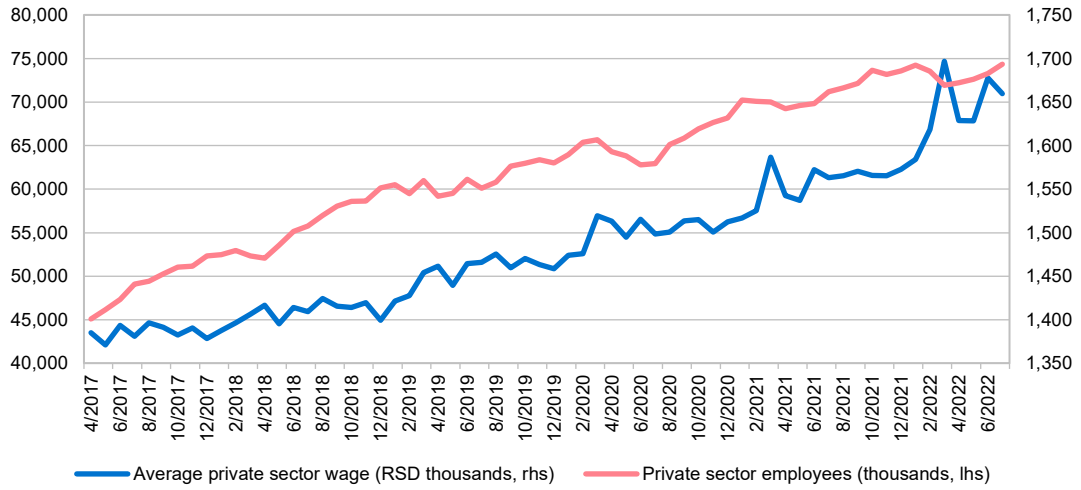
Source: SORS.

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:

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

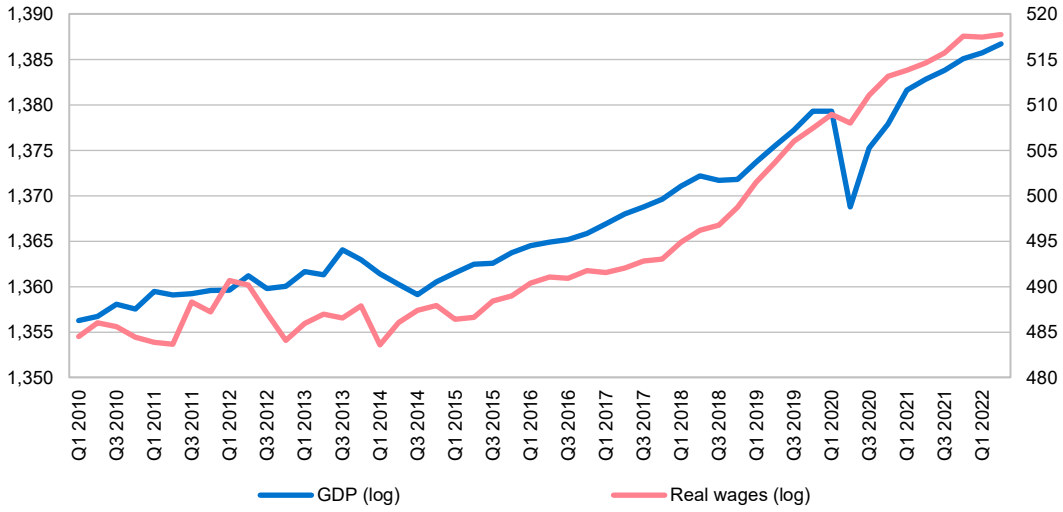
Wages and aggregate demand

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

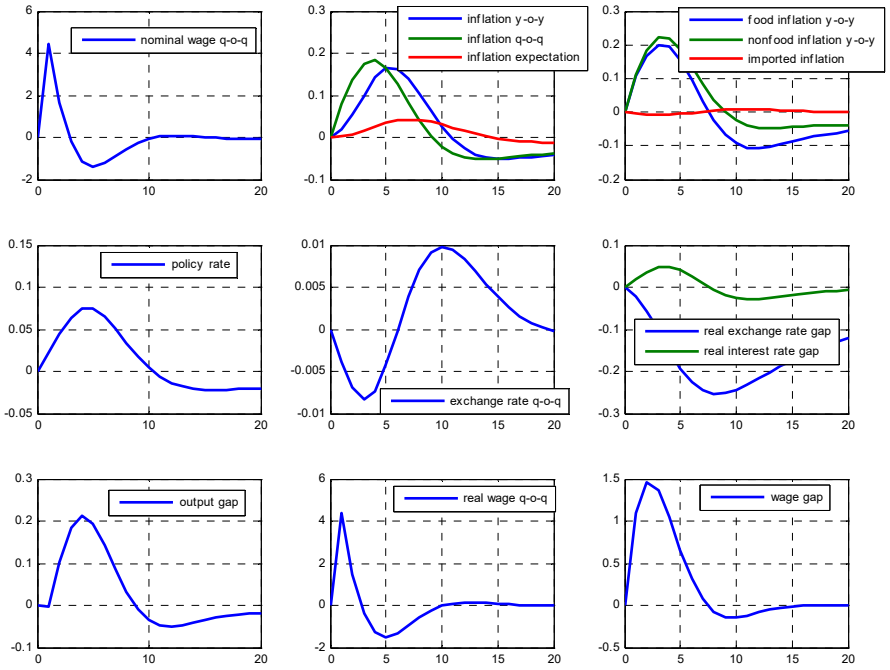
The properties of the model for medium-term projections are checked by using the impulse response function, which gives us the response of the most relevant macroeconomic variables to a shock in nominal wages. If we assume that there was (autonomous) growth in nominal wages by 10%, this generates an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

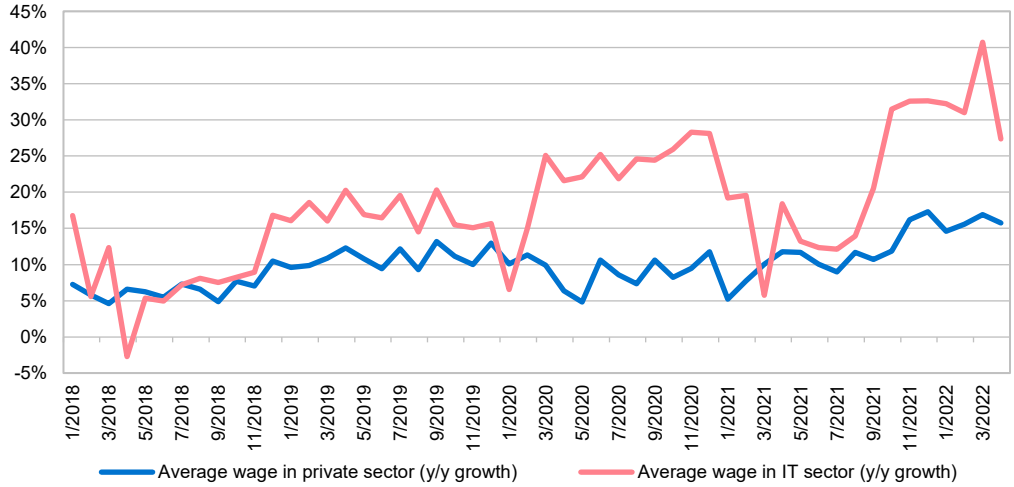
1 High wage growth in the IT sector and the wage fluctuation from 2020 deviate significantly from the rest of the private sector wages.

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.

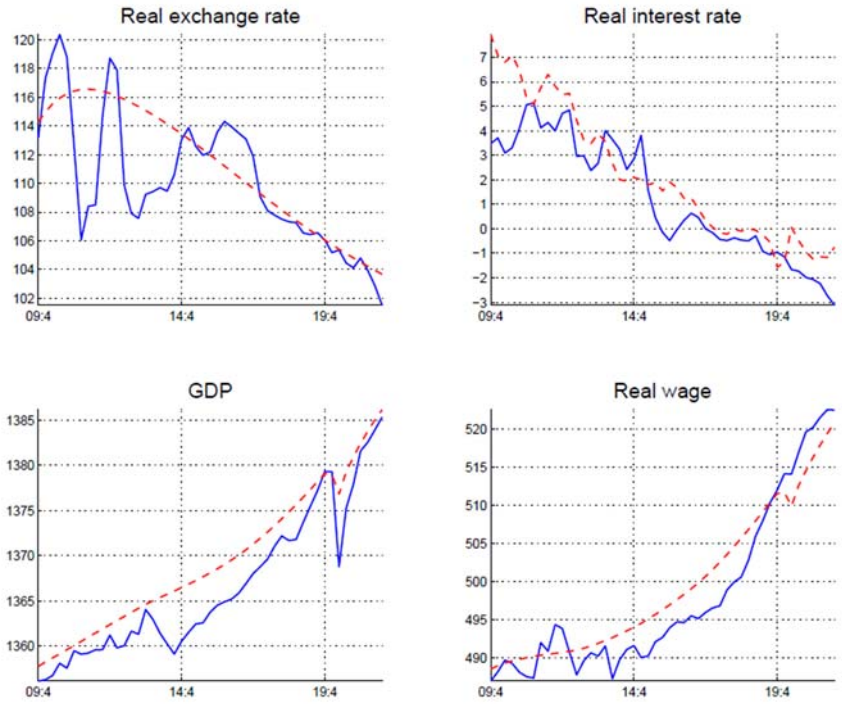
Chart 11 **Average wages in the ICT sector and entire private sector**



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.

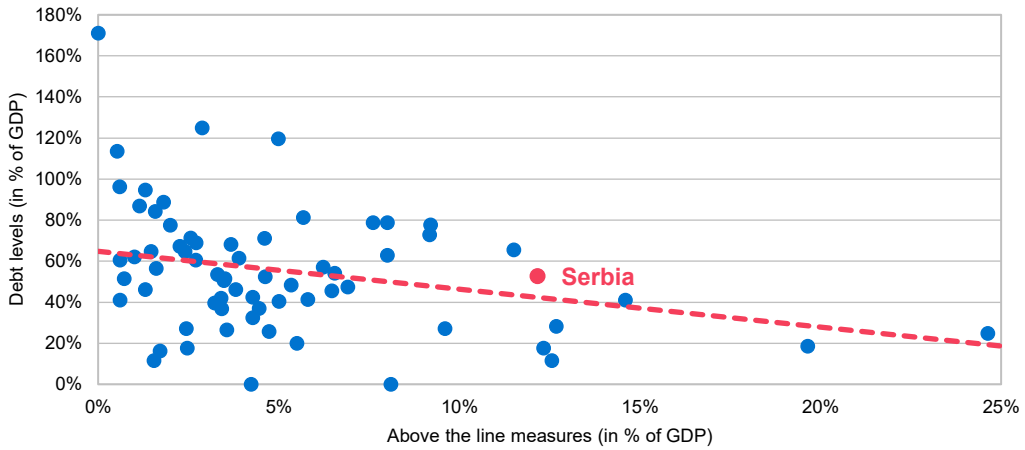
Table 3 **The estimate of a relationship between debt levels and "above the line" measures** (in % of GDP)

	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:

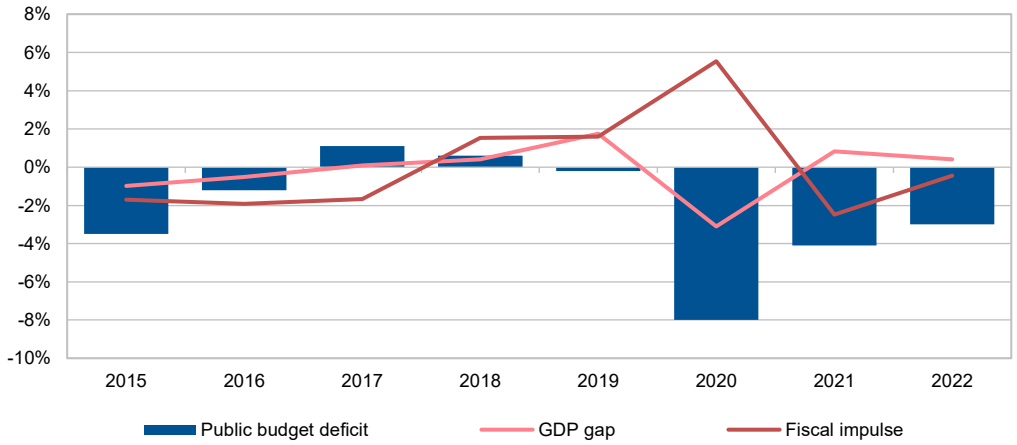
Table 4 **Top-down calculation of fiscal impulse**

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.

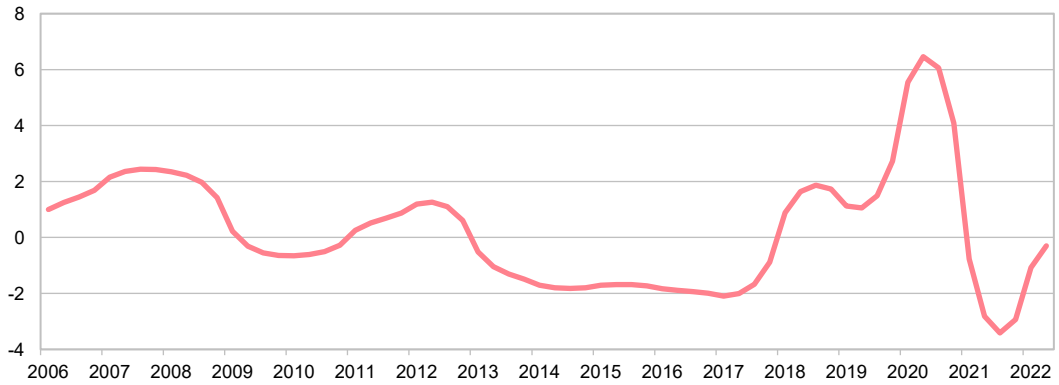
Taking everything into consideration, the fiscal impulse is a more appropriate indicator for the analysis of the fiscal policy impact on aggregate demand, and thus inflation, compared to the budget deficit.

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:

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

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,

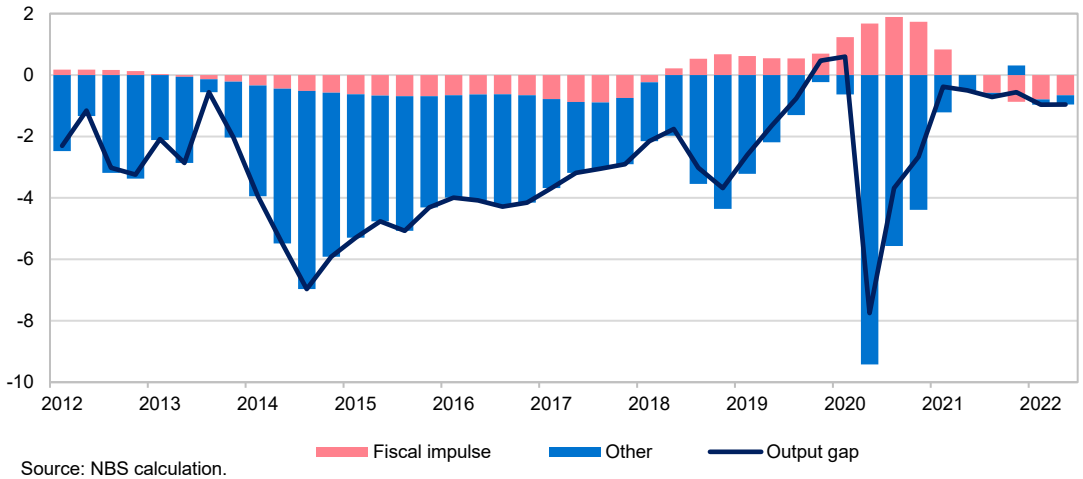
$rmci_t$ – monetary conditions index, i.e. linear combination of real interest rate gap and real exchange rate gap,

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.

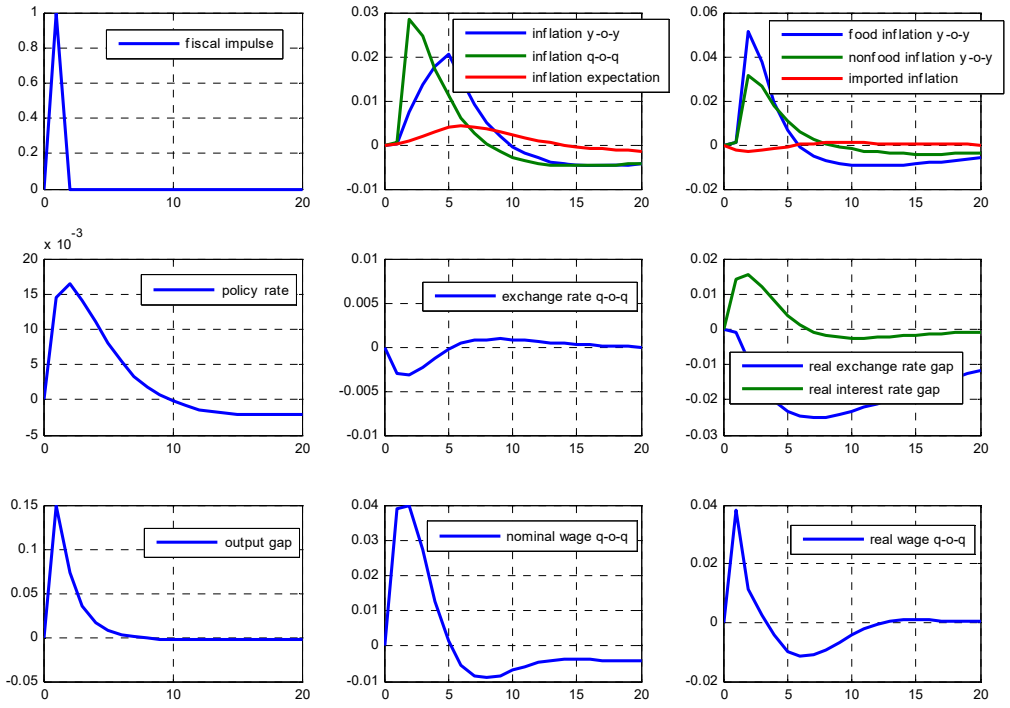
(4) Restrictive fiscal policy after expiration of anti-pandemic measures.

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)**

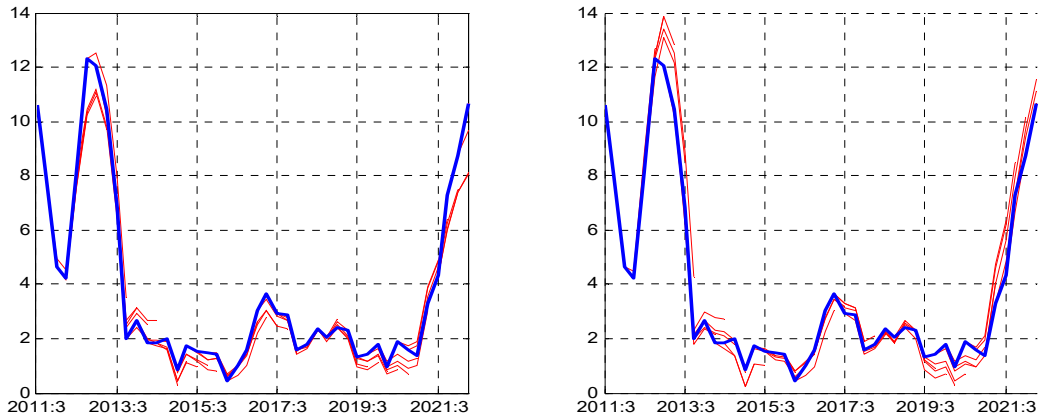


Table 5 **Forecast error statistics**

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

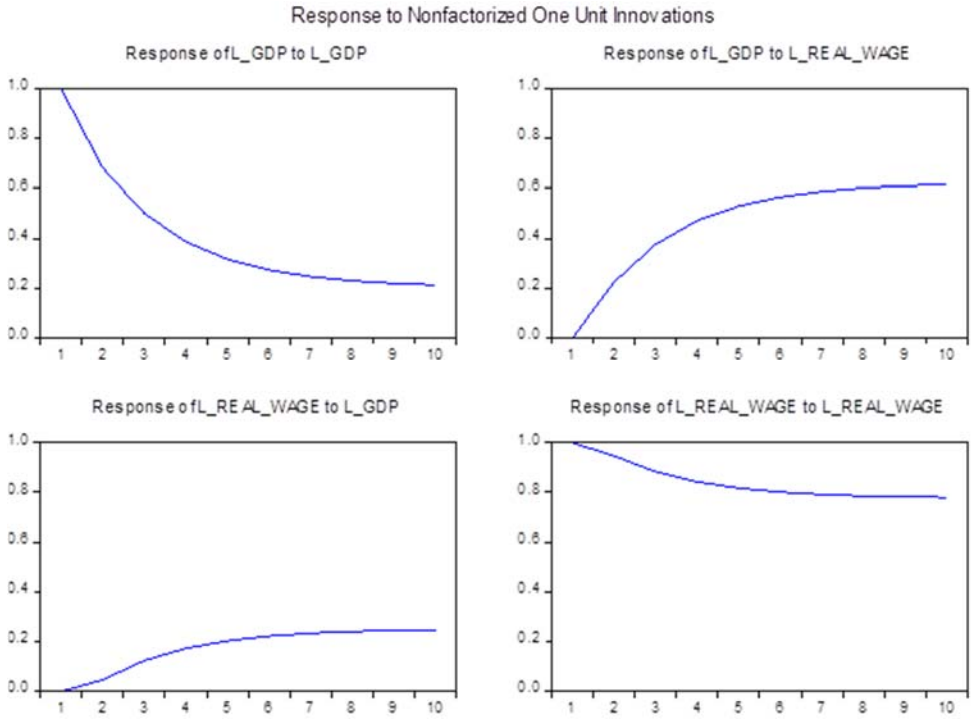
Lag	LogL	LR	FPE	AIC	SC	HQ
0	-324.8234	NA	778.3785	12.33296	12.40731	12.36155
1	-203.8651	228.2232*	9.430275*	7.919437*	8.142489*	8.005212*
2	-203.4840	0.690210	10.81974	8.056001	8.427754	8.198960
3	-200.9625	4.376988	11.46321	8.111793	8.632247	8.311934
4	-199.5412	2.359970	12.67955	8.209100	8.878256	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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ASSESSMENT OF INFLATIONARY PRESSURES USING NEWSPAPER TEXT ANALYSIS

Mirko Đukić

Available at www.nbs.rs

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

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Assessment of inflationary pressures using newspaper text analysis

Mirko Đukić

Abstract: In this paper we present the results of a dictionary-based text analysis of articles from the economic sections of four Serbian daily newspapers, caried out to estimate if those articles contain useful information for assessing inflationary pressures. We analyzed 117,113 economic articles in total for the period 2007–2022, by counting terms related to inflation and price rises and price falls, or counting texts containing those terms. Measures of newspaper inflation sentiment, obtained in this way, were found to be highly correlated with inflation, mainly driven by the periods of large inflation swings. During the period of stable inflation, the correlation is significantly lower. Causal relationship clearly goes from the newspaper inflation sentiment to inflation, and simple inflation models with the sentiment as an explanatory variable beat benchmark AR model in the out-of-sample forecast. We conclude that newspaper inflation sentiment can be used as an indicator of inflationary pressures, especially during periods of high inflation volatility**.**

Key words: inflation forecasting, text analysis.
JEL Code: C13, C55, E31, E37, E52.

Non-technical summary

Newspapers in Serbia often discuss various topics related to prices and inflation. In this paper we use this textual data to measure newspaper inflation sentiment and check if it can be used as an indicator of inflationary pressures.

We analyzed articles from the economic sections of four Serbian daily newspapers for the period between the beginning of 2007 and June 2022. The sample consists of 117,113 articles, or roughly 650 per month on average.

We quantified the articles using a dictionary-based approach, to obtain measures of inflation sentiment. We first predefined the lists of terms, one related to price rises and the other to price falls, then counted them across months and put those counts in relation to the total number of words in the corresponding months. We also used the so-called Boolean search, in which we counted the number of articles per month that contain at least one of the terms from the lists (in relation to the total number of texts). While the term count measures the intensity of price talk, the text count measures its frequency.

We found measures of inflationary sentiment to be strongly correlated with inflation over the full sample. This is mainly driven by the co-movement during inflation upswings to double-digit figures, preceded with a pick-up in inflationary sentiment in the newspapers. In all of the four such cycles, price-rise related terms jumped over 2.5‰ of total words, while during periods of low inflation they typically stayed below 1‰. During the period of low and stable inflation (mid-2013 to mid-2021), however, the correlation between inflation and inflationary sentiment drops significantly.

Causality between inflation and inflationary sentiment could in principle go both ways, as newspapers write about both past inflation, as well as price changes that will eventually be reflected in inflation. Granger causality test suggests that in all the combinations of inflationary sentiment and CPI, causality goes from the former to the latter, although in some cases it goes both ways.

We also found that a simple inflation model with inflationary sentiment performs better than the benchmark AR model when it comes to out-of-sample forecasting.

Taking everything into account, we concluded that newspaper inflation sentiment can be used as an indicator of inflationary pressures, especially during periods of high inflation volatility, while during stable times it may not perform that well.

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1 Introduction

At the time of writing this paper, global inflation is surging to levels not seen in decades, surprising monetary policy makers month after month. Could central banks have been more prepared for this shock had they given more importance to what newspapers were writing? In this paper we find that, in the case of Serbia, newspaper articles do indeed contain useful information for assesing inflationary pressures, especially during unstable times.

A large number of texts available online – such as newspaper articles, statements, blogs, social media posts, and so on – discuss economic developments in some form. Economic researchers are showing growing interest in exploiting this abundance of textual data for various kinds of analysis, like nowcasting and forecasting economic indicators, or creating measures of some economic concepts that are otherwise not measured well.

Textual analysis typically involves turning texts, as qualitative data, into a numerical measure, using some kind of method – from simple word count to sophisticated machine learning models – and estimating its relationship with observed economic variables. As texts are high-frequency data, correlation with an economic variable can be used to assess current economic trends before the actual data is published.

The early example of using text analysis dates back to 1933, when Cowles classified articles of a specific Wall Street Journal editorial as “bullish”, “bearish”, and “doubtful”, and found that it provided no useful information for forecasting stock prices. On the other hand, in his famous 2007 paper, Tetlock used the psychological Harvard IV-4 dictionary to give articles from a Wall Street Journal column a sentiment score and found it to be a good predictor of one-day-ahead stock market movements. Some researchers (Lucca and Trebbi (2009), Born et al. (2014), Hansen et. al (2018)) studied central bank communication in various ways and found that its sentiment does affect financial markets. Another famous example of text analysis is Baker et al (2016) who counted articles containing at least one word from three categories (“economy”, “policy” and “uncertainty”), and found that such measure of policy uncertainty is a predictor of investment, employment, and production.

Moving closer to our topic, a number of papers examine links between texts and inflation expectations. Carroll (2003), using simple epidemiological model, finds that during periods of intense news coverage of inflation, household expectations adjust more quickly to the expectations of professional forecasters than in the periods of low intensity of inflation-related news. Some papers deal with asymmetry in that respect: Lamla et al. (2012) find that news content sometimes induces bias, overexaggerating negative news, leading to overreaction in inflation expectations; while Drager (2015) finds that only media reports with negative news significantly affect inflation expectations. Larsen et al. (2021) find that news coverage of certain topics, some seemingly unrelated to inflation, have a high predictive power for consumers’ inflation expectations. Some researchers, like Angelico et al. (2021) analyze social media posts. They created a Twitter-based daily measure of inflation expectations (by combining Latent Dirichlet Allocation (LDA) with a dictionary-based approach) and find it to be highly correlated with conventional measures of inflation expectations.

Surprisingly, not many researchers tried to establish a direct link between texts and inflation itself, which is the very topic of our paper. One of the examples is Rambaccussing et

al. (2020), who found no evidence that economic policy content in the UK media improves short-term forecast of inflation (as opposed to unemployment and output). On the other hand, Kalamara et al. (2021), by combining counts of terms with supervised machine learning, did find that newspaper articles improve forecast for UK inflation, as well as output and unemployment.

In our paper, we focus on estimating the relationship between newspaper articles and inflation in Serbia. We don't look at inflation expectations because for Serbia it is a survey-based measure, influenced by the current inflation rate, not the other way around, which will be presented later in the paper. We also believe that for practical, policy support purposes, it is more useful to have a model that forecasts inflation directly, rather than indirectly, through expectations.

The link between newspaper texts and inflation comes from the simple fact that in the periods of more frequent and intensive price changes, newspapers write about it more, i.e. what is relevant for our analysis, they use more words related to price changes. These can be mentions of past price changes, or the ones that are about to happen. It is worth noting that prices are a frequent topic in Serbian newspapers. In our sample, 22% of articles from economic sections mention inflation or price changes in some way at least once, and as we will see later on, this topic is more frequently discussed in the periods of high inflation.

We analyzed articles from four Serbian daily newspapers for the period between the beginning of 2007 and June 2022, using a dictionary-based approach and the Boolean search. Concretely, we predefined the list of terms related to price rises and price falls, counted them across the articles, and put those numbers in relation to the total number of words in the corresponding articles. The Boolean search in our case consists of counting the articles that contain at least one word from the lists (relative to the total number of articles in the corresponding months). While the text count (Boolean search) measures how often newspapers talk about prices, the term count measures how intensely prices are discussed.

This way we created monthly series of various measures of newspaper inflation sentiment (NIS): price-rise (related) terms, difference between price-rise and price-fall related terms, price-rise related articles, difference between price-rise and price-fall related articles, as well as HP-smoothed versions of the first two series.

The fact that dictionary-based and Boolean methods take predefined list of terms for search makes them simple to use, but this is sometimes taken as their weakness, as other words are completely ignored[1] (unlike some more complex machine learning methods). We believe, however, that terms related to price changes in both directions are easily identifiable, especially in the Serbian language, making dictionary methods suitable for this kind of analysis. Also, the dictionary approach is more suitable if we want to measure the intensity of the sentiment, and not just clasify texts into topics, for which supervised machine learning techniques can be more appropriate. For instance, Angelico et al. (2021) use LDA to "reduce the noise", that is to extract inflation related tweets, but then use dictionary approach to count terms related to price increases and price declines. In our case, we already reduced the noise

[1] Bholat et al. (2015)

by selecting only economic articles, thus there was no need for machine learning for this purpose.

In the final stage, we looked at the relationship between these various measures of NIS and CPI inflation (y-o-y and m-o-m seasonally adjusted). We found the two classes of series to be highly correlated over the full sample, but not during periods of stable inflation. The high correlation for the full sample is driven by the periods of inflation upswing accompanied by or preceded with a significant increase in the inflationary sentiment in the newspapers.

Granger causality test suggests that in all the combinations of NIS and CPI, causality goes from the former to the latter, although in some cases it goes in both directions. This was important to investigate as newspapers could write about past inflation, and ongoing and future price changes that will eventually be reflected in the inflation figures.

Most models with NIS beat benchmark AR models in out-of-sample forecasts. The ones with the lowest RMSE in the very short term were the model with m-o-m inflation and difference between price-rise and price-fall terms, for nowcast, and the model with HP-smoothed version of the same series, for one month ahead. Also, including NIS in the existing inflation model yields a statistically significant coefficient for the variable of interest, and improves the fit of the model.

It is important to note that the term count outperforms the text count in both correlations and forecasting performance, meaning the intensity of price talk matters for inflation more than its frequency.

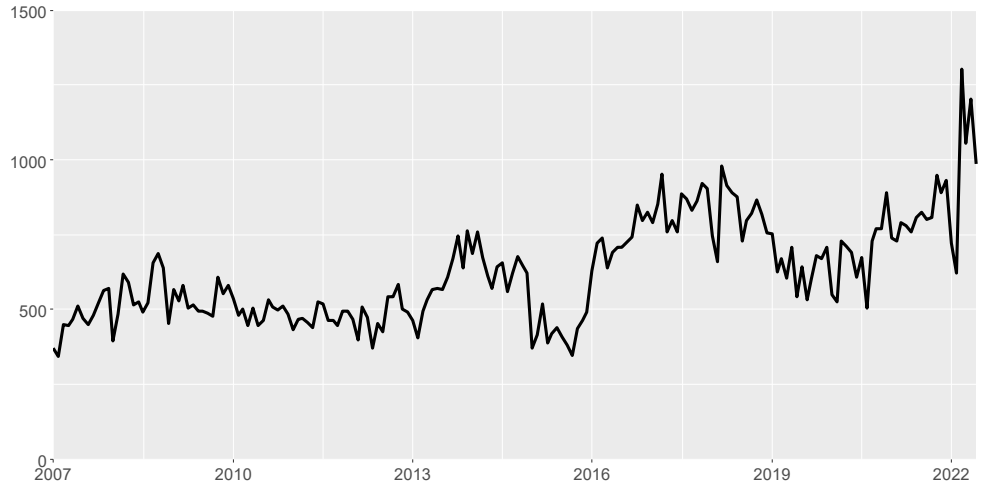
Taking everything into account, we concluded that the newspaper inflation sentiment can be used as an indicator of inflationary pressures, with a caveat that it may not perform well during stable times, but rather act as a predictor of large inflation swings.

The paper is structured as follows. First, we present the database of newspaper articles analyzed in the paper. After that we explain the methods used in the text analysis to construct time series of the newspaper inflation sentiment. Finally, we present the results of the estimation of the relationship between NIS and inflation.

2 The database of newspaper articles

The first, most challenging and time-consuming step in our analysis was to create the database of economic articles to be analyzed. We included four Serbian newspapers in the database with sufficiently long history to be exploited for this kind of analysis (see Appendix for details). We downloaded the articles using Rvest package within R software, which was also used for the text analysis in the next stage. The sample covers the period between January 2007 and June 2022, with the exception of one of the newspapers, which have available articles since March 2008. Articles were downloaded directly from available archives on their websites, or indirectly, through other websites that collect news from various sources. The final database analyzed here consisted of 117,113 articles (roughly 650 per month on average) from the economic sections of these newspapers.

Chart 1 **Number of economic newspaper articles in the sample by months**



We restricted our analysis to articles from economic sections as classified by the newspapers, for several reasons. One is that including all the articles could add a lot of noise to the series, as occasional big events, such as the covid-19 pandemic, could overshadow other topics, including the ones about inflation. Also, there are words, like “crises” or “depression”, which could have both economic and non-economic meaning. Restricting our analysis only to economic articles would reduce possible mistakes in that respect, although with the terms in our specific analysis that wouldn’t be a big issue.

Figure 1 **Word cloud of economic articles of four Serbian daily newspapers**

In the whole sample, there are over 600,000 different words, out of which we are interested in only a tiny fraction. The word cloud (Figure 1) is a common way of graphically presenting the most common words in the text (the higher the frequency, the larger the font).

Before analyzing, the texts were pre-processed to leave out words that are not directly part of the article (such as "copyrights…", "BONUS video…", and so on). Once this cleaning was done, the articles were ready for the analysis.

3 Text analysis – measuring newspaper inflation sentiment

The text analysis was caried out using a dictionary-based approach, meaning that in the articles we searched for predefined specific Serbian terms related to price rises, on the one hand, and terms related to price falls, on the other hand. A term for the search in this paper is defined as a part of a word ("poskup"), or a shortened phrase ("rast cen"). The algorithm will count any word or a group of words that contain the searched terms.

A term for the search is ideally defined as a part of various types of a desired word. For instance, term "poskup" will pick up nouns in single and plural, in various case forms ("poskupljenje", "poskupljenja", "poskupljenju",…)[2], as well as verbs in different genders and tenses ("poskupeti", "poskupeo", "poskupela", "poskupljuje"…). What is also important is that this term cannot be a part of a word unrelated to prices. When it comes to phrases, the situation is a bit more complex, as only the last word can be defined in a shortened form, whereas for the first one it is necessary to predefine various types of a word ("*rast/rasta/rastu/rastom*"). Table 1 shows the lists of terms that we included in the count.

Table 1 **Lists of terms related to price rises and price falls (in Serbian)**

Searched terms related to price rises	Searched terms related to price falls
poskup	*pojeft*
skuplj	*jeftinij*
rast/rasta/rastu/rastom cen	*pad/pada/padu cen*
povećanje/povećanje/povećanju cen	*sniženje/sniženja/sniženju cen*
viša/više/višoj cen	*niža/niže/nižoj/nižu cen*
visoka/visoke/visokim/visokoj cen	*niska/niske/niskim/niskoj cen*
skok/skoka/skoku/skokovi cen	*deflaci*
digao/digli/dižu/diže cen	*pad inflaci*
inflaci	

Note that we conducted case insensitive search, meaning we treated upper and lower case letters as being the same. Thus, there was no need to transform letters from upper to lower case in the previous stage, as it is often done in this kind of analysis.

The left column in the table 1 includes various combinations of words related to increases (rise, hike, jump, increase, high, higher, inflation) and prices, while the right column combines words related to falls (fall, reduce, decline, lower, low, deflation) and prices. As an example,

[2] "Poskupljenje" is a single Serbian word for a price rise.

in the short article from 2008, based on these predefined terms the algorythm counted 10 terms related to price rises (yellow), and 2 related to price falls (blue):

A litre of petrol to cost 101.6 dinars

Unless the global oil price falls within the next two days, petrol price will go up by 4 dinars, "Blic" found out. According to these estimates, a litre of unleaded petrol would be sold at the price of 101.6 dinars.

The forecast, according to which the price of oil will speed up once it crosses the magical figure of 100 dollars per barrel, is coming true. In recent days, the price of crude oil moved somewhat below its historical peak of 103.05 dollars per barrel (159 litres). Such a high price of the main energy commodity is mainly a result of the weakening of the dollar, but also expectations that members of the OPEC will not increase their daily production. Accordingly, in Serbia another price rise of petrol is expected by the end of this week. As Blic finds out, it is likely that the petrol price increase could amount to four dinars, with a possibility that, if the oil price jumps continue, this could be even stronger. Last price increase took place on 20th February, and the Ministry of Energy confirmed that another one could come on Friday morning.

"After this price increase, I think that within the next month we will not see major jumps in the prices in Serbia. Given that the price of crude oil is near its historical record, it is realistic to expect that in the near term it could go down. However, over the longer horizon, throughout this year oil price rises are expected" – said Nebojša Atanacković from "Oil".

The lower price could be achieved by reducing the excise tax, whichwas increased during the previous price hike. This tax is set by the Ministry of Finance, but, according to earlier statements, its reduction is not expected.

We are aware that this kind of count is not perfect. In this example it included two terms related to price falls, even though they are in conditionals "…unless the global oil price falls in the next two days, the price of petrol will go up by 4 dinars…"), at the same time failing to recognize phrase about price increase in the third sentence ("The forecast, according to which the price of oil will speed up …"). Despite that, we can say that the count clearly captures the inflationary sentiment of this article, and that, given the large number of texts in this analysis (over 650 per month), these occasional failings cannot change the overall tendency in the newspaper sentiment.

Another approach we used in this analysis is the Boolean search, which consists of counting articles that satisfy certain logical conditions, in our case – articles that contain any of the searched terms from Table 1. This approach is less sensitive to extreme values, but its disadvantage is that it neglects the intensity of term usage. Note that, using this approach, a single article can be counted as both price-rise related and price-fall related, as would be the case with the article in our example.

Finally, given that the raw series are quite noisy, we also used smoothed time series using HP-filter with the smallest possible smoothing parameter (lambda=1), just to get rid of the noisiest part of the series, while keeping the short-run fluctuations in the trend.

In total we define six **measures of newspaper inflation sentiment**:

- **Price-rise terms (PRT)**, as a ratio between price-rise term count (PRTC) and total number of words (w_m) in the corresponding months (m), per thousand:

$$\mathrm{PRT}_m = \frac{\mathrm{PRTC}_m}{w_m} \cdot 1000$$

- **Price-change terms (PCT)**, as a difference between PRTC and price-fall term count (PFTC) in relation to the total number of words in the corresponding months (per thousand):

$$\mathrm{PCT}_m = \frac{\mathrm{PRCT}_m - \mathrm{PFTC}_m}{w_m} \cdot 1000$$

- **Price-rise articles (PRA)**, as a ratio between counted price-rise related articles and the total number of articles (a_m) in the corresponding months (in %):

$$\mathrm{PRA}_m = \frac{\mathrm{PRAC}_m}{a_m} \cdot 100$$

- **Price-change articles (PCA)**, as a difference between PRAC and price-fall articles count (PFAC) in relation to the total number of articles in the corresponding months (in %):

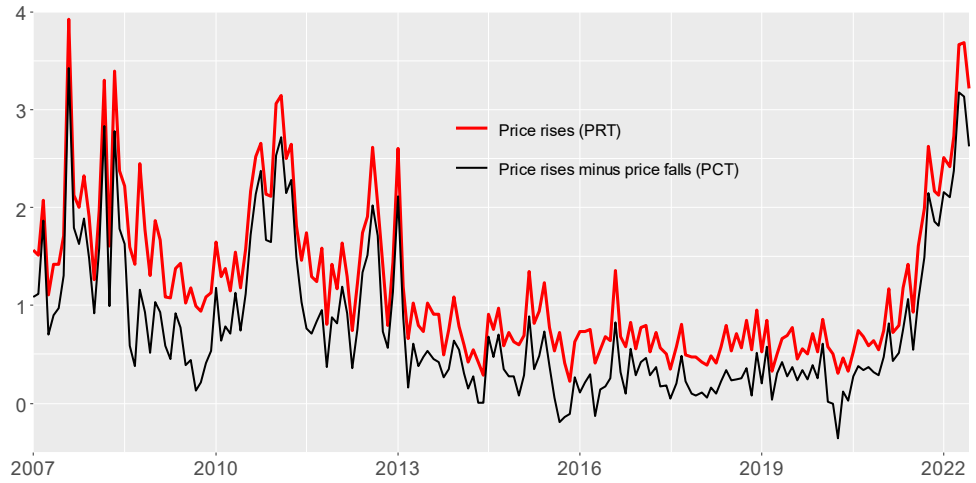
$$\mathrm{PCA}_m = \frac{\mathrm{PCA}_m - \mathrm{PRAC}_m}{a_m} \cdot 100$$

- **Price-rise terms – smoothed (PRT-HP)**, as an HP-filter of PRT, with smoothing parameter lambda = 1, and

- **Price-change terms – smoothed (PCT-HP)**, as an HP-filter of PCT, with smoothing parameter lambda = 1.

The next chart shows term-count measures, PRT and PCT. The latter can take negative values as in some periods the words related to price falls exceed those related to price rises.

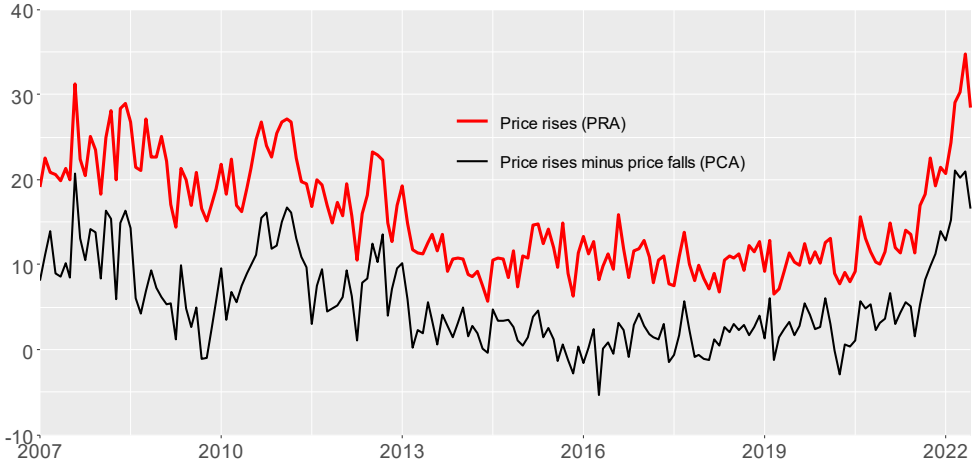
Chart 2 **Newspaper inflation sentiment based on term count** (share of total monthly number of words, in ‰)



Although these time series are very noisy, one can clearly observe four major cycles in the inflationary sentiment during the analyzed period. Both series peak in 2008, 2010, 2012, and 2022, at over 2.5‰ in case of PRT, and 2‰ in case of the PCT. In the period 2013-2021 the series were rather stable, most of the time between 0 and 1 per thousand.

When it comes to the article count, we can also observe four major cycles, although less pronounced than in the case of the term count. The share of articles with at least one mention of a price increase varies between 10% of total in stable times, to 25–30% at its peaks. The series of differences peaks at around 15%, while mostly hovering between 0–5% in stable times (2013–2021).

Chart 3 **Newspaper inflation sentiment based on text count** (as a share of total monthly number of articles, in %)

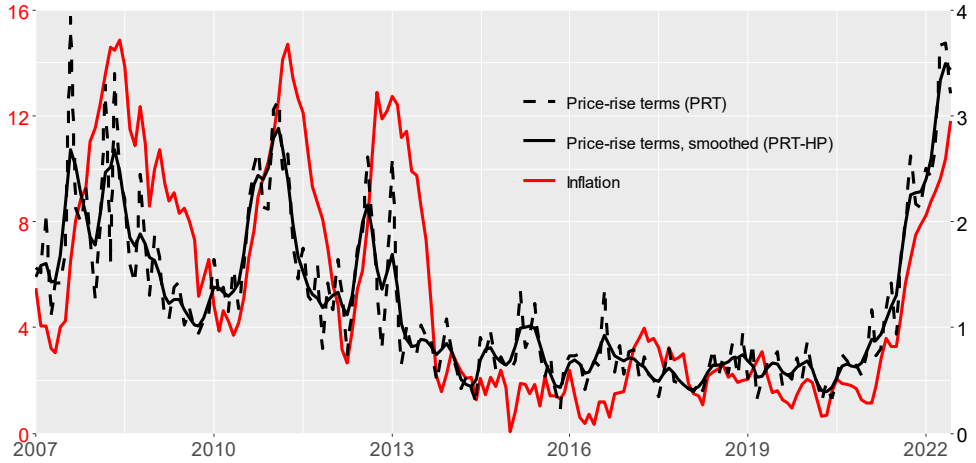


4 Relationship between newspaper inflation sentiment and inflation

There are multiple ways in which the frequency of price-related terms and articles could be related to inflation itself. For instance, a rise in inflation, once it's published, could trigger increased media interest in inflation figures and individual price changes that drove the rise. On the other hand, newspapers could be writing about ongoing and future price changes that will eventually be reflected in the inflation figures. Another option is that inflationary sentiment in the newspapers is a reflection of inflation expectations that are themselves a driver of inflation movements.

Chart 4 shows that the time series of price-rise related terms, despite being very noisy, is clearly related to inflation. (For relationship between inflation and other measures of NIS see Appendix).

Chart 4 **Inflation and newspaper inflation sentiment**



Inflation in the observed period had four major upswings, with double-digit peaks in 2008, 2011, 2012, and 2022. All these inflation cycles were accompanied by or preceeded with a significant increase in the frequency of price-rise related terms in the newspapers to over 2.5 per thousand words.

Also, during the eight-year period of inflation stability (mid-2013 to mid-2021), PRT remained comparably low, never exceeding 1.5‰, although it seems that during that period the two series occasionally diverged. Like, for instance, in 2015 when the newspaper mentions of price-rises was not followed by the inflation pick-up, or in early 2017 when the newspapers failed to predict a rise in inflation.

We also checked how measures of NIS correlate with the seasonally adjusted monthly inflation rate. In this case, the analyzed series would be fully consistent – monthly price increase with monthly term count.

Here, it's worth noting that all of the term-count series do not have seasonality, so there was no need to seasonally adjust them. Also, all of the inflationary sentiment measures, as well as two inflation series are stationary, according to Dickey-Fuller test.

Table 2 shows statistically significant correlations in all the cases over the full sample. The most strongly correlated series are y-o-y inflation and smoothed series of PRT on the 4th lag. Measures of inflation sentiment show somewhat weaker correlations with the monthly measure of inflation.

Table 2 **Peak correlations between measures of NIS and inflation for the period 2007–2022** (lags in brackets)

	terms		terms smoothed		articles	
	PRT	PCT	PRT-HP	PCT-HP	PRA	PCA
y-o-y inflation	0.75 (2)	0.71 (3)	0.86 (4)	0.83 (4)	0.76 (3)	0.72 (4)
m-o-m inflation s.a.	0.64 (0)	0.62 (0)	0.62 (0)	0.62 (0)	0.58 (0)	0.55 (0)

In line with our visual inspection, over the period of stable inflation (mid-2013 – mid-2021) correlations are much weaker (Table 3). In this case, monthly inflation rates show somewhat stronger correlation with the measures of inflationary sentiment.

Table 3 **Peak correlations between measures of NIS and inflation for the period mid-2013 – mid-2021** (lags in brackets)

	terms		terms smoothed		articles	
	PRT	PCT	PRT-HP	PCT-HP	PRA	PCA
y-o-y inflation	0.22 (0)	0.26 (0)	0.23 (0)	0.26 (0)	0.14 (0)	0.23 (3)
m-o-m inflation s.a.	0.30 (0)	0.37 (0)	0.25 (0)	0.31 (0)	0.22 (5)	0.17 (0)

Here, it's important to note that the inflation figures in Serbia are published on the 12th day of a month for the previous month, so even if the correlations are only contemporaneous (with no lags), we can say that inflationary sentiment measures precede inflation figures, and therefore hold some predictive power.

However, before drawing such a conclusion, we need to establish the direction of the causality. Based on the Granger causality test (Table 4), measures of inflationary sentiment cause inflation in all the combinations, with causality going both ways in some of the cases. (See Appendix for detailed results).

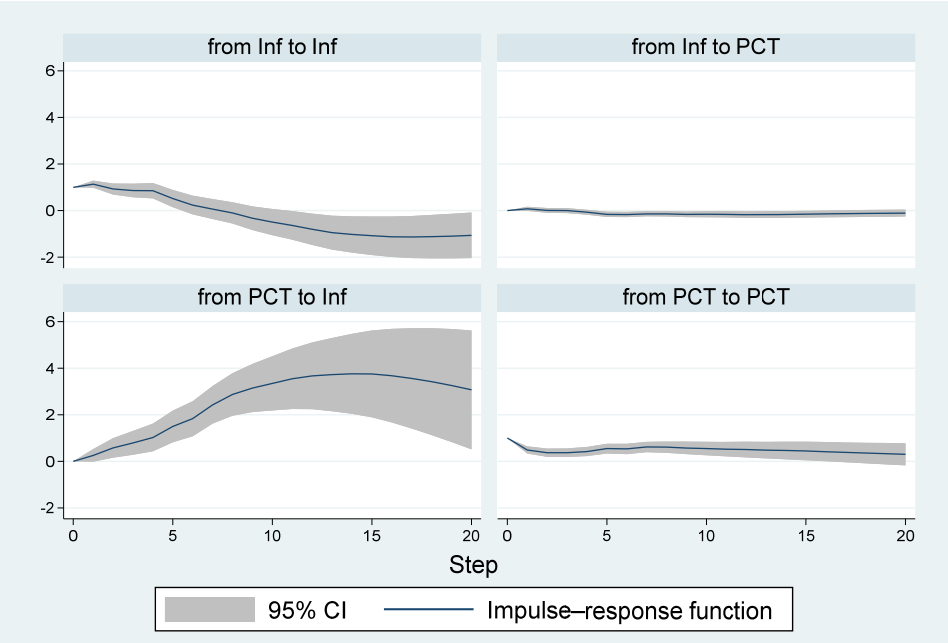
Table 4 **Direction of Granger causality between measures of NIS and inflation*** (full sample)

	terms		terms smoothed		articles	
	PRT	PCT	PRT-HP	PCT-HP	PRA	PCA
y-o-y inflation	☑↗	☑	☑↗	☑↗	☑	☑↗
m-o-m inflation s.a.	☑	☑	☑↗	☑↗	☑	☑

*☑ means causality from inflationary sentiment to inflation, ↗ the other way around, while – means no Granger causality in either direction

Impulse response function from a VAR(7) model with inflation and PCT is a nice illustration of the relationship. As shown on Chart 5, inflation clearly reacts to inflationary sentiment in newspapers. The peak response of inflation to a 1‰ increase in PCT is 4%, which is roughly in line with observations on Chart 2 (increase in PRT from 0–0.5‰ to 2–3‰ is followed by inflation pick-up by 8-10%, from trough to peak).

Chart 5 **Impulse response from a VAR model with y-o-y inflation and PCT**

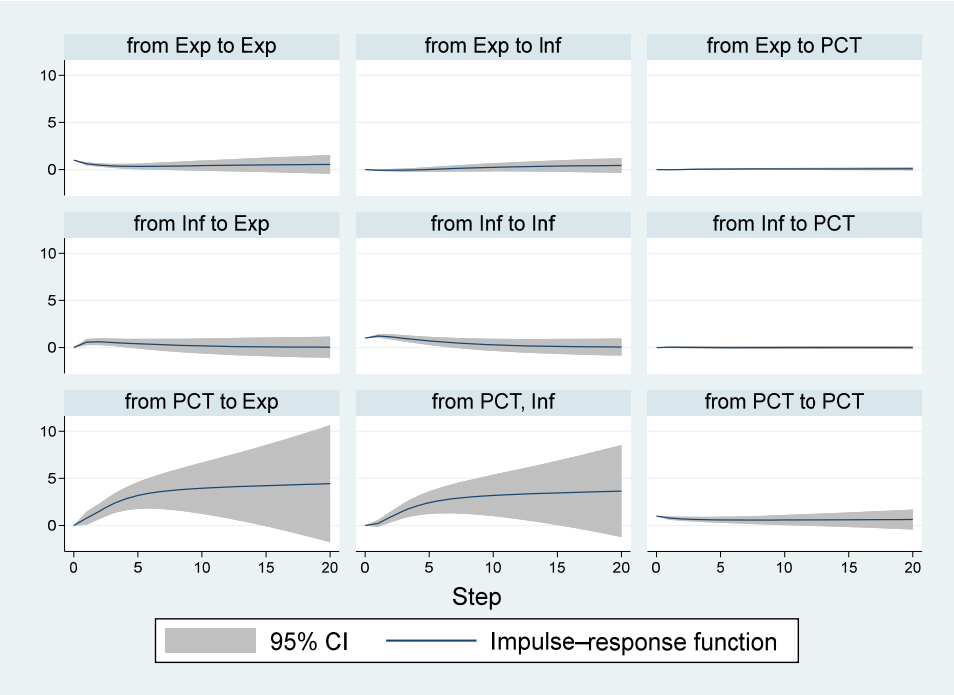


So far, we have concluded that inflationary sentiment is a leading indicator of inflation. But what could be the reason behind such a relationship? Is it that newspaper reports on ongoing and future price changes are eventually reflected in inflation figures; or could it be that these reports reflect inflation expectations, which are themselves a factor of inflation?

If the latter was the case, we should see inflation expectations causing inflation. However, Granger causality test tells a different story, showing that inflation expectations are Granger-caused by inflation itself, and not the other way around (Appendix).

Impulse response function from a VAR(2) model with inflation, PCT and household inflation expectations (Exp) show that inflation expectations react to PCT, as well as to inflation itself. We can also observe that the inclusion of expectations in the model, doesn't change our conclusion that PCT causes inflation, and not the other way around (Chart 6).

Chart 6 **Impulse response from a VAR model with y-o-y inflation, PCT, and inflation expectations**



Now, could we exploit this relationship for inflation forecasts? To make a verdict, we did a standard out-of-sample forecast exercise with models including various inflationary sentiment measures and two inflation measures, comparing them to AR(1) models for y-o-y and m-o-m s.a. inflation (Table 5). We tested VAR(2) models, as well two-equation models, where one is linking inflation to various NIS measures, and the other one being an AR(2) equation for NIS:

$$\mathrm{Inf}_m = \alpha_1 \cdot \mathrm{Inf}_{m-1} + \alpha_2 \cdot \mathrm{NIS}_{m-1} + \varepsilon_m$$

$$\mathrm{NIS}_m = \beta_1 \cdot \mathrm{NIS}_{m-1} + \beta_2 \cdot \mathrm{NIS}_{m-2} + \gamma_m$$

To make it comparable to simulations with y-o-y inflation, in case of m-o-m inflation we calculate RMSE for cumulative forecasting errors. See Appendix for details.

The RMSEs of various models are shown in Table 5.

Table 5 **Out-of-sample RMSE for different inflation models with NIS measures (leads in columns)**

	nowcast	1	2	3	4	5	6
Modes with y-o-y inflation							
AR(1) - benchmark	0.613	0.613	0.929	1.172	1.384	1.556	1.739
PRT model	0.567	0.549	0.770	0.958	1.145	1.307	1.516
PCT model	0.558	0.548	0.770	0.968	1.160	1.303	1.499
PRA model	0.582	0.569	0.843	1.062	1.253	1.411	1.574
PCA model	0.601	0.563	0.824	1.054	1.249	1.414	1.609
PRT VAR	NA	0.662	1.007	1.286	1.583	1.893	2.194

	nowcast	1	2	3	4	5	6
Modes with y-o-y inflation							
PCT VAR	NA	0.658	0.994	1.275	1.576	1.880	2.189
PRT-HP model	0.593	0.654	0.963	1.204	1.447	1.583	1.742
PCT-HP model	0.586	0.641	0.956	1.240	1.520	1.652	1.804
Modes with m-o-m inflation							
AR(1) - benchmark	0.396	0.396	0.699	1.016	1.345	1.649	1.969
PRT model	0.324	0.338	0.522	0.704	0.890	1.048	1.258
PCT model	0.322	0.342	0.540	0.748	0.960	1.141	1.372
PRA model	0.334	0.338	0.527	0.712	0.879	1.004	1.188
PCA model	0.347	0.342	0.546	0.766	0.974	1.156	1.400
PRT VAR	NA	0.350	0.552	0.764	0.986	1.176	1.413
PCT VAR	NA	0.346	0.536	0.728	0.932	1.111	1.336
PRT-HP model	0.329	0.262	0.413	0.582	0.763	0.891	1.057
PCT-HP model	0.328	0.256	0.422	0.629	0.830	0.969	1.153

We can see that the models with NIS improve forecasting performance relative to benchmark AR(1) models in almost all the cases, with the exception of VAR models with y-o-y inflation. Models with monthly inflation perform better than the ones with y-o-y inflation. The lowest RMSE is achieved for models linking monthly inflation to some of the term count measures: PCT for nowcast, PCT-HP for one lag, and PRT beyond the 1st lag.

The reason we used ARs as benchmark models is that the NBS short-term inflation forecasts are made on disaggregated inflation data, as a combination of model-based approach (for some components), judgement and external information on various price changes. There is an NBS medium-term projection model described in Đukić, Momčilović, Trajčev (2010), but we don't have an ambition to use newspaper sentiment for the medium-term forecasts.

Finally, we checked if NIS brings some additional information to models with usual factors of inflation. For that purpose we used ARDL model for the headline inflation in Serbia from Ivković, Jakovljević, Miletić (2022), that includes euro area inflation, agricultural product prices, wages and exchange rate as explanatory variables. In that model we introduced PCT as another variable, and found that it is statistically significant, both in the short and long run (Table 6). Therefore, we can say that NIS holds explanatory power of inflation, even when we control for main factors of inflation. As this is a single equation model, it cannot be used for forecasting purposes, so that's why we didn't use it as a benchmark model in the out-of-sample forecast exercise.

Table 6 **Estimated results of the ARDL inflation model**

Conditional Error Correction Regression

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.632643	0.375823	-1.683354	0.0991
LOG(PRICES_SA(-1))*	-0.082318	0.027850	-2.955764	0.0049
LOG(EA_PRICES_SA)**	0.199081	0.135368	1.470666	0.1482
LOG(AGRIC_PRICES)**	-0.003742	0.008988	-0.416369	0.6791
LOG(WAGES_SA(-1))	0.018141	0.020716	0.875701	0.3857
LOG(NEER)**	-0.011635	0.021442	-0.542639	0.5900
PCT**	0.016931	0.002373	7.133902	0.0000
DLOG(WAGES_SA)	-0.193639	0.062357	-3.105336	0.0033
VES2012Q4	0.035339	0.005320	6.642341	0.0000

* p-value incompatible with t-Bounds distribution.
** Variable interpreted as Z = Z(-1) + D(Z).

Levels Equation
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(EA_PRICES_SA)	2.418436	1.214257	1.991700	0.0524
LOG(AGRIC_PRICES)	-0.045461	0.137099	-0.331593	0.7417
LOG(WAGES_SA)	0.220374	0.257840	0.854692	0.3972
LOG(NEER)	-0.141345	0.321418	-0.439756	0.6622
PCT	0.205681	0.097416	2.111374	0.0402
C	-7.685328	2.595410	-2.961123	0.0048

EC = LOG(PRICES_SA) - (2.4184*LOG(EA_PRICES_SA) -0.0455
*LOG(AGRIC_PRICES) + 0.2204*LOG(WAGES_SA) -0.1413*LOG(NEER)
+ 0.2057*RAZLIKA -7.6853)

F-Bounds Test — Null Hypothesis: No levels relationship

Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	37.18888	10%	2.08	3
k	5	5%	2.39	3.38
		2.5%	2.7	3.73
		1%	3.06	4.15
			Finite Sample: n=55	
Actual Sample Size	55			
		10%	2.226	3.241
		5%	2.617	3.743
		1%	3.543	4.839

5 Conclusion

The purpose of the analysis presented in this paper was to investigate if newspaper articles in Serbia contain information that could be used as an indicator of inflationary pressures. We found that they indeed do.

The text analysis was carried out by applying a dictionary-based approach and Boolean search on four Serbian newspapers, for the period between the beginning of 2007 to June 2022. We first predefined two lists of terms for the search – one related to price rises, and the other one related to price falls – then we counted those terms, as well as articles containing at least one of the terms from the lists, by months. Using that information, we created several measures of newspaper inflation sentiment: price-rise terms, price-change terms, price-rise articles, price-change articles, HP-smoothed price-rise terms, and HP-smoothed price-change terms.

These measures were found to be highly correlated with inflation over the full sample. The correlation is stronger with y-o-y inflation with a certain lag (around 0.8), than with m-o-m inflation (around 0.6). The relationship between inflation and the sentiment is striking during periods of high inflation volatility. For instance, in all four cycles when inflation exceeded 10%, price-rise related terms jumped over 2.5‰ of total words, while during periods of low inflation they tipically remained below 1‰. On the other hand, during stable times this link seems to be much weaker. Thus, restricting the sample to the period of low and stable inflation (mid-2013 to mid-2021), the correlation between NIS and inflation drops to 0.2–0.3, way lower than for the full sample.

It was also important to establish the direction of causality, which could in principle go both ways, as newspapers write about about both past inflation, as well as price changes that will eventually be reflected in inflation. Granger causality test suggests that in all the combinations of NIS and CPI, causality goes from the former to the latter, although in some cases it goes both ways. This suggests that NIS holds predictive power for inflation. Impulse response function from VAR model with price-rise terms and inflation suggests a one-way causal relationship, where a 1‰ jump in price-rise terms predicts a 4% rise in inflation. This is roughly in line with observations from Chart 4, where we can see that upswings in inflation of 8–10 percentage points were accompanied by jumps in price-rise related terms of 2–2.5‰.

A number of papers treat textual information as a reflection of inflation expectations, which themselves are a factor of inflation. For that reason, we investigated whether the causal relationship between the sentiment and inflation works through the expectations. This notion is disputed by the Granger causality test and VAR model with the sentiment, inflation and inflation expectations. Expextations were found to lag inflation movements, while the relationship between the sentiment and inflation doesn't change significantly after including expectations in the model. Therefore, we conclude that the main reason behind the causality is the information content in the newspapers about price changes that are eventually reflected in the inflation figures.

Next, we found that various combinations of NIS measures and the two inflation measures in most cases perform better against the benchmark AR inflation models when it comes to out-of-sample forecasts. Although correlations were stronger with the y-o-y inflation, the models with m-o-m inflation showed better forecasting performance. In the very short term, the best

performing models were the one with m-o-m inflation and difference between price-rise and price-fall terms, for nowcast, and the model with HP-smoothed version of the same series, for one month ahead.

It is worth noting that in each stage of the analysis, the term count measures outperformed the text count measures, meaning the intensity of price talk is more relevant than its frequency.

Finally, we included price-rise terms in a quarterly headline inflation model published in Ivković, Jakovljević and Miletić (2022) and found that the coefficient for NIS is statistically significant, even when most relevant factors of inflation are included in the model.

Taking everything said into account, we conclude that newspaper inflation sentiment is a good indicator of inflationary pressures, with a caveat that it may not be the case in stable times. Its usefulness may, therefore, come mainly in sounding alarm bells about possible major inflation upswings, such as the one observed globally since late 2021.

Appendix

Out-of-sample forecast

This exercise is used to check forecasting performance of the models on the history. We run forecasts with small inflation models with various measures of NIS (PRT, PCT, PRA, PCA, PRT-HP and PCT-HP), and autoregresive equations for NIS:

$\text{Inf}_m = \alpha_1 \cdot \text{Inf}_{m-1} + \alpha_2 \cdot \text{NIS}_{m-1} + \varepsilon_m$

$\text{NIS}_m = \beta_1 \cdot \text{NIS}_{m-1} + \beta_2 \cdot \text{NIS}_{m-2} + \gamma_m$

In this "horse-race" we also included VAR(2) models with Inf and NIS, while as a benchmark models we used AR(2) models for inflation.

We carried out the exercise in the usual manner: we first estimate models for the sample that ends at a certain moment in history (we begin with June 2014), forecast the inflation using that model for 0 to 6 months ahead, and then calculate the deviation of the forecast from the actual values of that variable for all the leads. We then extend the estimation sample month by month, and do the same excercise again, until we reach the last month in history. Finally, we calculate root-mean-squared error, as a root of average squared deviation of forecast to the actual values for all the samples, for 0 to 6 leads. RMSE for lead *l* would be calculated in the following way:

$$\text{RMSE}_l = \sqrt{\frac{\sum_{m=t+1}^{endhist} (\text{Inf}_{m+l}^{fcast} - \text{Inf}_{m+l})^2}{endhist - m}}$$

where t is the last period of the estimation sample, and endhist the last month of the full sample (June 2022).

When it comes to monthly inflation models, we cumulated the errors, thus making them comparable to y-o-y forecast errors:

$$\text{RMSE}_l = \sqrt{\frac{\sum_{m=t+1}^{endhist} (\sum_{i=1}^{l} (\text{Inf}_{m+i}^{fcast} - \text{Inf}_{m+\text{i}}))^2}{endhist - m}}$$

Here, it's important to explain how we calculated the nowcasting error (0 leads), since literally speaking it is not an out-of-sample forecast. We did it by forecasting one-period ahead inflation with actual, realized NIS measure for t+1 (which makes it out-of-sample). The idea is to simulate the situation at the end of a month where we have indicators of newspaper sentiment, but we still don't have the inflation figure for that month. This is different from out-of-sample forecast for one month ahead, where we run forecast not with an actual NIS, but with a model-based prediction.

Chart A1 **Inflation and indicators of newspaper inflation sentiment**

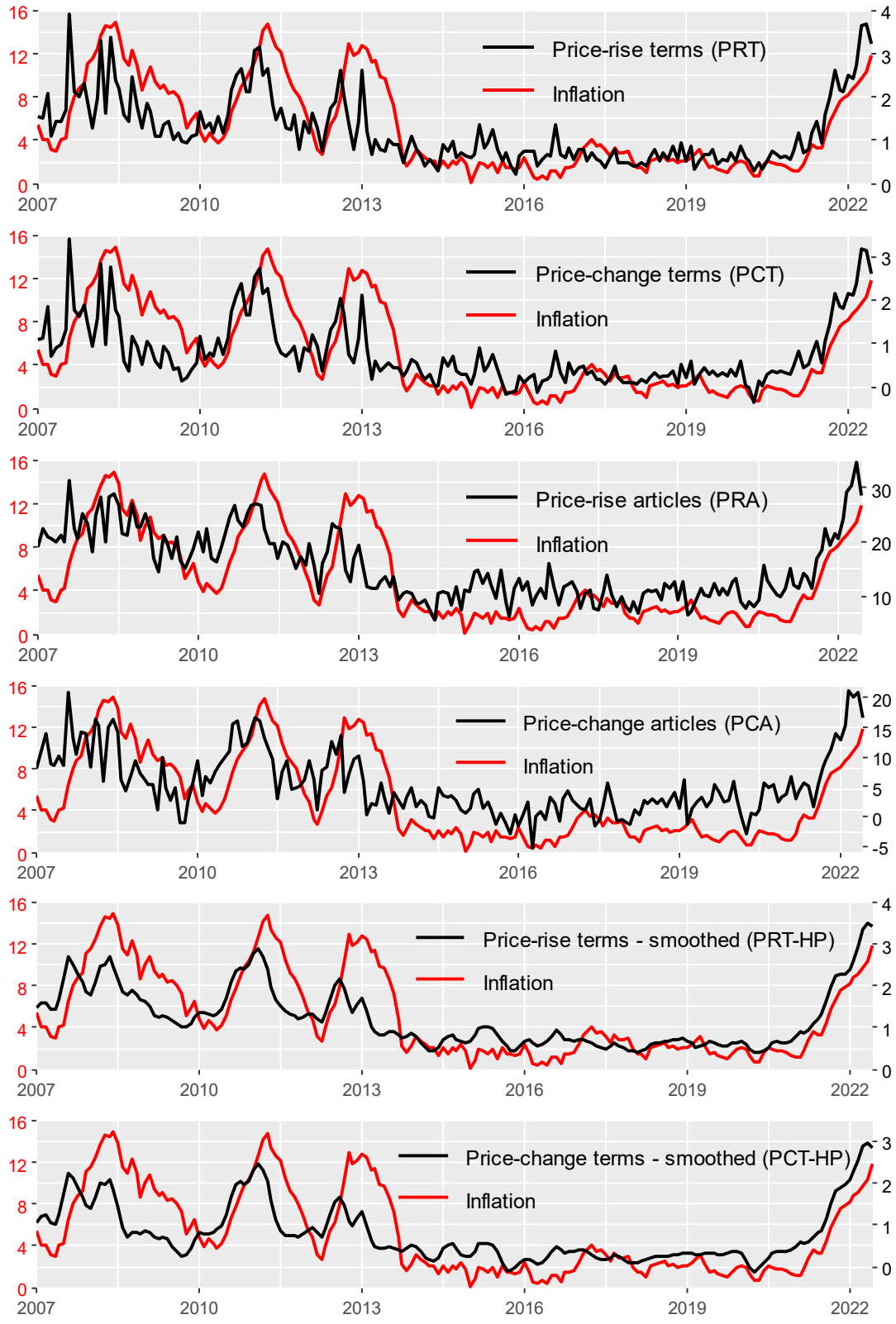


Chart A2 **Monthly inflation and indicators of newspaper inflation sentiment**

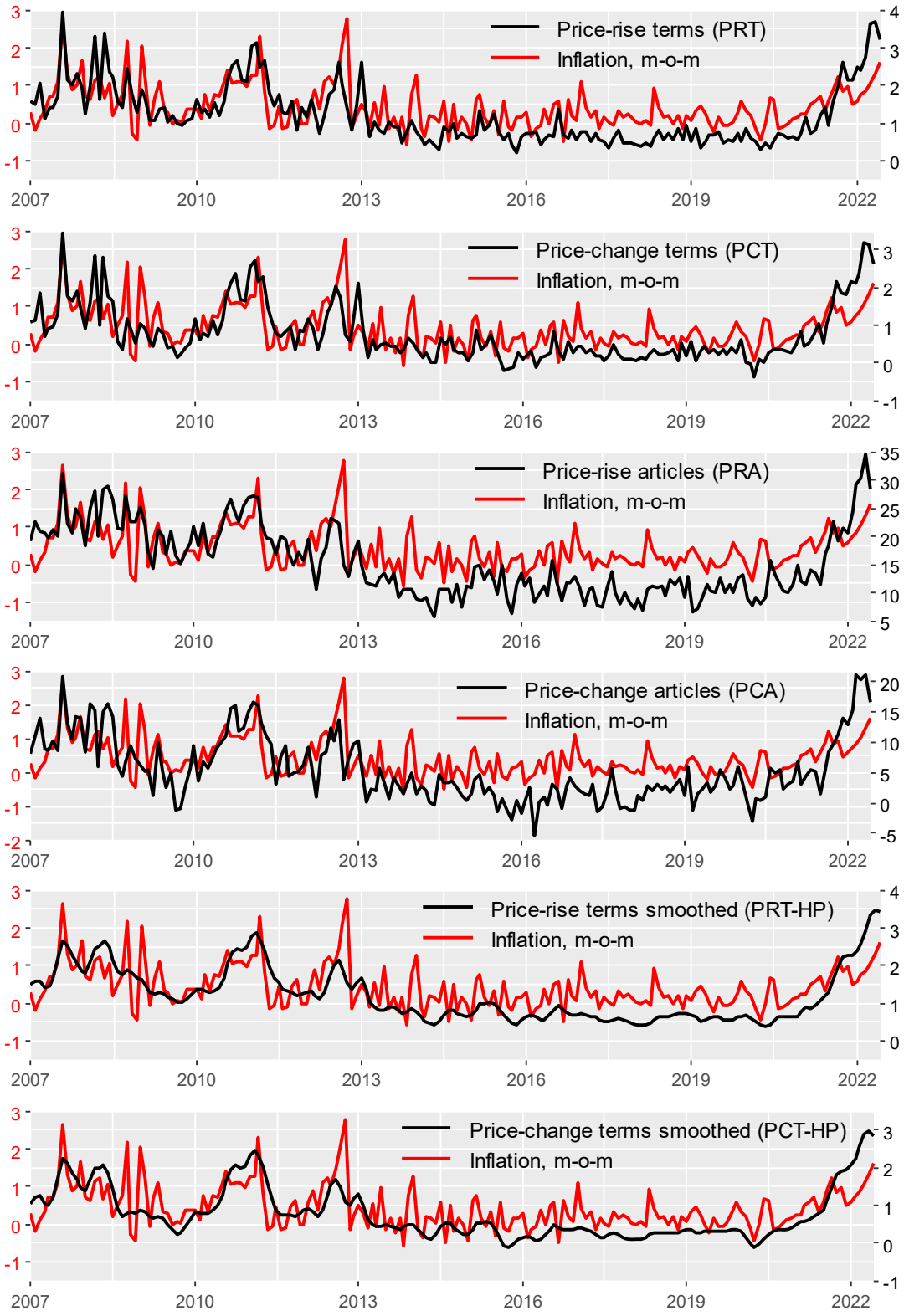


Table A1 **Granger causality between measures of NIS and inflation ** (full sample)**

	terms		terms smoothed		articles	
	PRT	PCT	PRT-HP	PCT-HP	PRA	PCA
y-o-y inflation	5.95017*	11.4523*	18.5593*	19.2880*	5.10133*	6.73472*
	3.04455*	0.98914	5.84182*	4.70734*	1.73623	2.56426*
m-o-m inflation s.a.	10.8278*	2.31504*	11.8014*	12.1729*	10.2410*	11.2649*
	2.31504	0.80398	5.08440*	3.90030*	2.36838	1.95995

* means statistical significance at the 5% level, meaning there is causality

** first term in the field is F statistics for causality from NIS to inflation, and second term the other way around

Table A2 **Granger causality test between inflation and inflation expectations**

From expectaions to inflation: F = 0.35442 (p=0.7023)
From inflation to expectaions: F = 15.1907* (p=0.0000)

The database of articles

The database includes four Serbian newspapers: Politika, Večernje Novosti, Danas and Blic. For three of them (Politika, Danas, and Blic), we found available articles since January 2007, while for Novosti the sample begins with March 2008. While some of the newspapers (Politika and Danas) have publicly available archives of articles on their websites, others (V. Novosti and Blic) don't, so we had to download their articles through other websites that collect news from various sources. We used only articles from economic sections.

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EUROPEAN GOVERNMENT GREEN BONDS: ANALYSIS OF YIELD BEHAVIOUR DETERMINANTS

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Available at www.nbs.rs

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European government green bonds: analysis of yield behaviour determinants

Jelena Basarić

Abstract: The subject of this paper are euro denominated green bonds issued by European governments. The aim is to determine the impact that: (1) volatility index of S&P 500 index – VIX, (2) six-month EURIBOR, (3) remaining maturity of the bond, (4) issuer's credit rating and (5) absence of an independent external opinion on compliance of the green bond framework with the *Green Bond Principles* have on green bond yields, as well as whether yields of these bonds provide premium called greenium. Panel regression results show that higher values of volatility index VIX, 6M EURIBOR, a longer remaining maturity of the bond and the absence of an independent external opinion on compliance of the green bond framework with the *Green Bond Principles* lead to an increase in green bond yields, while a higher credit rating allows for a lower required yield. Additionally, a comparison of green and conventional bonds does not show the existence of a greenium.

Key words: green bonds, greenium, sustainability
JEL Code: G10, C10, C21, C22, C23.

Non-technical summary

In recent years, environmental protection and the desire to contain or stop polluting activities harmful to biodiversity and human health have become increasingly important. Agreements such as the UN Agenda 2030, the Paris Agreement and the European Green Deal were made with the aim of putting global warming and climate change on our planet under control and enabling a healthier, better quality life. In order to fulfil these goals, significant amounts of resources and money are needed for projects and investments that would contribute to slowing down environmental threats. This is why the financial sector has largely joined the fight to preserve the planet, because if no action is taken, investments required to remedy the negative environmental consequences would need to be even larger in the future.

Financial markets have recognised the problem and are trying to solve it in different ways, partly through the development of green debt financing instruments such as green bonds. This market is still in its infancy, although the value of these instruments' issuances has seen exponential growth since the publication of the Green Bond Principles in 2014. However, it still represents only a small part of the total bond market. The focus of this paper is on euro-denominated government green bonds issued by the European countries, a market segment that has not been extensively studied so far.

In the paper we test the impact of the volatility index of S&P500 index – VIX, six-month EURIBOR, absence of an external party's opinion on compliance of the green bond framework with the Green Bond Principles, credit rating and the remaining maturity of the bond on green bond yields. The results suggest that higher values of the VIX, six-month EURIBOR, longer remaining maturity of the bond and absence of an independent external opinion lead to an increase in green bond yields, while a higher credit rating allows for a lower required yield.

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1 Introduction

Humanity faces numerous environmental challenges as well as extreme weather events – floods, melting glaciers, rising sea levels on the one hand, and heat waves, droughts, falling river levels, strong storms on the other, all as a consequence of climate change. The Earth was about 1.1±0.1°C warmer in 2021 compared to the end of the 19th century. The previous decade was the warmest on record and it is likely that the temperature difference compared to the pre-industrial levels will reach 1.5°C in the next two decades (World Meteorological Organization, 2022). This can lead to more extreme weather conditions, which would result in lower crop yields, increased hunger and poverty in the world, disappearance or change of habitats for numerous plant and animal species, etc. The consequences of global warming, in addition to the destruction of the world we live in, contribute to large natural and economic losses and costs. The pursuit of environmental protection and healthier living has led to the need for a change in people's habits and behaviour. It has also led to an effort to save the planet, which is in line with the warning of former United Nations Secretary-General Ban Ki-moon in 2016: "We do not have a plan B, because there is no planet B" (Ki-moon, B., 2016).

The first frameworks and protocols aimed at reducing greenhouse gases emissions were adopted during the 1990s: the United Nations Framework Convention on Climate Change and the Kyoto Protocol. At the United Nations Conference on Climate Change in Paris in 2015, the Paris Agreement was adopted with the goal to limit global warming to well below 2°C, preferably to 1.5°C compared to pre-industrial levels. This agreement was signed by almost all the countries in the world with the obligation to report on efforts made to achieve the goal beginning from 2024 on. In the same year the 2030 Agenda of the United Nations was adopted, the goals of which relate to environmental protection, eradication of extreme poverty and reduction of inequality by 2030. In 2019, the European Commission presented the European Green Deal with the aim of making Europe the first continent without greenhouse gas emissions by 2050.

Given that tackling these changes requires extremely large investments, the green bond market is developing as well. Green bonds are debt securities whose proceeds are used to (re)finance environmentally sustainable activities and projects. The first green bond was issued by the European Investment Bank in 2007 (European Investment Bank, 2021). However, this market continues to represent only a small segment of the bond market, which is still not regulated by a single framework. A substantial increase in the volume of issued green bonds began when the International Capital Market Association (ICMA) adopted the *ICMA Principles of Green Bonds* in 2014, which represent a set of guidelines and recommendations for the purpose of achieving maximum efficiency and further development of the green bond market. These principles should relieve investors' concerns that the funds will not in fact finance appropriate green projects, that is, they try to reduce the possibility and risk of the so-called *greenwashing*.

According to Cevik and Jalles (2020), global warming has a significant impact on government bond yields and spreads. This is especially true for developing countries where "a 1% increase in vulnerability to climate change leads to a 3.11% increase in long-term

government bond spreads compared to the US benchmark, while a 1% improvement in climate resilience lowers spreads by 0.75%" (Cevik & Jalles, 2020).

The subject of this paper are green bonds issued by European countries, denominated in euros. The aim is to examine whether there is a price difference between green and conventional bonds and also to examine the impact that the volatility index VIX, remaining maturity of the bond, six-month EURIBOR, credit rating and absence of an external opinion on compliance of the green bond framework with the *Green Bond Principles* have on green bond yields. Daily data from Bloomberg Professional Software Service were used to examine the existence of a greenium, as well as the impact that the before mentioned variables have on green bond yields.

Investors might be willing to pay more for a green bond than for a conventional one, and thus accept a lower yield, in order to finance projects that would have a positive impact on the environment. The negative difference between the yield on green and comparable conventional bonds that occurs in this case is called green premium (greenium) (UNDP, 2022). There is no clear consensus about the existence of a greenium as some authors have managed to identify it, while others have not. In order to test the (non)existence of a greenium, we will use two methods: first, we will compare green bond yields on the first day of trading with reference yield curves, and second, we will compare the average yields of green bonds and conventional benchmarks (in the case of Serbia, since there are two relevant benchmarks that mature in the year before and in the year after the maturity of the green bond, we estimated the yields of a hypothetical bond using linear interpolation). The sample will refer to government green bonds denominated in euros issued until the end of June 2022.

We will use panel regression to test the impact that VIX, 6M EURIBOR, remaining maturity, absence of an external opinion and credit rating have on green bond yields. Thirteen outstanding European government bonds will be sampled over a six-month period (31 March 2021 – 30 September 2021). In search of the best fitting model, the results of two models will be presented: a model with fixed effects and a model estimated by the generalized least squares method.

This paper consists of four chapters. The first chapter describes the basic characteristics of the green bond market and its growth. The second chapter will be devoted to the analysis of the difference between the yields on green and conventional bonds. The results and conclusions of research from the relevant literature will be described, and the differences between government green and conventional bonds of European countries denominated in euros will be analysed. In the third chapter of the paper, hypotheses about the effects that VIX, six-month EURIBOR, remaining maturity, credit rating and absence of an independent external opinion have on green bond yields will be tested using panel regression. The last chapter consists of concluding remarks.

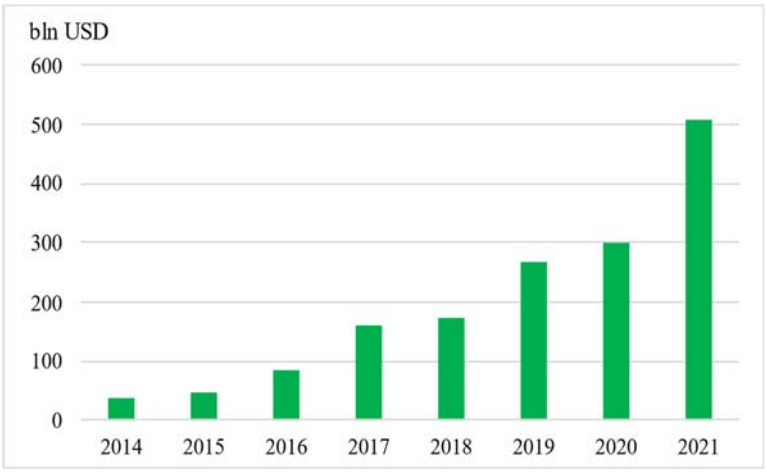
2 Growth and development of the green bond market

Supranational institutions have played a key role in the development of the green bonds market. The first green bond was issued by the European Investment Bank in 2007 in the

amount of USD 807 million (Climate Bonds Initiative, n.d.a). In the next few years, the value of these bond issues was small, and the issuers were usually supranational institutions. This market's growth gained momentum when the International Finance Corporation (IFC) issued a USD 1 billion green bond in 2013, the largest issue at that time. These institutions have contributed significantly to drawing the attention of financial market participants to financing sustainable projects. The importance of supranational institutions lies in the fact that they enter the markets through bonds of different maturities denominated in different currencies. They also use their knowledge and expertise in establishing best practices, training and advising market participants and contributing to the development of taxonomy, principles and standards.

The next important step in green bond market development was the publication of the *Green Bond Principles* in 2014, which represent the first non-binding document at the global level with the aim of reducing risks for all market participants and creating a regulated single market. The publication of the *Principles* contributed to the exponential growth of this market which reached a cumulative value of USD 1.6 trillion in green bonds issued in 2021. The value of green bond issues in 2021 exceeded USD 500 billion for the first time, which meant an increase of 75% compared to 2020 (Climate Bonds Initiative, 2022a).

Chart 1 **Annual value of green bond issues between 2014 and 2021**

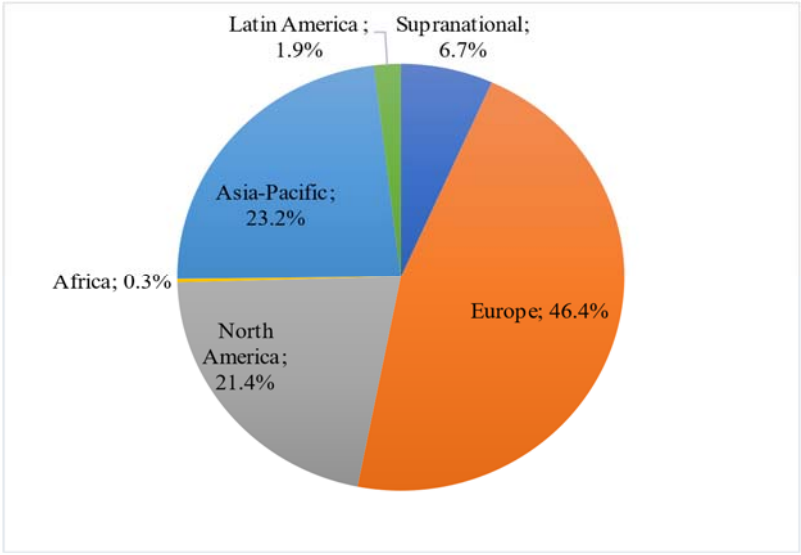


Source: Climate Bonds Initiative, 2022b.

The expertise of supranational institutions and the publication of the *Green Bond Principles* were crucial for the entrance of other types of issuers into this market: governments, municipalities, companies and financial institutions. In recent years financial institutions and non-financial companies are among the issuers with the highest share of issuance. Municipalities and companies entered the market in 2012 and financial institutions – one year later. The first country to issue a green bond was Poland in 2016. In the following year, France entered the market with the largest issue at that time. According to Climate Bonds Initiative data (2022a), financial institutions and non-financial corporations had the dominant share in the cumulative green bond volume, while governments had a share of only 10% at the end of 2021.

Observed by region, Europe had the largest share of cumulative issued green bonds at the end of 2021 (over 46%), followed by Asia-Pacific (23%) and North America (21%). Almost two-thirds of the value of issued green bonds in 2021 comes from developed countries.

Chart 2 **Share of regions in the total green bond issuance (ending with 2021)**



Source: Climate Bonds Initiative, 2022b.

Taking into account all issuer types, the United States has the highest cumulative value of issued green bonds (over USD 300 billion), followed by China (around USD 200 billion), France (over USD 160 billion) and Germany (over USD 150 billion). It was found that countries with better macroeconomic (gross domestic product, trade openness, stock market capitalisation) and institutional factors (capital controls, regulatory quality, rule of law) have a positive impact on green bond issuance volume (Tolliver et al., 2020).

Observed by currency, the euro (43%) and the US dollar (26%) had the highest share in the total issued green bonds in 2021 (Climate Bonds Initiative, 2022a). In recent years, there has been an evident increase in the share of larger market size deals. Those deals are mostly made over a ten-year period, but longer tenors have become more frequent in recent years (European Investment Bank, 2021).

Most of the proceeds are used for energy, buildings and transport (Climate Bonds Initiative, 2022a). Tolliver et al. (2019) explained these allocation patterns by the fact that greenhouse gas emissions reductions "are long-established, priority objectives among environmental policies", which channel money toward categories that would bring about a more substantial decrease in greenhouse gas emissions.

The pursuit of a healthier and better life induced growing interest in sustainable finance, which is not only reflected through green bonds or green loans. There are also instruments such as social bonds, sustainable bonds, sustainability-related bonds and transition bonds. A yearly increase in issuance is characteristic of these bonds too. Recently, the "blue" bonds have attracted attention. They represent a type of green bonds which are intended for funding projects and activities that can improve oceans and water sustainability (International Capital

Market Association, 2021). Oceans cover about 70% of the Earth and are of high importance in mitigating climate change.

3 Examination of the yield difference between green and conventional bonds

3.1 Literature results overview

The existing literature describes some of the incentives for issuing and holding green bonds. Higher ownership concentration was found in green bonds compared to conventional bonds (Baker et al., 2018). Another motive can be the signalling effect, indicating that these investors care about the environment and are ready to hold green bonds even if they bring lower returns compared to the conventional ones (Gilchrist et al., 2021). Hedging strategies, as described in Kanamura (2021) on the example of high yield ETFs (exchange-traded funds), may also attract investors.

Similar motives can be found for issuers as well. Gilchrist et al. (2021) found managerial opportunism as one of the reasons for sustainable business, emphasizing that the presentation of the company as socially and environmentally responsible and, thus, approaching a larger number of customers, brings benefits not only to the company, but also to managers. Thus, the reputation of a company can influence the terms of its funding in the long run. The reaction of the stock market to green bond issues is positive, which means that investors expect no greenwashing. If companies did not take actions toward sustainable projects, announcements of green bond issues would not cause a positive market reaction (Flammer, 2021).

One of the frequently asked questions is whether green bond issues can provide for cheaper financing, that is, whether investors are willing to accept a lower return, compared to conventional bonds, in order to finance sustainable projects. The results that can be found in the literature differ. Baker et al. (2018) found green premium on issued green municipal bonds compared to conventional ones. Zerbib (2019) examined the existence of a green premium on bonds of various issuers: financial institutions, corporations, supranationals, municipals, and found small, but significant negative premium of two basis points on green bonds. On the other hand, Bachelet et al. (2019) found that green bonds have higher yields, while Flammer (2021) found no pricing difference between green and conventional corporate bonds. Hachenberg and Schiereck (2018) came to the same conclusion in relation to bonds of different issuers. As the results found in the literature differ and none of these studies explicitly analysed government green bonds only, this encouraged us to analyse yield differences on European government green bonds.

3.2 European government green bond yield analysis

The preceding two years (2020 and 2021) were very important for the development of the government green bond market. The first sovereign issuance was in 2016 and the market has been increasing since then. Many countries entered this market for the first time during 2020 and 2021, e.g. the United Kingdom, Germany, Italy, Serbia, Spain. According to Climate

Bonds Initiative (2022b), total issuance of government green bonds was USD 72.8 billion in 2021, which is almost equal to the value of issuances in the 2018–2020 period. Europe is the continent with the highest share of the government green bonds volume. Alongside international commitments, the COVID-19 crisis has further drawn attention to environmental problems and the need for addressing them.

The question is whether green bonds enable cheaper borrowing for governments. Since the characteristics of these bonds do not differ much from ordinary ones, the first hypothesis was tested: There is no greenium on government green bonds compared to conventional ones. European government green bonds issued in euros until the end of June 2022 were analysed. There are twenty bonds issued by twelve countries. The analysis is done by comparing the yield on a green bond on the first trading day with the reference yield curve and comparing the average yield on a green bond with the conventional benchmark. The latter method has certain constraints, since there are usually no perfect benchmarks. In the case of sovereign bonds, much depends on the government's activities in the market in which the green bonds are issued. For example, some countries do not have a developed yield curve for bond issues in the international market and green bonds are issued in that market. The analysis compares green bonds with conventional bonds issued in euros in the same market, maturing as close as possible to the green bonds. Also, bonds with a date of issue and coupon rates approximate to that of the green bonds were selected. All data were collected from the Bloomberg Professional Software Service. The largest difference between maturity dates of green and conventional bonds is four years (in the case of Italy). The average yield was calculated from the first trading date of a green bond until the end of June 2022. Bonds issued by Serbia and Germany were reviewed in particular.

The first government to issue the green bond was Poland in 2016. This bond matured in December 2021. After 2016, three more issuances followed: one in 2018 (bond matures in 2026) and two in 2019 (bonds were issued on the same day and mature in 2029 and 2049).

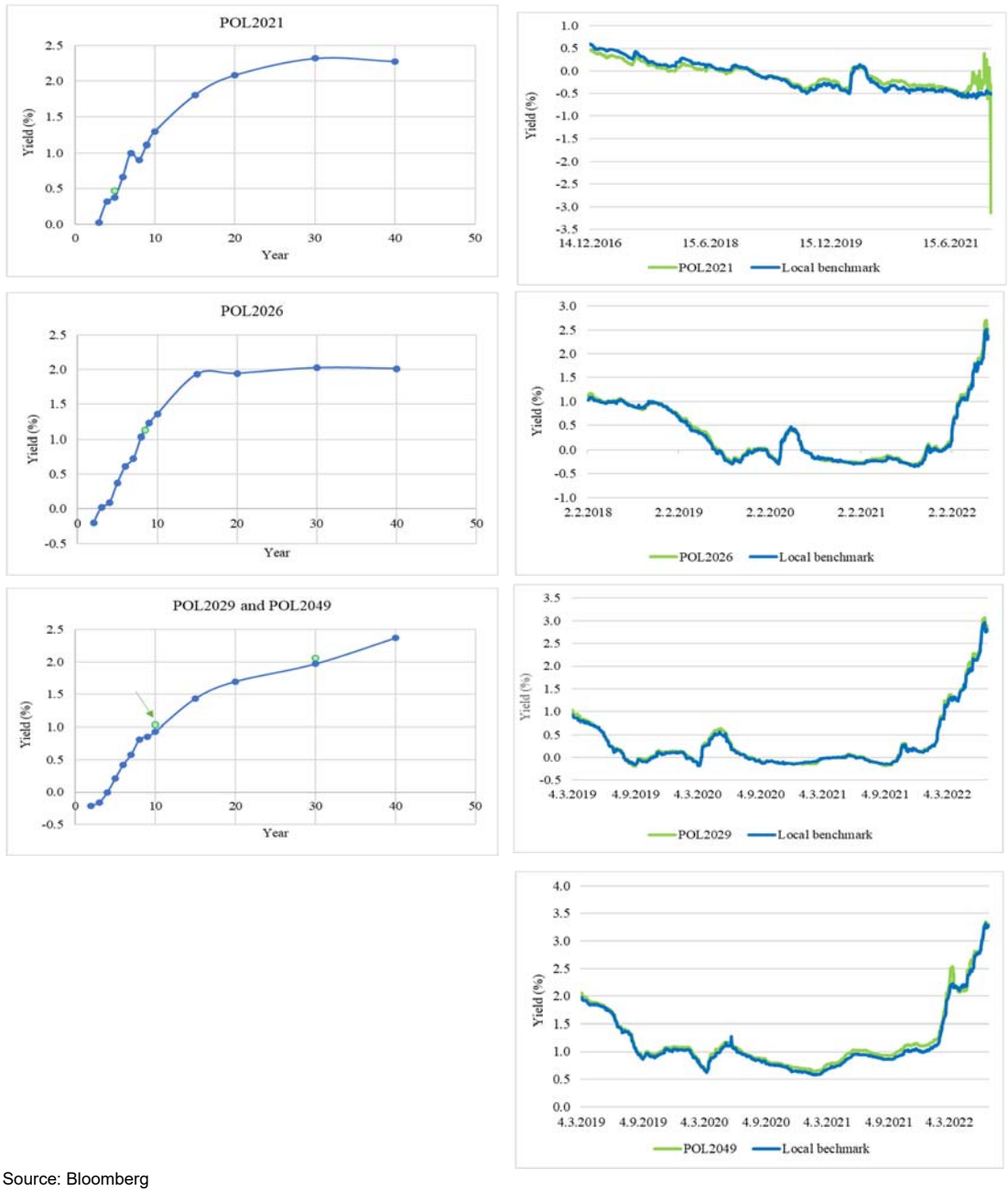
In order to examine the existence of a green premium, the yield on the first trading day was compared with the reference yield curve (left-hand side of Chart 3; the green bond yield is marked with a green circle). The right-hand side of the chart shows the movement of green bond yields from the first trading day until 30 June 2022, as well as the yields on their selected local benchmarks. The results of both methods reveal that the differences in yields are small, but still suggest the absence of a greenium. The average yield on a five-year green bond that matured in December 2021 (shown as POL2021 in the Chart) is almost equal to the yield on its selected benchmark (it is higher by 1 bp) which matured two months later. The average yields on the remaining three green bonds are 2–6 bp higher than the yields on their benchmarks.[1]

France entered the green bonds market in 2017 and has issued three bonds so far: with a maturity of 22 and a half years in 2017 (OAT2039) and with a maturity of 23 years in 2021

[1] The selected benchmark of POL2026 also matures in 2026, while the benchmarks of POL2029 and POL2049 mature five months earlier and two years and five months earlier, respectively. An overview of the differences between the average yields on green and conventional bonds will be presented at the end of the chapter.

(OAT2044), while in 2022 it issued a green bond linked to the harmonized index of consumer prices (HICP) for the first time. This bond has a maturity of 16 years (OAT€i2038).[2]

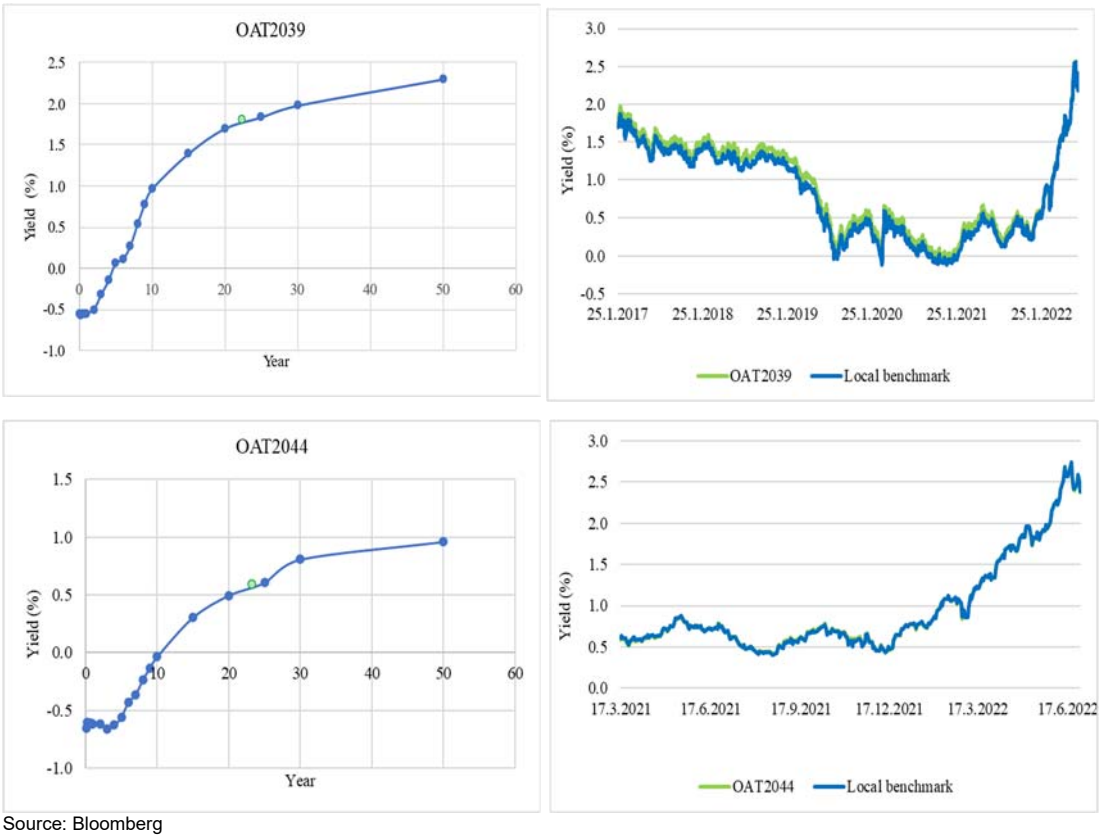
Chart 3 **A comparison of Poland's green bond yields with yield curves and benchmarks**



Source: Bloomberg

[2] The benchmark of the first bond matures three years before the green bond, the benchmark of the second bond matures one year after the green bond and in the case of the third bond the benchmark matures two years before the green bond.

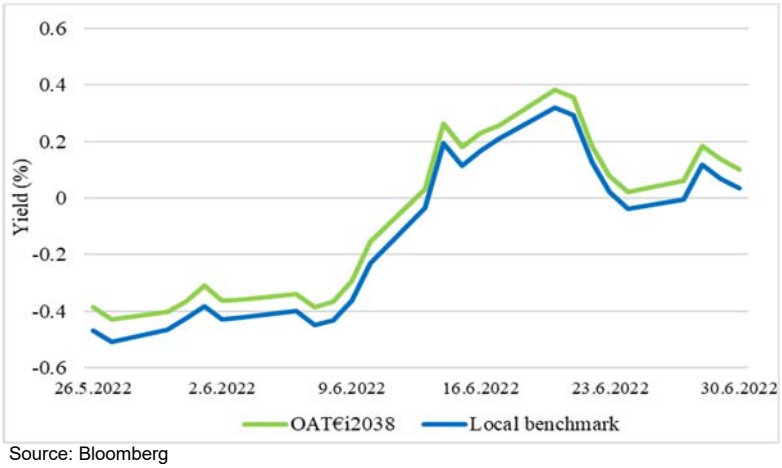
Chart 4 **A comparison of France's green bond yields with yield curves and benchmarks**



Source: Bloomberg

Chart 4 shows the yields on bonds that mature in 2039 and 2044 and, using both methods, we can conclude that the greenium does not exist. The average yields on OAT2044 and its benchmark are almost completely equalized, while the yield on OAT2039 is higher than on its benchmark. The yield on the first trading day of the last issued bond has not been compared with the yield curve, as it is linked to inflation. The second method suggests that, for the time being, the yield on this bond is higher than the yield on its benchmark.

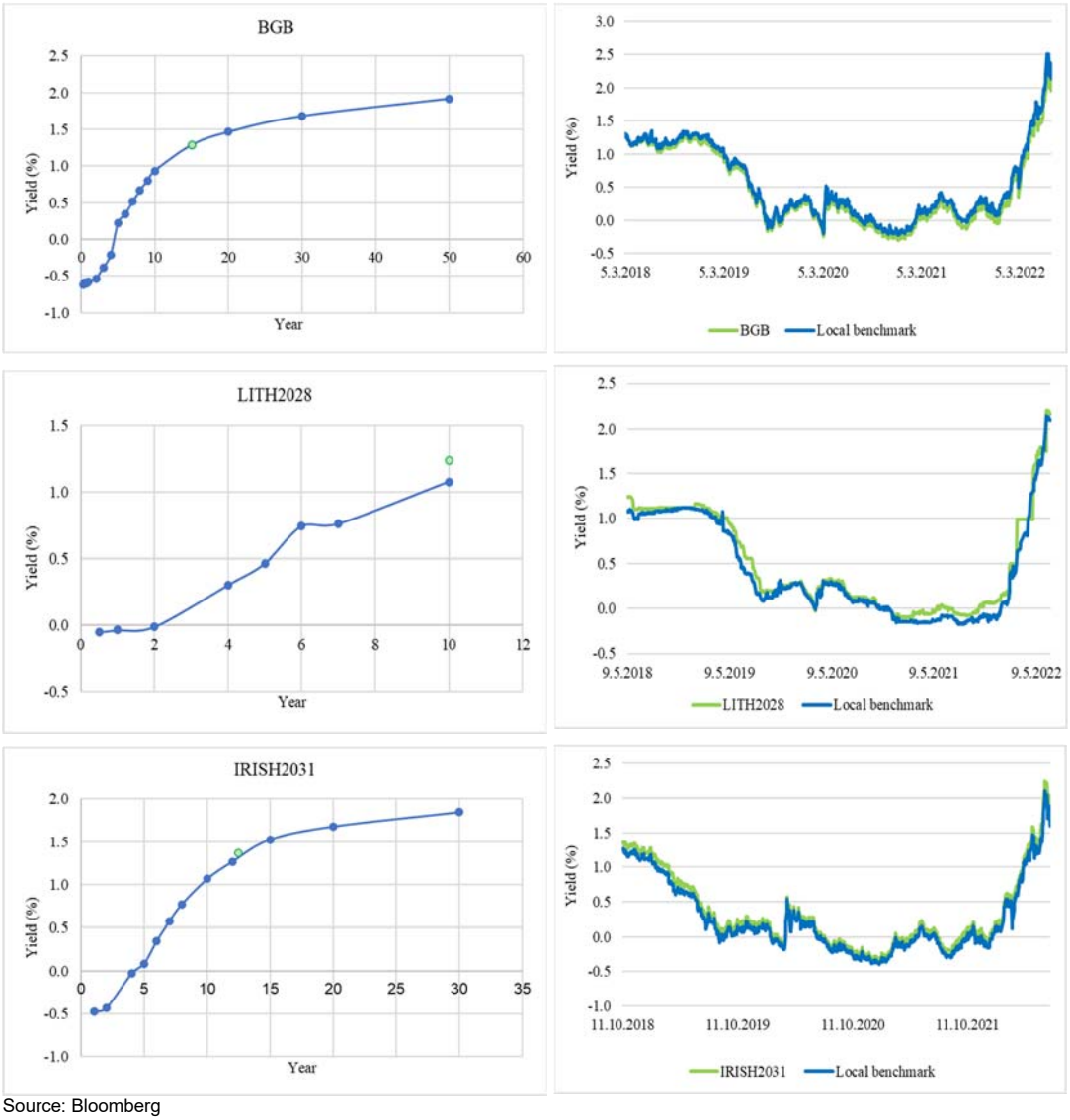
Chart 5 **A comparison of France's green bond yield OAT€i2038 with its benchmark**



Source: Bloomberg

In 2018, three countries entered this market: Belgium, Lithuania and Ireland. Belgium issued a bond with a maturity of 15 years (BGB), Lithuania with a maturity of 10 years (LITH2028) and Ireland with a maturity of 12 years and 5 months (IRISH2031).[3] Using both methods to test for the existence of a greenium, no premium was found in the case of Lithuania and Ireland. However, in the case of Belgium, the average green bond yield in the observed period is lower than the benchmark by 8 basis points. When compared to the yield curve, the greenium is extremely low – 0.3 basis points.

Chart 6 **A comparison of Belgium's, Lithuania's and Ireland's green bond yields with yield curves and benchmarks**

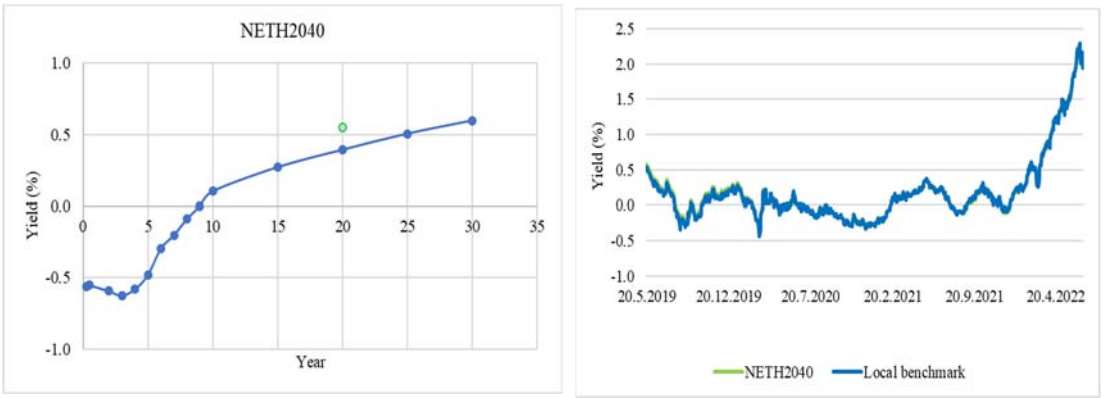


Source: Bloomberg

[3] Belgium's benchmark matures one year after the green bond, while Lithuania and Ireland's benchmarks mature one year before the green bonds.

The Netherlands issued its green bond in May 2019. It matures in January 2040 (NETH2040), while its selected benchmark matures two years later. Chart 7 shows that the yield on the first trading day of this bond is above the yield curve on that day, while the difference in the average yields on this bond and its benchmark is only one basis point – the benchmark has a lower yield, which suggests the absence of a greenium.

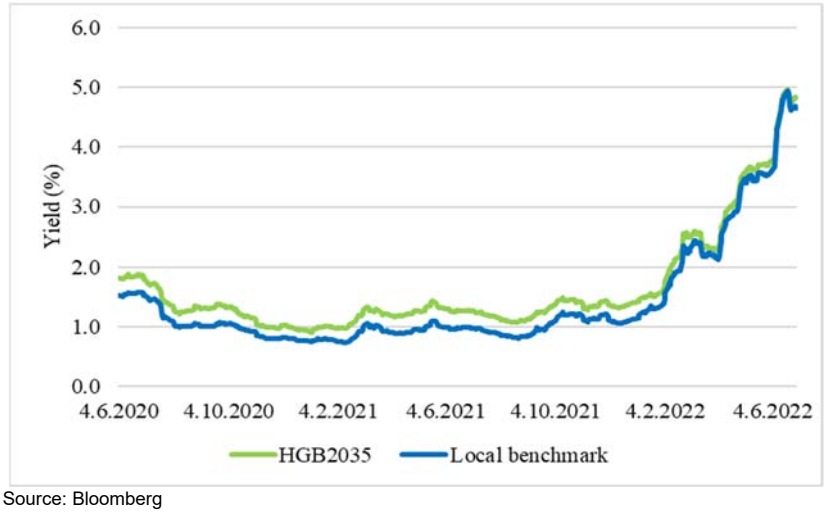
Chart 7 **A comparison of the Netherland's green bond yield with yield curve and benchmark**



Source: Bloomberg

Hungary is the country that has issued green bonds in several different currencies so far: in the yen, yuan, forint and euro. It entered this market in 2020, when it issued two bonds in the Japanese yen and one in euros in the international market. The euro-denominated bond matures in 2035 (HGB2035) and its benchmark in 2032. Given that there is no developed yield curve for bonds issued in the international market in euros, this comparison was not possible. Chart 8 shows that the yield on the green bond is higher than the yield on the benchmark in the observed period, which means that greenium was not found using the second method.

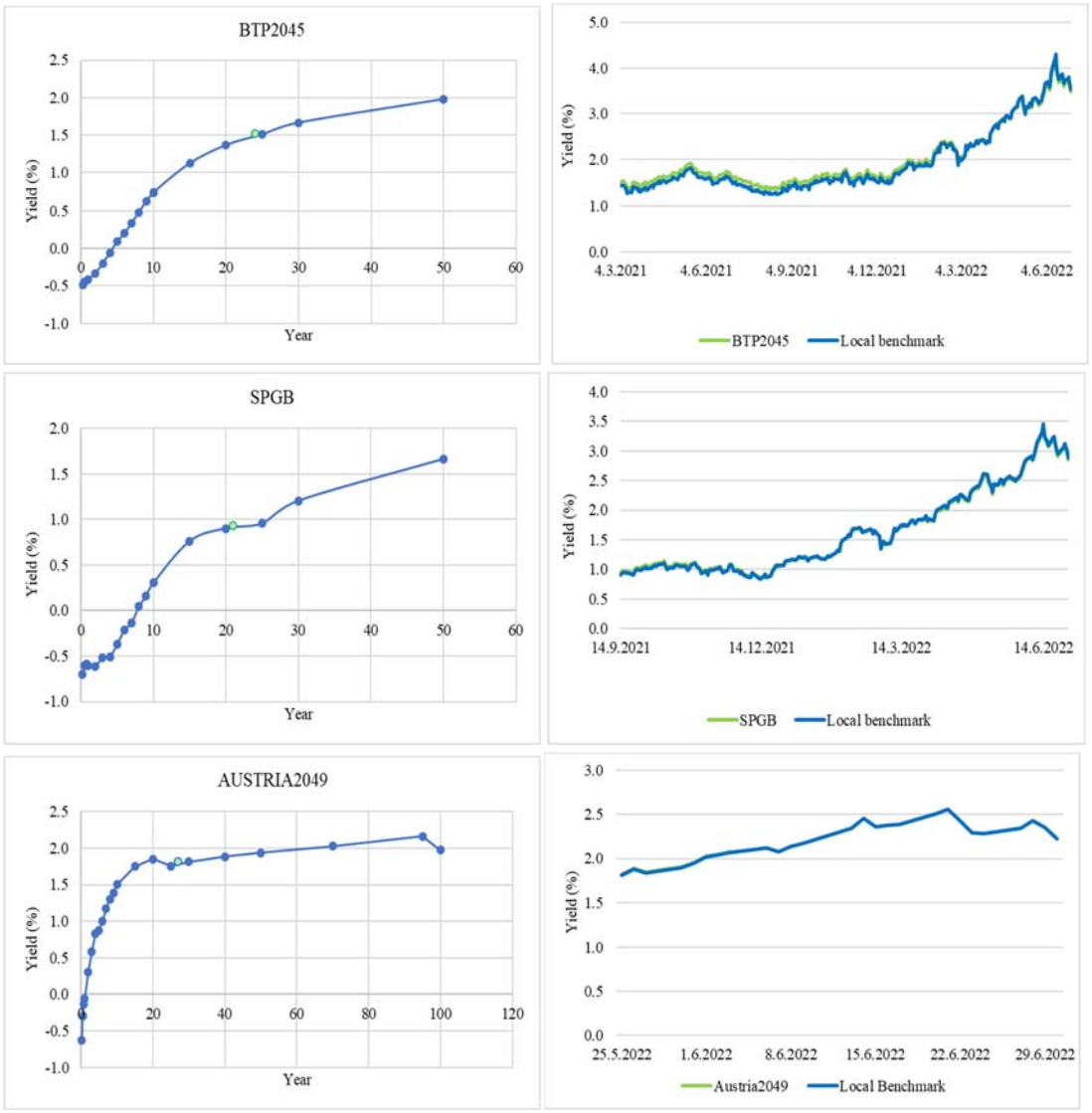
Chart 8 **A comparison of Hungary's green bond yield with benchmark**



Source: Bloomberg

Italy and Spain issued their bonds in 2021. The Italian bond has a maturity of 14 years (BTP2045), and the greenium was not found in this case either.[4] The Spanish bond was issued for a longer term and matures in 2042 (SPGB). No greenium was found when comparison was made with the yield curve and the average yield on it is only 0.1 basis points lower than in the case of its benchmark, suggesting the existence of a premium.[5]

Chart 9 **A comparison of Italy's, Spain's and Austria's green bond yields with yield curves and benchmarks**



Source: Bloomberg

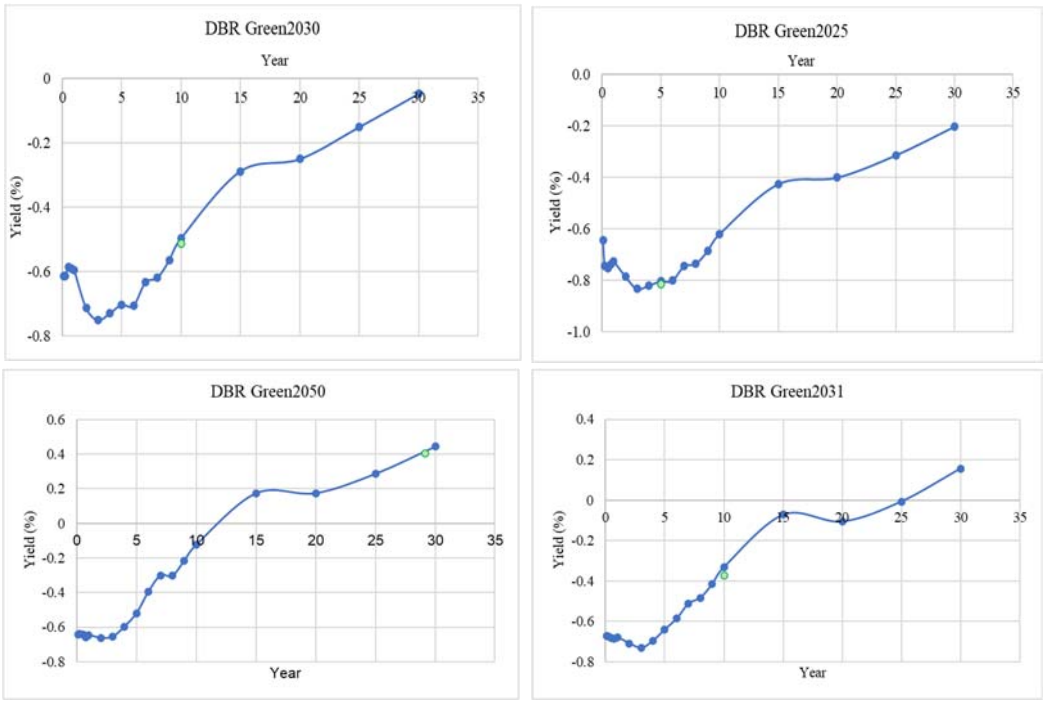
[4] Benchmark matures four years before the green bond.

[5] Benchmark matures two years before the green bond.

In 2022, Austria issued a 27-year green bond. However, the greenium was not found when comparison was made with the yield curve, or when the average yields were compared with the benchmark – the yields are almost equal.[6]

As evident from the example of the previously described countries' bonds, there is no perfect reference conventional bond. The difference between the maturity dates of these bonds is usually in the range of 1–3 years. However, Germany entered the green bond market in a different way in 2020. The Twin Bond Strategy is defined in Germany's Green Bond Framework, meaning that green bonds will be issued together with conventional bonds that have the same key characteristics: coupon rate, interest payment dates and maturities. The difference between these bonds is in the volume of issuance (conventional bonds will be issued in larger amounts), date of issuance (conventional bonds will be issued first) and the ISIN. The goal is to establish a green yield curve with the same maturities as the conventional curve (Federal Republic of Germany, Federal Ministry of Finance, 2020a). It was also pointed out that that the German Finance Agency will "strongly support" secondary market liquidity. The Agency can carry out outright sales and purchases, repurchase agreements and securities lending, using the Federal Government's own stock of Green Bonds and switch transactions. If demand for the conventional twin is higher than that for the green bond, the German Finance Agency can use the switch option and meet demand. In the opposite situation, market regulation is expected. In such a case, the Agency may or may not meet such demand (Federal Republic of Germany, Federal Ministry of Finance, 2020b).

Chart 10 **A comparison of Germany's green bond yields with yield curves**



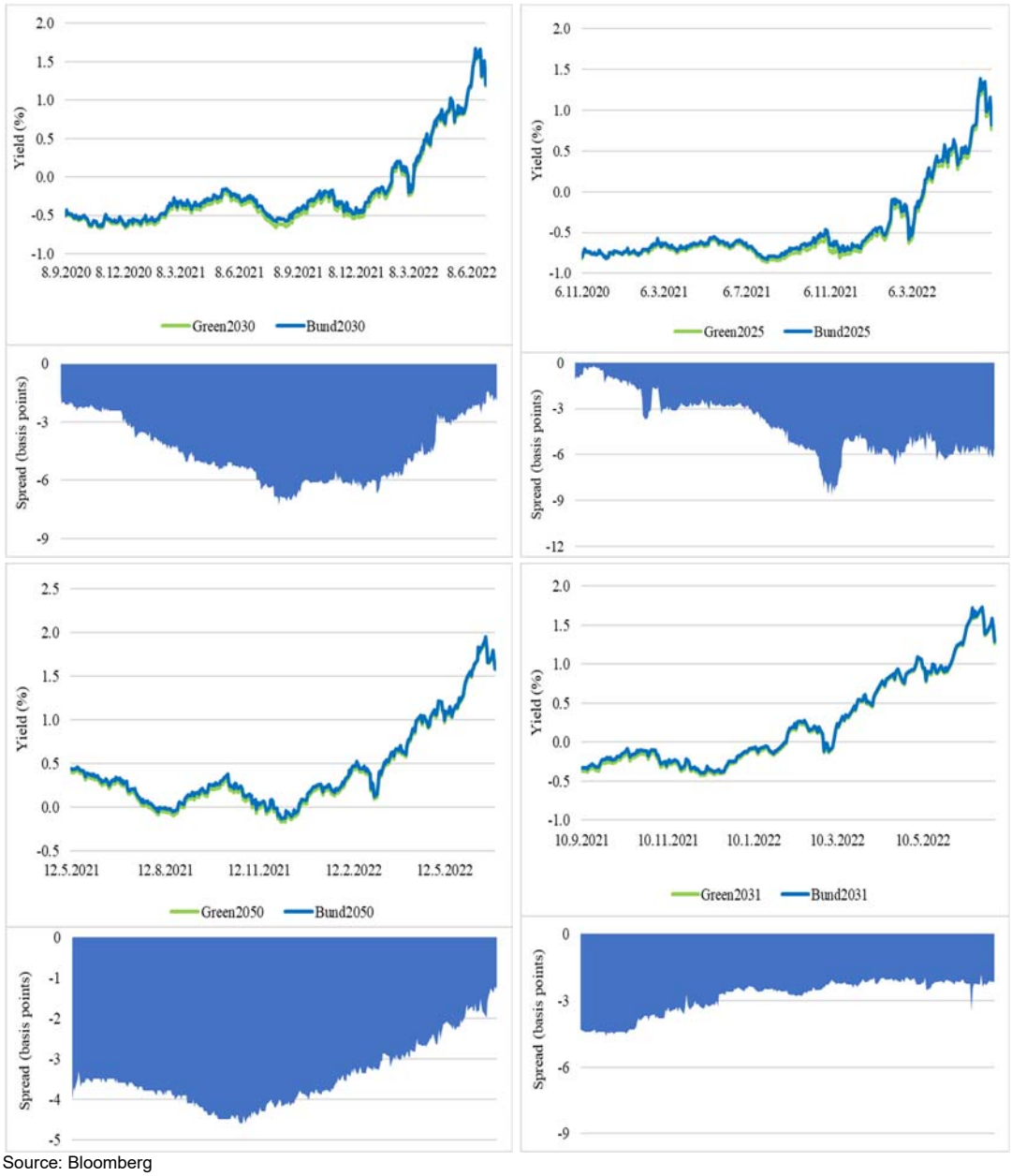
Source: Bloomberg

[6] Benchmark matures two years after the green bond.

Germany has issued four green bonds so far: two in 2020 (with maturities of ten and five years) and two in 2021 (with maturities of ten and twenty-nine years). When yields on the first trading day are compared with the yield curve, the existence of a greenium is observable.

Chart 11 shows the movement of green and conventional bonds. It is noticeable that during the observed period (from the first day of trading of green bonds until the end of June 2022) the green bond yields are lower than the yields on conventional bonds. Using the second method based on average yields, this also means the existence of premium. The average greenium for bonds that mature in 2031 and 2050 is 3 basis points, and for bonds that mature in 2025 and 2030 it is 4 basis points.

Chart 11 **A comparison of Germany's green bond yields with benchmarks**



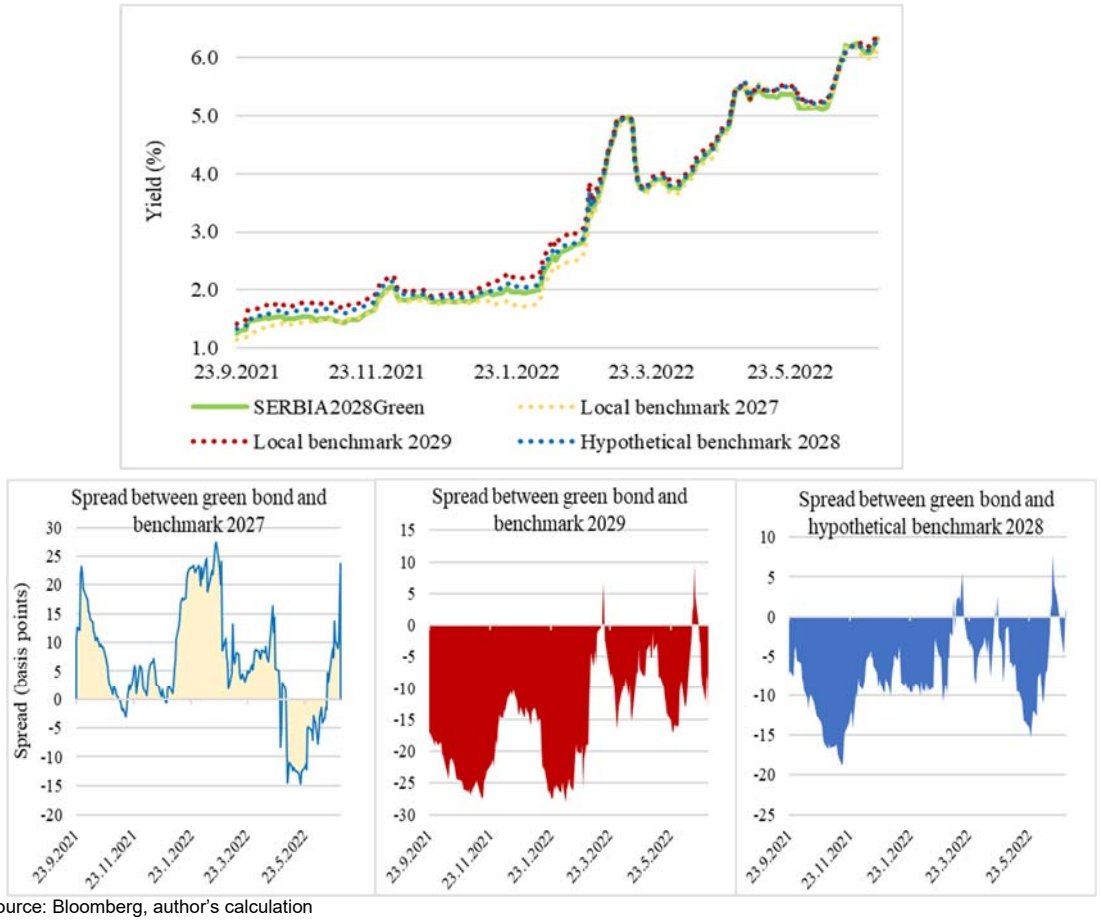
Source: Bloomberg

In 2021, Serbia issued its first green bond in the international market, making it the first (and so far the only) non-EU country in Europe to do so. In its case, as well as in the case of Hungary, there is no developed yield curve for euro-denominated securities issued in the international market. For this reason, it is impossible to implement the first method for determining the existence of the green premium. This bond has a maturity of 7 years and matures on 23 September 2028, that is, in the year between the maturities of other two conventional bonds issued in the international market, but a little closer to the bond that matures in 2029. As there are two relevant benchmarks (one matures in 2027 and the other in 2029) and the results relating to the existence of greenium depend on the decision as to which of the two bonds we take as the benchmark in our analysis, linear interpolation has been done, using the following formula:

$$Y_n = \frac{Y_1 \times (t_2 - t_n) + Y_2 \times (t_n - t_1)}{t_2 - t_1} \quad (1)$$

where Y_n is estimated yield, Y_1 yield on bond with shorter maturity, Y_2 yield on bond with longer maturity, t_n days to maturity of estimated hypothetical bond, t_1 days to maturity of bond with shorter maturity, t_2 days to maturity of bond with longer maturity (Martellini et al., 2003). It shows us the estimated yields that the conventional bond maturing in the same year as the green one (2028) would have.

Chart 12 **Comparison of Serbia's green bond with benchmarks**

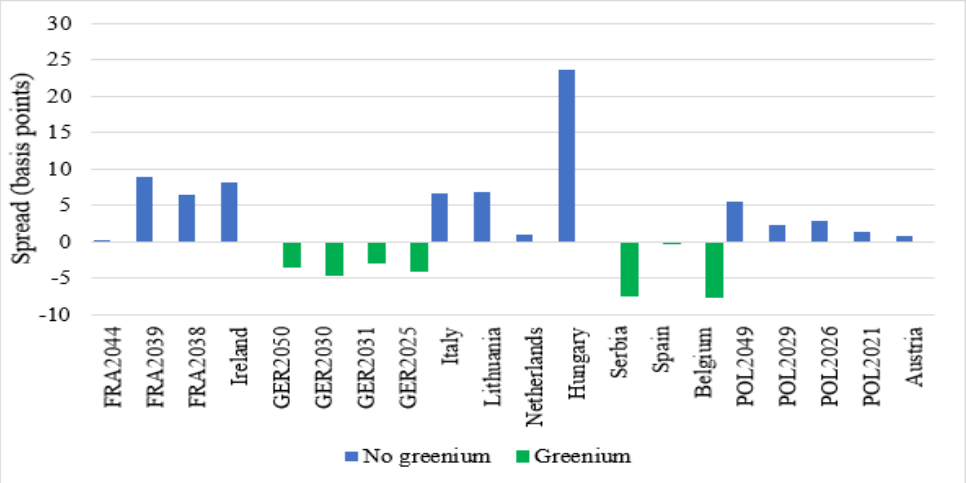


Source: Bloomberg, author's calculation

If the average yields on the green bond were compared to the average yields on the bond maturing in 2027, no premium would be found, although it is noticeable from the lower left part of Chart 12 that there was a premium during certain periods (several days in November and December 2021, few days in April 2022 and in the period from 4 May to 15 June 2022). On the other hand, a comparison of the average yield on the green and the conventional bond maturing in 2029 would show the existence of greenium. Therefore, the comparison of average yields was done over the estimated yields of the hypothetical bond. Given that the maturity of the green bond is closer to the maturity of the bond maturing in 2029, the yields of this benchmark had a higher weight than the yield of the benchmark maturing in 2027 (0.65 vs. 0.35). As a result, the comparison of the average green bond yield and the average hypothetical bond yield shows a greenium of 7 basis points.

Looking at the results of 20 green securities (issued by twelve countries), only seven of them have a greenium. These are the bonds issued by Germany, Spain, Serbia and Belgium. These findings are represented in Chart 13. According to these results, we can accept the first hypothesis that there is no greenium when European government green bonds are compared with conventional ones denominated in euros.

Chart 13 **Differences in average green and conventional (benchmark) bond yields**



*in the case of Serbia, the green bond was compared to an estimated hypothetical benchmark

Certainly, we should not forget that there are no perfect benchmarks for green bonds (except in the case of Germany). This is a market in its infancy and the following years may allow us to make better comparisons and examine the existence of a greenium. However, given the serious environmental warnings and the signed agreements, it may happen that almost every bond or loan in the future will finance sustainable projects and that the label “green” would no longer have the meaning it has today.

4 Analysis of green bond yield determinants[7]

4.1 Descriptive statistics

In this part of the paper we are examining the impact that:

- remaining maturity of the bond,
- six-month EURIBOR,
- volatility index of Standard & Poor's 500 index – VIX,
- credit rating and
- absence of an independent external opinion on compliance of the Green Bond Framework with the *Green Bond Principles*

have on green bond yield behaviour. We use daily data (working days) on outstanding European government green bond yields from 31 March 2021 until 30 September 2021 (data were collected from Bloomberg)[8]. The sample contains of 13 bonds: two bonds issued by France, two by Germany, one by Ireland, one by Italy, one by Lithuania, one by the Netherlands, one by Hungary, one by Belgium and three bonds issued by Poland.

The volatility index VIX represents the volatility of the S&P500 index based on market expectations of stock price movements over the next 30 days. Credit rating and no second party opinion are two dummy variables. All countries that have a credit rating of A3 or higher given by Moody's take value one, and zero otherwise. Absence of an independent external opinion is a dummy that takes value one if the country does not have an external opinion on compliance of its Framework with the *Green Bond Principles*, and zero otherwise. An overview of the variables is shown in Table 1 below.

Table 1 **Dependent and independent variables**

Variable name	Variable label	Source
Yield	Yield on European government green bonds	Bloomberg Professional Software Service
Remaining Maturity	Remaining maturity of bond	Created by author
VIX	Volatility Index of S&P500 index price movements	Bloomberg Professional Software Service
6M EURIBOR	Six-month EURIBOR	Bloomberg Professional Software Service
Dummy Credit Rating	Takes 1 if Moody's credit rating is A3 or higher, zero otherwise	Created by author
Dummy Absence of external opinion	Takes 1 if there is no external opinion on the compliance of the Green Bond Framework with the Green Bond Principles, zero otherwise	Created by author

[7] The results of this analysis were presented at the scientific meeting SYM-OP-IS 2022.

[8] Poland's 2016 bond was not included in the analysis, because it matured in December 2021.

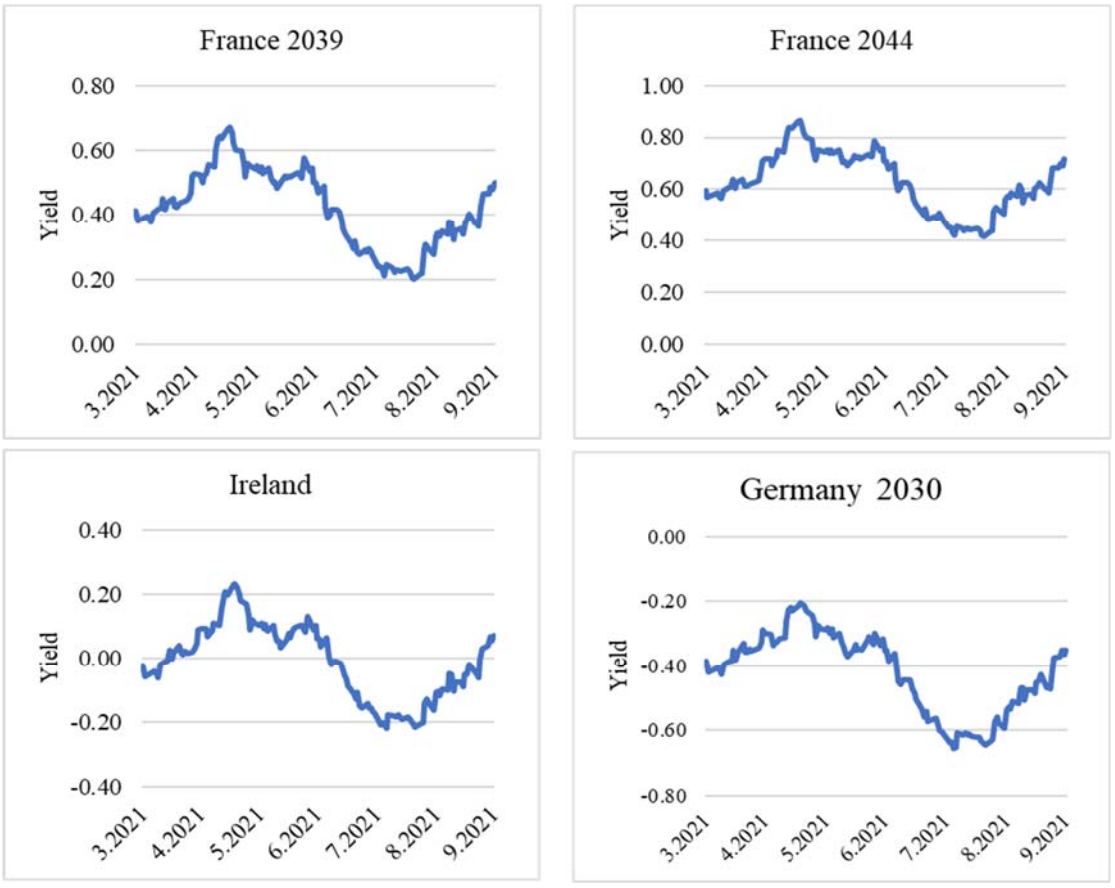
Table 2 shows mean, standard deviation, minimum and maximum of dependent and independent variables. Minimum yield refers to the German 5-year green bond that has a rating of Aaa, while the maximum refers to the Italian bond that has a rating of Baa3. The average yield is 0.27 and the standard deviation 0.64, meaning that there was no high return on these bonds, but also no high risk. All green bond yields during the observed period are represented in Chart 14.

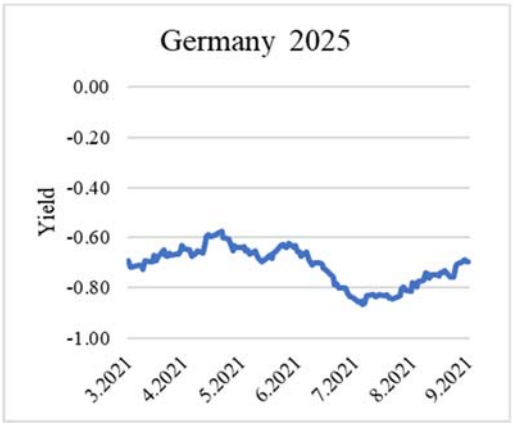
Table 2 **Descriptive statistics**

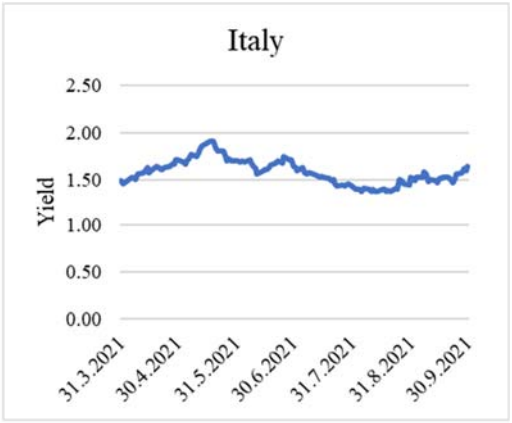
Variables	Observations	Mean	Standard deviation	Minimum	Maximum
Yield	1,690	0.2747373	0.6443952	-0.868	1.912
Maturity	1,690	13.24438	7.366417	4	27
VIX	1,690	18.10946	2.173647	15.07	27.59
6M EURIBOR	1,690	-0.5182385	0.0061522	-0.531	-0.505

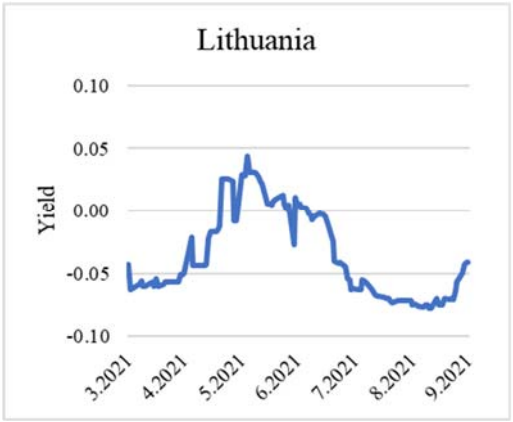
The average remaining maturity of bonds is 13 years. The average value of the volatility index during the observed period is 18, which means that high volatility was not expected. 6M EURIBOR is -0.52 on average and it shows no significant movements during the observed six-month period (from -0.53 to -0.51).

Chart 14 **Green bond yields from 31 March 2021 to 30 September 2021**

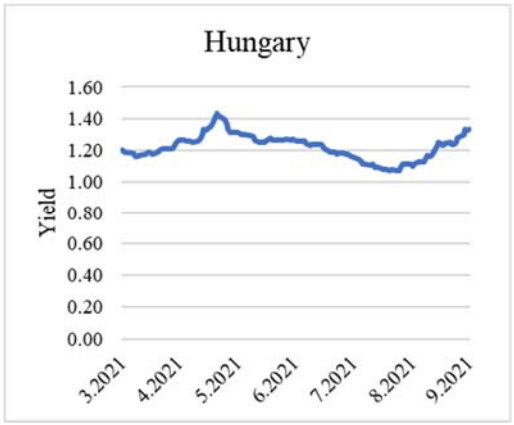


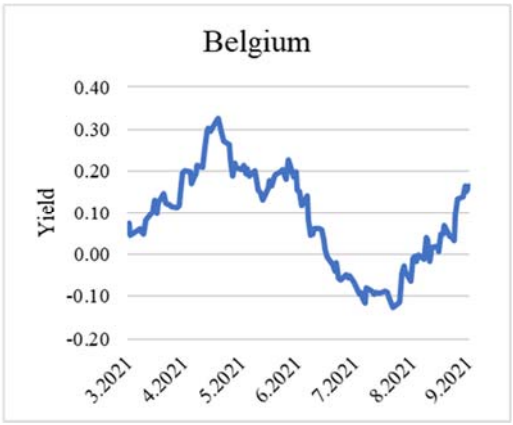

Germany 2025
Yield
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
3.2021
4.2021
5.2021
6.2021
7.2021
8.2021
9.2021

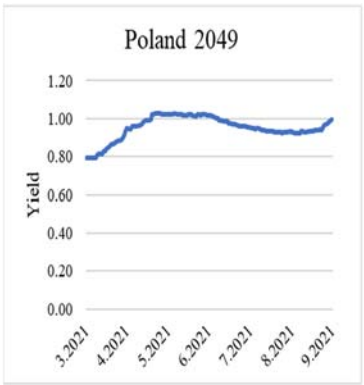

Italy
Yield
2.50
2.00
1.50
1.00
0.50
0.00
31.3.2021
30.4.2021
31.5.2021
30.6.2021
31.7.2021
31.8.2021
30.9.2021


Lithuania
Yield
0.10
0.05
0.00
-0.05
-0.10
3.2021
4.2021
5.2021
6.2021
7.2021
8.2021
9.2021


The Netherlands
Yield
0.60
0.40
0.20
0.00
-0.20
3.2021
4.2021
5.2021
6.2021
7.2021
8.2021
9.2021


Hungary
Yield
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
3.2021
4.2021
5.2021
6.2021
7.2021
8.2021
9.2021


Belgium
Yield
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
3.2021
4.2021
5.2021
6.2021
7.2021
8.2021
9.2021


Poland 2049
Yield
1.20
1.00
0.80
0.60
0.40
0.20
0.00
3.2021
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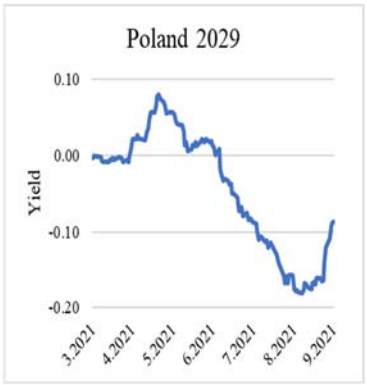
5.2021
6.2021
7.2021
8.2021
9.2021


Poland 2029
Yield
0.10
0.00
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-0.20
3.2021
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5.2021
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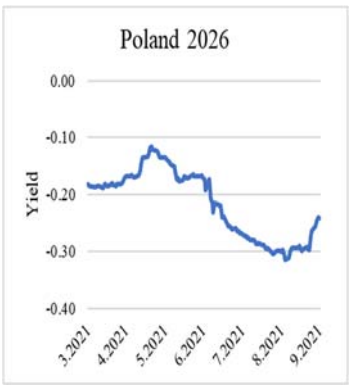
8.2021
9.2021


Poland 2026
Yield
0.00
-0.10
-0.20
-0.30
-0.40
3.2021
4.2021
5.2021
6.2021
7.2021
8.2021
9.2021

From Table 3 we can conclude that there is no multicollinearity between explanatory variables. Correlations between independent variables are smaller than ±0.5. These results have been confirmed by the Variance Inflation Factor (VIF), where the VIF for all independent variables is between 1.02 (in the case of VIX) and 1.17 (in the case of Remaining maturity).

Table 3 **Correlation between variables**

	Yield	Maturity	VIX	6M EURIBOR	Credit rating	No external opinion
Yield	1,0000					
Maturity	0,7787	1,0000				
VIX	0,0202	-0,0028	1,0000			
6M EURIBOR	0,0985	0,0164	-0,1465	1,0000		
Credit rating	-0,7462	-0,2903	0,0000	0,0000	1,0000	
No external opinion	-0,1389	-0,2773	0,0000	0,0000	0,1231	1,0000

4.2 Panel regression analysis

We are testing two hypotheses:

- Higher values of volatility index VIX, 6M EURIBOR, a longer remaining maturity of the bond and the absence of an independent external opinion on compliance of the green bond framework with the Green Bond Principles lead to an increase in green bond yields.
- Green bonds with a higher credit rating allow for lower required yields.

To assess the effect of these variables on yields, it is necessary to determine which model we should use: a fixed or a random effects model. Applying the Hausman test at a 5% level of significance, we reject the null hypothesis that suggests the use of a random effects model and start with a fixed effects model (FE) for balanced panel data, which can be described by the following equation:

$$Y_{it} = \alpha + \beta X_{it} + \mu_i + \vartheta_{it} \quad (2)$$

for t = 1, ..., T and i = 1, ..., N, where Y_{it} is the dependent variable, α the intercept, β the coefficients, X_{it} the independent variables, μ_i, the individual specific effects, and ϑ_{it} remainder disturbance (Brooks, 2019). The advantage of this model is that it takes into account individual specifics.

Problems that we have are cross-section dependency, autocorrelation and heteroskedasticity in residuals. We have managed to overcome the last problem by using the fixed effects model, however, but not the others. Given that time dimension in our panel is larger than the number of cross-sections, we used a model estimated thorough the generalized least squares method (GLS) to address the before mentioned issues. The results of the evaluated models are shown in Table 4:

Table 4 **Testing impact of independent variables on Yield using a fixed effects model and a model estimated by the generalized least squares method**

	(1) FE	(2) GLS
Maturity	0,0319	0,0428***
	(0,0201)	(0,000944)
VIX	0,0105***	-0,000342
	(0,00189)	(0,000276)
6M EURIBOR	10,24***	0,0216
	(1,334)	(0,147)
Credit rating		-0,931***
		(0,0137)
No external opinion		0,0171
		(0,0192)
Constant	4,965***	0,631***
	(0,804)	(0,0817)
N	1690	1690
r2	0,449	
r2_o	0,602	
r2_b	0,620	
r2_w	0,449	
sigma_u	0,493	
sigma_e	0,0758	
Rho	0,977	

Standard errors are shown in parentheses.
* p<0,05 ** p<0,01 *** p<0,001

We conclude that not all explanatory variables are statistically significant in both models by comparing the results obtained by the evaluation of the panel model. We can derive the following conclusions: The longer the remaining maturity, the higher the yield. The higher the expected volatility, the higher the yield. 6M EURIBOR, as one of the main reference rates for euro, also suggests that the yields move in the same direction as it does. Bonds that do not have an external opinion on compliance of the green bond framework with the *Green Bond Principles* bear higher yield, since they may carry a higher risk that the proceeds may not be used to finance environmentally sustainable projects. According to these results, we can accept the hypothesis that higher values of volatility index VIX, 6M EURIBOR, a longer remaining maturity of the bond and the absence of an independent external opinion on compliance of the green bond framework with the *Green Bond Principles* lead to an increase in green bond yields. Countries that have a lower credit rating (Italy and Hungary in this case) have higher yields than those with higher credit ratings. Hence, we can accept next hypothesis – green bonds with a higher credit rating allow for lower required yields.

5 Conclusion

Recently, more and more attention has been paid to ecology, environmental protection and healthier living. This is a consequence of different "warnings" from nature, which also encouraged the adoption of international frameworks, agreements and strategies in order to slow down global warming. High investments in environmentally sustainable projects enabled the creation and development of the green bond market. This market is still emerging and the amounts and number of issued green bonds is rising every year. The base of investors and issuers of these bonds is increasing, as is the number of currencies in which green bonds are issued. Still, there are some challenges that need to be overcome in order to increase confidence that these bonds will finance green projects. One of the major questions is what projects can be considered as environment-friendly and how to avoid investing in "green" bonds that do not actually finance sustainable projects. The number of standards and taxonomies is increasing in order to prevent greenwashing and regulate this market.

The entry of governments into the green bond market can have a positive impact on the entry of other participants and increase investor confidence that green projects will be financed (Tolliver et al., 2020). The government green bond market is currently dominated by European countries, especially since the beginning of the COVID-19 pandemic. That is the reason why we focused on European government green bonds in our analysis. The goal was to examine whether green premium exists and how 6M EURIBOR, VIX, remaining maturity of the bond, absence of an external opinion on the green bond framework and credit rating affect green bond yields.

We compared green bond yields on the first trading day with their reference yield curves and found no greenium in most of the cases. The same conclusion was reached when the average yield on these bonds was compared with conventional benchmarks. That can be due the fact that there are no perfect benchmarks for green bonds. Germany is the only country in the sample that issued both conventional and green bonds with the same key characteristics and in that case greenium was found. In the case of Serbia, where the results of the analysis depend on which of the two conventional bonds we choose as the benchmark, we estimated the yield of the hypothetical conventional bond using linear interpolation, and the results of this comparison show the existence of greenium. Also, some countries lack various maturities when forming the yield curve, which can also affect the results. Since this market is rising, it is expected that more countries will enter this market and that issuance of these bonds will continue to grow rapidly. Furthermore, with a larger sample the existence of greenium could be assessed more accurately.

We used panel regression to test the impact of 6M EURIBOR, remaining maturity, VIX, credit rating and absence of external opinion on green bond yields. The following can be concluded:

- higher values of volatility index VIX, 6M EURIBOR, a longer remaining maturity of the bond and the absence of an independent external opinion on compliance of the green bond framework with the *Green Bond Principles* lead to an increase in green bond yields;
- green bonds with a higher credit rating allow for lower required yields.

Appendix

Table 1 **Decomposed variances of variables**

Variable		Mean	Std. Dev.	Min	Max	Observations	
Yield	overall	.2747373	.6443952	-.868	1.912	N =	1690
	between		.6621129	-.7150846	1.582177	n =	13
	within		.1016594	.0220527	.6045604	T =	130
Maturity	overall	13.24438	7.366417	4	27	N =	1690
	between		7.65674	4	27	n =	13
	within		.3406872	12.50592	14.12899	T =	130
VIX	overall	18.10946	2.173647	15.07	27.59	N =	1690
	between		0	18.10946	18.10946	n =	13
	within		2.173647	15.07	27.59	T =	130
MEURIBOR	overall	-.5182385	.0061522	-.531	-.505	N =	1690
	between		0	-.5182385	-.5182385	n =	13
	within		.0061522	-.531	-.505	T =	130
Credit~g	overall	.8461538	.360908	0	1	N =	1690
	between		.3755338	0	1	n =	13
	within		0	.8461538	.8461538	T =	130
NonSec~n	overall	.0769231	.2665482	0	1	N =	1690
	between		.2773501	0	1	n =	13
	within		0	.0769231	.0769231	T =	130

*Abbreviation NonSec refers to the absence of an independent external opinion.

Table 2 **Partial correlations between independent variables and Yield**

Variable	Partial Corr.	Semipartial Corr.	Partial Corr.^2	Semipartial Corr.^2	Significance Value
Maturity	0.9047	0.5933	0.8184	0.3520	0.0000
VIX	0.1251	0.0352	0.0156	0.0012	0.0000
MEURIBOR	0.3133	0.0922	0.0982	0.0085	0.0000
CreditRat~g	-0.8910	-0.5483	0.7938	0.3006	0.0000
NonSecond~n	0.3520	0.1051	0.1239	0.0110	0.0000

Table 3 **Hausman test**

	Coefficients (b) fe	(B) RE	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
Maturity	**.0319438**	**.0402662**	**-.0083224**	**.0034003**
VIX	**.0105255**	**.0105356**	**-.0000101**	**4.13e-06**
MEURIBOR	**10.23539**	**10.0726**	**.1627884**	**.0665108**

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

chi2(**1**) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= **5.99**
Prob>chi2 = **0.0144**
(V_b-V_B is not positive definite)

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TRENDS IN DIGITAL PAYMENTS – SERBIA'S DIGITAL PAYMENTS INDEX

Ilija Etinski, Bogdan Stanišić, Aleksandar Aleksić, Ivan Radanović

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Trends in digital payments – Serbia's Digital Payments Index

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Abstract: Technological advances over the past decades were conducive to the payments industry and exerted a significant impact on its trends. Today, payment service providers offer a wide range of payment instruments, applications and services and all these elements often rely on information technologies. Owing to the development of these solutions by the payments industry and their acceptance by users, the processes of payment service digitalisation and digitisation unfold. To track these processes as much as possible, this paper proposes a method for the analysis of payment transactions in Serbia, which captures all the elements relevant for the digital payments industry in our country. The result of the proposed analysis method is Serbia's Digital Payments Index (DPI), which gives a new dimension to monitoring the evolution of payment transactions, specifically in the digital segment. The DPI is an index that shows the evolution of the use of digital payments in Serbia over time. It is based on five pillars. Digital payments trends in Serbia are in sync with global trends and the most state-of-the-art payment methods are on offer. When it comes to the use of cards and e- and m- banking channels, the number of users and transactions are on the rise, making a significant and steady upward pressure on the DPI in recent years, which means that the spread of digital payments in Serbia increases year after year.

Keywords: payments, digitalisation, development, payment services, NBS, cards, mobile phones, DPI, COVID-19, statistical reporting, Serbia
[JEL Code]: C43, C80, E42, E58

Non-technical summary

Money transfer methods are improving every year owing to the technological progress applied in the creation of payment services. For this reason, digital payment methods are gaining in prominence. They entail the use of mobile smart devices, computers, cards and other media which enable the transfer of funds without a physical exchange of cash at brick-and-mortar and online points-of-sale, as well as in other transactions of natural and legal persons. Efforts to improve and globally expand the digital payments market were stepped up in the last two decades of the 20th century. Beside technological progress, the widespread use of digital payments is additionally supported by i) the changes in the supply of payment services which are becoming increasingly competitive and are no longer in the hands of financial institutions only, but also non-financial payment service providers, ii) regulations conducive to the development of safe payment methods and increased market efficiency, and iii) acceptance by end-users which depends on setting competitive price structures in the payments market, use value for consumers, but also external events, such as the COVID-19 pandemic, which shape users' perception and preferences.

Trends in Serbia indicate a greater use of digital payment methods, the most dominant being m- and e- banking and payment cards, where innovations are the most frequent and are duly recognized by users as such. The main contributors are a regulatory environment conducive to the introduction of new payment services and digitisation of existing ones, the establishment of modern payments systems (NBS IPS payment system), and connecting the existing payment methods to smart devices in the market, i.e. using available technology to cover additional market niches. The effects of the COVID-19 pandemic inevitably encouraged Serbian citizens to pay even more attention to contactless, digital payment methods.

Serbia's Digital Payments Index (DPI) was created by adjusting the Reserve Bank of India's DPI to the conditions in our market. The purpose is to show the spread of digital payments in Serbia over time. The Index covers only digital payment methods, without cash and paper-based instruments (paper transfer orders, payment slips, cheques, etc.), in the following categories: payment services infrastructure; degree of technological development; payment performances and customer experience. These categories are separate areas in the payment ecosystem, starting from the infrastructure which entails the issuance and acquiring of digital payment instruments, through the degree of technological development which analyses the conditions enabling the use of digital payments in the territory of Serbia, payment performances which measure the extent of use, i.e. digitisation of payments, all the way to customer experience that relates to the data about the awareness and experience of consumers with the use of digital instruments. The methodology for making the DPI is based on the calculation of the value of each individual pillar for every year, using the indicators of that pillar, after which these values are weighted by the relative importance carried by each pillar in the Index, and then added up. Using the indicator whose result is a unique value, a steady increase in the value of the Index was established in the observed period, which means that the condition of digital payments in Serbia is improving year after year. The Index measured 180 last year (2021) and this value is interpreted as an improvement of the condition of digital payments by 80% compared to the base year (2016). The increase serves as positive feedback about the development of the digital payments ecosystem in Serbia.

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1 Introduction

Payments and payment services industry is an exceptionally wide area having gone through significant changes in the past several decades, which resulted in increased efficiency, security and use of services. Amid such developments, smart devices are increasingly used for digital payments and the payments industry is becoming more and more popular with financial service providers.

To attain their market goals, financial service providers, more specifically payment service providers and technological companies greatly exert a positive influence on the deepening and penetration of digital payments. Payment systems executing those payments record the same trend and today the quantity of information they process is much larger than in the previous decade, which enables more efficient cash flow management and monitoring. A payment system is a part of the financial infrastructure of a country which enables the transfer of monetary assets between participants in the system. It comprises a set of instruments, procedures and systems for the transfer of monetary assets that enable money circulation. The system should be reliable, which primarily implies safe transactions and the continuity of availability for users.

In meeting these and other requirements, without losing sight of the still indisputable importance of cash, a modern payment system relies on the rising importance of digital payment services, i.e. digital payments. In the broadest sense, digital payments may be considered transactions which do not use cash or other analogue payment instruments (cheques, paper transfer orders, payment slips, etc.). In this paper, the concept of digital payment primarily refers to the transfer of funds from the payer's to the payee's account based on the exchange of information in the digital form from the payer to the payee through their payment service providers who do the transfer.

Digital payments are constantly evolving, reflecting ongoing interaction between payment service providers, information technologies and the needs of end-users. As a result of such developments, and partly due to the need for better speed and safety, innovations replacing the use of cash may be traced back to the second half of the 19th century up until the latest trends such as digital currencies.

As digital payments are undergoing intense development, the need for measuring their trends, results and ultimate impact on the economic system rises. Many institutions, companies and independent researchers are trying to keep track of developments in this area and this paper is only one in a series of attempts to contribute to a better understanding of the ways of monitoring the digitalisation of payment services and measuring the achieved results. The digitalisation of payment services on its own does not automatically and necessarily bring better conditions for economic development or for collective positive impact. Keeping track of the evolution of digital payment services enables the establishment and analysis of their direction and potential for contributing to economic growth. Accordingly, this paper constructs the DPI which observes the most important five categories in the digital payments ecosystem, trying to define the value that represents their cumulative development in the territory of Serbia. The Index helps define and monitor the data relevant for further productive

development of digital payment services and is an instrument which can help identify the drivers and the stoppers of payments digitisation in our country.

The paper is divided in six sections. The next section will give a historical overview of the development of payments technology and its evolution starting from traditional fiat money - cash, more precisely, from the first recorded payment which did not involve physical transfer of money in a direct interaction between the payer and the payee, up to modern tendencies including digital payments. What follows are analyses of the global landscape of modern payment types and the trends in Serbia. After that, the Serbian DPI is presented, as a new method for the analysis of the use of digital payments in Serbia over time.

2 A brief history of digital payments

An important breakthrough in using technology for payments was recorded in the second half of the 19th century. In 1871, American company Western Union made a "remote payment" using the telegraph. First a payer would pay the money to the nearest telegraph station and then the station would send a telegram to another station where the payee would take the funds. Different passwords were used as a security mechanism for payment authorisation and the estimate is that in the years that followed the value of such transfers exceeded two million dollars a year. After the initial breakthrough, cashless payments progressed at a moderate but constant pace technologically, at an already established main principle – what was in fact transferred from one point to another was the message to debit the payer's account and credit the payee's account.

At the very beginning of the 20th century the described payment method, though somewhat modernised, was used by the Fed for the transfer of funds, while in the following several decades the technological development of cashless payments was associated mainly with payment cards, also in the western hemisphere.

The next chapter of the evolution of cashless payment instruments was dominantly written by Farrington Manufacturing and Diners Club between the 1930s and 1950s. The former was a pioneer in producing metal payment cards largely like the ones used today – of rectangular shape and bearing the payer's personal data. The latter launched the first card in the market. Unlike previous cards, this one was in general use, used with more merchants. It was Diners Club innovation in particular that provided the necessary momentum to intensifying market competition and thus, to new technologies and business innovations of other participants in the national and international market. The 1970s were marked by the penetration of two innovations in the issuance and acceptance of cashless payments (dominantly card payments back then): the magnetic stripe card with information about the name of the holder, account number and date of expiry (as a non-patented IBM invention) and the ATM. In the same decade the ATM was upgraded by PIN verification by the user. By 1984 the number of ATM terminals across the world is assessed at around one hundred thousand. In 1979, Visa invented a payment terminal, i.e. POS terminal, without which card payments are unthinkable. It was widely used already during the eighties. Later in the decade, specifically in 1986, a French card brand Carte Bancaire launched the first chip & pin payment card in the market, which required an identification number as a security mechanism at a point-of-sale.

The 1990s saw new IT breakthroughs, as a result of intersecting the internet and payments. In this way, soon after the initiation of mass commercialisation of the internet via applications, i.e. browsers like Navigator, somewhat later Internet Explorer, or the founding of companies such as Amazon and Yahoo!, e-commerce also became a mass phenomenon. Following the first online transaction at a book shop website in 1992 and the first consumer system for online payments introduced by Stanford Federal Credit Union in 1994, online payments became widely recognised by the market with the establishment of Paypal, an institution specialised in online payments, which was acquired later by another great e-commerce market player, eBay. Though Paypal was established in 1998 as one of the cornerstones of modern e-commerce, the first traces of what is today called m-commerce already emerged at the time as an attempt at transferring payment functions from computers to mobile phones which today are the key instruments in modern cashless payments.

Last, it is important to approach the phenomenon of increased use of cashless payments from the market demand side i.e. without overlooking consumers' tendency to respond to incentives, particularly price incentives. Namely, consumers react to incentives, but the reaction is neither unambiguous nor easily definable. For instance, a research exploring the dynamics of cashless payments in the Netherlands and Norway in the period between 1990 and 2004, demonstrated an intuitive correlation between an increase in debit card payments (positive correlation from the point of view of cashless payments), a rise in money withdrawals from ATMs (indicator of cash use) and the average price of using these instruments. Namely, in the said period, the average hike in the prices of using/accepting debit cards was 2% and ATMs 14% on an annual level. At the same time, the average annual increase in debit card transactions in Norway and the Netherlands stood at 25% and 33%, respectively. The dynamics are clear when previously matched with the annual rise in ATM money withdrawals: 3% and 9%, respectively. One should bear in mind that on the supply side, in addition to banks, merchants and other technological companies, even the governments themselves have an interest in increasing cashless payments. Knowing that e-transactions are considerably cheaper than those executed by means of physical instruments and that costs of payment transactions may amount to 1–2% of GDP, it is clear why the digitalisation of payments, i.e. their gradual transition from dominantly paper-based to dominantly digital form is welcomed and promoted by various policies.

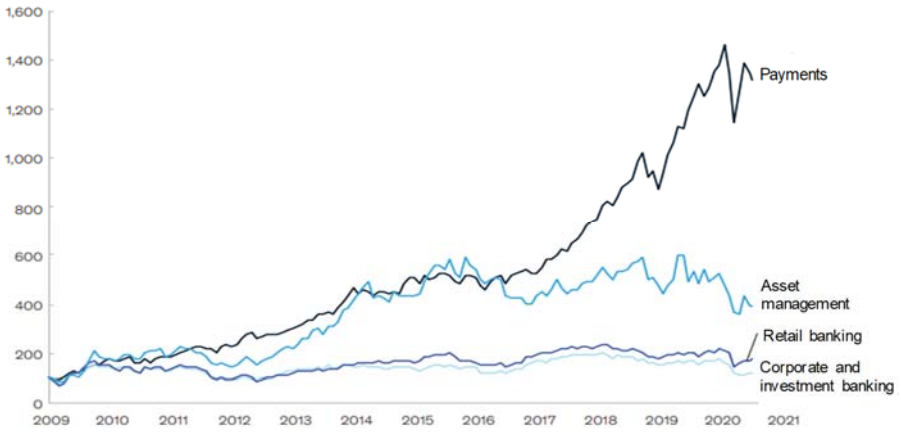
3 Digital payments today

Digital payments have gained traction in the last couple of years. The activity of market players in digital innovations in this area would have continued at least linearly. However, the main incentive to the globally stepped-up trend of innovations unequivocally came from the COVID-19 pandemic. Despite the initial destructive impact on the real economy of a great number of countries, the pandemic provided a strong market incentive to many banks, card and fintech companies, encouraging them to innovate, speed up and simplify cashless payments. In addition to the immanent profit motive, the need for new innovations was also induced by the rising market demand for cashless payment modes, i.e. consumers' fear of using cash. Accordingly, considering technological innovations in digital payments in recent

years, it is important to have in mind the catalyst and not the causal significance of the pandemic. In other words, innovations in digital payments would have occurred anyway, but not with such intensity and to such extent.

The above is no surprise bearing in mind that in recent years payments, as a global market segment, proved to be one of the most dynamic and promising banking/financial services. This is easily discernible in a comparative overview of standard banking activities from the point of view of overall value creation, approximated with a total shareholder return (TSR) of selected publicly listed companies. Such an overview for the 2009–2020 period can be found below.

Chart 1 **Comparative overview of added value creation by different banking/financial activities**



Source: Denecker, Lishinsky et al. "A burning platform: Revamping bank operating models for payments", The 2020 McKinsey Global Payments Report, October 2020. Adapted by the author.

In addition, Chart 1 shows a unique business vitality of the payments industry. Owing to the dynamic upward trends in recent years, if not decades, and despite the direct negative impact of different government measures implemented as a protection from the contagious virus – primarily lockdowns – the largest payments companies have rebounded surprisingly quickly. When governments lifted radical prevention and protection measures, the usual business processes resumed in these companies and continued developing almost as normal.

According to available information, the total value of payments by credit transfers initiated digitally recorded a robust growth in both advanced and developing economies (BIS, 2021). More specifically, an increase in the number of e- and m- banking transactions, as well as standing orders transactions, induced a notable rise in the value as a share in GDP of countries across the globe. There is another perspective to qualitative changes in payments, an insight obtained through polls surveying consumer habits of the population. According to the McKinsey's Digital Payments Consumer Survey conducted in 2020, more than three quarters of Americans use some form of digital payment instruments. In terms of dynamics, it is important to note that in 2016, 34% of respondents making digital payments used a single instrument i.e. a form of digital, cashless payments. However, in 2020 the share dropped to 20%, while 58% of consumers using digital forms of payments stated that they used two or

more different instruments. In terms of the pandemic, an even more significant insight was that in 2019, 36% of respondents stated that they were interested in contactless payment card (27 pp), or were already using it, while at end-2020, 53% stated the same (interested in using – 32 pp, using– 21 pp).

Considering the obvious advantages of cashless payments for payment service providers and consumers, and their dynamics and impact on the global economy, one can succumb to the impression that the use of cash is declining. Nevertheless, it is still rightly perceived as a rather safe payment method. Also, according to the data of Simon Kucher marketing agency which explored the American consumer experience, cash is perceived as the fastest payment method, followed by payment cards which are swiped or inserted in a POS terminal. In fact, mobile phones, regarded as the key instrument in technological innovations in payments, are deemed a considerably slower method (Ke, Chung et al, 2019). The said study concluded that the reason was the time distance (e.g. ten seconds) between the initiation of a mobile payment and electronic authorisation, i.e. receipt of confirmation of its final realisation – perceived as too long. During this interval, the focus of consumer's attention is on the waiting and the waiting time is overestimated, while cash payment does not suffer from such a problem, bearing in mind the payment procedure is fraught with action (taking out the cash and handing it over, taking over of cash by the salesperson, handing over the merchandise and the receipt, etc.), which reduces the consumer's feeling of wasted time, i.e. time lag. On top of that, almost a half of the reasons stated against the use of mobile phones are concerns over identity theft and fraud. This goes hand in hand with the information that barely 7.6% of respondents consider their mobile phones the preferred payment method.

The above means that cash and payment cards are frequently used payment instruments. The fact that at this point as much as 7.6% of the population prefer using their mobile phones for payments indicates that mobile payments have a large development potential. Promoting this method by offering different combinations of rewards and incentives, more simplified applications and hence consumer experience, as well as by creating a stimulating environment where mobile phones are desirable payment devices, may increase the presence of phones in the payment services market in the future. At the same time, this is the guidance for future bank and company operations in applying finance, i.e. information-communication technologies in payments.

4 Digital payment trends in Serbia

The digital payment trends in Serbia are in line with the global trends in the supply of modern methods of executing payments, whether at a brick-and-mortar (physical) or online point-of-sale. The use of digital payments has recorded a continuous rise in recent years, in terms of both the number of executed transactions and new users. Factors affecting their rise depend, among other things, on the payment instruments that market participants offer to users, while at the same time ensuring services that are secure and high-quality. Innovations implemented in the framework of payment instruments further affect the development of services and their acceptance by end-users. These innovations concern improvement of available smart devices in the market, such as the capacity of mobile phones to use QR codes

or the ability to connect payment cards to smart devices (mobile phones, smart watches and similar devices), but also innovations related to the improvement of the speed of processing and sending payments, and therefore faster transfer of money between accounts. Moreover, it is the users' preferences that ultimately determine the choice of the instrument from a range of instruments offered in the market. Last but not least, events such as the COVID-19 pandemic gave rise to new influences on users' preferences, such as reducing health risks, and hence giving importance to online stores and contactless payment methods.

In recent years, the most common channels for initiating digital payments used by consumers and corporates were m-banking, payment cards and e-banking. In 2021, the annual number of m-banking transactions increased by 8.5 times (up by 47 million), payment cards by 2.4 times (up by 205 million), and e-banking by 1.6 times (up by 58 million) compared to 2016. Hence, in this group, the highest growth rate is recorded by m-banking, which reflects the positive influence of innovations, as well as the fact that mobile phones are used every day. On the other hand, although they do not have the fastest growth dynamics (due to the large base of transactions), payment cards carry the status of the most used instrument in the payment market, primarily due to their simple use and the range of physical and online points-of-sale with implemented solutions for their acceptance. Also, payment cards in their digital or tokenised form (NFC technology in mobile phones or smart watches) expand the possible ways to initiate card payments and thus cover a larger segment of the payment market. Greater use of cards is evidenced by the expansion of the network of POS terminals with the function of accepting card payments at physical points-of-sale by over 30,000 from 2016 to 2021. This is how the market of payment services develops on the side of both acquiring and issuance of this instrument.

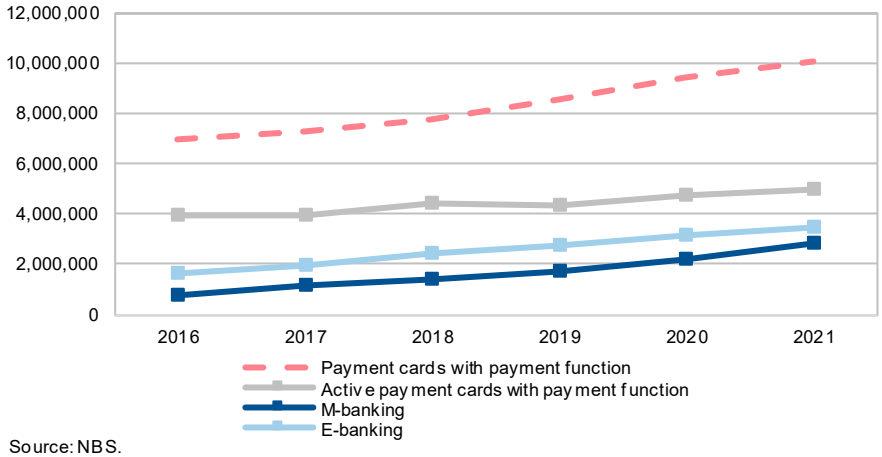
Owing to innovations that contribute to the efficiency of payment execution, above all to the speed of execution, additional benefits are created for end-users, primarily in terms of availability of funds in the recipients' accounts within a few seconds. This type of innovation was implemented through the Instant Payment System of the National Bank of Serbia –the NBS IPS, a system for processing retail payments (individual payments whose amount does not exceed RSD 300,000) in the territory of the Republic of Serbia. The system operates 24/7/365, that is, in real time. Since its launch on 22 October 2018, the average time required to process a transaction sent to the system is 1.1 seconds, which makes the services connected to this system the fastest channels for transferring funds from the payer to the payee's account.

Beside the basic possibility of making an instant (credit) transfer to any payee with a bank current account, additional services enabled in the NBS IPS payment system refer to the payment of monthly bills for public utilities and other services by scanning the unique NBS IPS QR code on the bill/invoice; using the IPS Scan and IPS Show methods at physical and internet points-of-sale; using Transfer service – with a specific payee's code, i.e. his mobile phone number. There are also the Generator and Validator services that enable the generation (technical preparation) of the NBS IPS QR code, as well as the validation (technical check) of an already prepared NBS IPS QR code. The acceptance of this innovation is evidenced by the number of transactions processed in the NBS IPS payment system, which has been growing year after year, with the average daily number of transactions in 2019 reaching 19,066 payments, while in 2021 that number was six times higher – 115,787 payments. Also, market

players offer applications that use the NBS IPS QR code concept, that is, they create and offer a service which allows their users to simply request the transfer of funds to their account from the payer by showing the payer the NBS IPS QR code with their current account for scanning. Therefore, the established payment system and its products do not only affect the execution of payments, but encourage innovation in the economy, with greater inclusion and opportunities for the providers of technical and/or payment services within the Serbian payments industry.

The growth in digital transactions correlates with the number of new users who are increasingly opting for digital payment channels. Firstly, generally speaking, the basic prerequisite for their increase is the percentage of the number of people who have been using the internet daily in the past three months relative to the population of Serbia – 57% in 2021 vs. 44% in 2016. This data is particularly important for payment methods that require an internet connection, starting with online purchases with payment cards, which increased by more than 23 times in the same period (from 870 thousand to 20.5 million). When it comes to the number of users of digital instruments, in the period from 2016 to 2021, the number of m-banking users increased by 3.8 times (to 2.8 million) and e-banking users by 2.2 times (to 3.5 million). The total number of issued payment cards with payment function increased by 1.5 times (to 10.1 million) and the number of active payment cards by 1.25 times (to 5 million). The mentioned indicators are shown in the following chart:

Chart 2 **Number of registered m- and e-banking users, issued and active payment cards with payment function**



Source: NBS.

The COVID-19 pandemic has undeniably led to the accelerated adoption of digital and contactless payment methods since 2020, significantly determining consumer preferences. The results of a study conducted between 7 April and 4 May 2020 in the Republic of Serbia showed that 24% of respondents who made online purchases after the pandemic did not have this habit before the pandemic (Ivanović & Antonijević, 2020). The authors also state that the three main motives for online shopping are as follows: most stores are online only, reduction in health risk, and saving time. For those who did not purchase online before the outbreak, but started doing so afterwards, the first two motives for shopping online are the same, while the third one is different – lower costs. In addition, it was determined that the majority of respondents purchased the following product categories online: food (groceries), medicine and books (magazines, newspapers). Respondents who did not shop online before the outbreak of the

pandemic, but started afterwards, mostly bought clothes and sports equipment and household necessities, followed by food and books, magazines, and newspapers.

Considering the above, the process of digitalisation of payments in Serbia directed towards m-banking applications is in full swing. M-banking is currently the fastest growing payment instrument. As a global trend, mobile phones stand out as the drivers of development and innovation in the field of changes in payments, with mobile phone payments gaining in popularity after the outbreak of the pandemic. The increasing use of m-banking applications encourages the use of technology not only by customers but also by banks. Given that banks are not only providers of payment services but also of other financial services, the greater use of m-banking applications, which is currently associated with digital payments, may provide other benefits outside this area, such as the digitisation of internal and other external banking processes (not only payment services). It can be an incentive and an example for greater efficiency in the provision of various banking services and, consequently, for an additional increase in the efficiency of the banking system in our country through the use of information technology.

The popularisation of the use of mobile phones and their applications in payments leads to the formation of new business models and to a better user experience when paying, especially via internet. In addition, the presence of smart mobile devices in everyday life is increasing and contributes to greater possibilities for users when it comes to choosing the time and place to initiate payments. The development of technology enables greater security and simplicity in making payments and using cards, which shows evident results in our market. The domestic card network has recently started issuing chip cards which increase the security of executing transactions at points-of-sale, while international card systems in Serbia have provided contactless payments for card users for many years. They also allow the card to be connected to the aforementioned smart devices and their applications (mobile/digital wallets). Along with the development of retail payments, e-banking, which has been used for high-value transactions for many years, has recorded positive results in the market, increasing the number of users, as well as the number and value of transactions executed in this way. Therefore, card payments, e-banking, m-banking and mobile smart devices are considered as the primary, market-recognised drivers of the expansion of digital payments in the Republic of Serbia.

5 Serbia's Digital Payments Index

A proliferation of initiatives and trends in the field of digital payments is relatively difficult to track. While many of them are extremely interesting, only some products (results of initiatives and trends) live to become massively used among the population, developing a significant impact on payment services and, consequently, on the economy. Digital payments development can generally be divided into digitalisation and digitisation of payments.

Payments digitalisation is a process of creation of a payment service or a payment instrument which provides certain services within a digital format. It is not a rare case that an existing service, relying on paper instructions, is translated into a digital form which may emphasize one or more of their existing features, or create new ones. This is one of the reasons why many payment services experts are not surprised by innovations and may easily offer an

example of a relatively similar service which is not in a digital form. Payment services digitalisation leads to the emergence of a large number of same-type services in payment operations and upgraded features of the existing "analogue" payment services. The upgrades are generally reflected in higher security and simplicity of use of a payment service and easier processing of a larger data quantity (enabling large-scale use of payment services).

On the other hand, digitalisation in itself will not make the service more pertinent to the economy. There are trends of digitalisation of different payment services where a multitude of same-type services compete both between themselves and with other digital service clusters. Looking at market competition between payment services, we need to distinguish the concept of payment service digitisation. Digitisation is a diffusion of digital payment services across the economy. Wishes and abilities (e.g. digital literacy) of payment services consumers also play a part in this process, i.e. their consumer ability to use digital payment technologies in payment, manner of placement of new services, their business models and added value they bring to consumers, as well as many other factors. In a general case, digitisation may be considered to mean the success of spreading of digital payment services. Accordingly, when payment services in a country or region are digitised, this turns out to be only a small part of the work that needs to be done on development of the digital payments ecosystem. In order for the corporate sector to benefit from advantages of service digitalisation, great efforts need to be invested in digital service digitisation to the widest possible consumer base. A digital payment service that is most widely disseminated across the economy is the most important for that economy, while a service that is merely created is as good as a non-existent one.

In order to monitor payment services digitisation in our country, we use the digital payments index (DPI). There is a multitude of indices and analyses aiming to keep track of the digitisation of all or some payment services on a global, regional or local level and to consider in more detail the areas of operation or development of those payment services. In line with that, the Reserve Bank of India recently published its DPI analysing five important areas related to digital payment services provision in that country. The analysis and idea of the Reserve Bank of India have spurred thoughts about creating a similar unit of measurement for the Republic of Serbia.

Given that these are two hardly comparable economies, the DPI model developed for the Republic of Serbia, while resembling in some parts that of India's, is nevertheless unique, and cannot be compared to it. Given the state of play of Serbia's payment services market, some of the indicators captured by the DPI and the manner of their clustering and valuation under the index differ from those in India. While there are some indicator clusters which are identical to those from India's index, they are however universal for every payment services market (e.g. card number, account number, number of POS terminals…).

While the Reserve Bank of India did not specify their index calculation method nor did it explain in detail data monitoring methodology, it can be observed that its index also captures data on cash use (e.g. cash withdrawal). In creating DPI for the Republic of Serbia, any data on use of cash or paper payment orders were strictly avoided.

The DPI did not include elements relating to payments via paper payment orders, such as the in-payment order, out-payment order, transfer order or cheques, or any cash payments. Inclusion of such instruments in the index would create a false picture on digital payments

development, as they could only double the positive effects impacting the index or falsely inflate the index. Aiming to avoid both these effects, these instruments are not considered.

For the sake of explanation, let us consider paper transfer orders. They would have a negative sign in DPI, because a larger number of paper orders means lower payment services digitisation which DPI should monitor. If the number of paper orders were to decrease, with other digital payments indicators remaining unchanged, the index would be falsely inflated (decrease in an indicator with the negative sign produces +), and in case that some of DPI's indicators were to go up by the amount of decrease, a double positive effect would be recorded. DPI captures digital payment services, so positive or negative movements in other payment services/instruments should not impact its value, but only changes in the sphere of digital payment services.

5.1 Definitions and areas captured by Serbia's DPI

Specifically, DPI is a digital payments index focused on digital services of money transfer. Based on DPI movements we draw conclusions on the current state of digitalisation and digitisation of payment services in our country. Further, by revealing factors and influences that shape DPI and its development, it can be concluded which elements serve as drivers or stoppers in digitalisation and digitisation of payments in the Republic of Serbia. Based on such knowledge, public and private agents may make well-informed decisions on their further actions in digital payments. The following payment methods serve as a basis for Serbia's DPI:

- Card-based payments
- Mobile banking payments
- Online banking payments
- E-money payments
- ATM payments
- Direct debit transactions
- Standing order transactions
- Telephone payments

Considering the above, we may offer a final definition of the described concept. **DPI is a unit of measurement showing the evolution of digital payments use in Serbia over time, calculated for the one-year period.**

The index captures:

1. Infrastructure of payment services
2. Degree of technological development
3. Payment performances
4. Consumer experience in payments

The infrastructure can be divided in two areas *i*) the acquiring side and *ii*) the issuance side. On the acquiring side, we look into the indicators related to acceptance of digital payments, enabling consumers to use their instruments in a variety of ways. The issuance side on the other hand relates to channels and instruments facilitating the use of payment instruments for consumers (e.g. payment cards, mobile banking applications etc.).

The degree of technological development relates to influences outside of the wide range of payments operations of a particular country, which impact the execution of digital payments. These include internet connection, mobile phones, general technology use and possibilities to connect technology with payments. For example, internet use in itself has no relevance for payments unless the consumer has opened a bank account. However, if the consumer has such an account and is skilled and capable of using the internet, then there is a possibility to use e-banking and execute digital payments. This is similar to mobile phones and m-banking applications or an m-wallet containing a payment instrument (e.g. card). This cluster includes items that may not be classified as payment services infrastructure, but which are nevertheless extremely important for its use.

Payment performances include statistical indicators of digital payments use in the period observed. They are represented by the amount of transactions carried out through digital channels and the number of transactions executed in the period observed. The number and value of digital transactions are indicative of the cumulative effect of the infrastructure used, factors outside of the scope of the payment system in a broader sense and consumer satisfaction with the current services. Previously mentioned index elements also capture this effect, but their development directly impacts payment performances, while performances on their part do not have such impact on the above elements, but are rather the result of their effective use.

Consumer experience in digital payments means unhindered use of payment instruments for the sake of performance of digital payments. It also includes financial literacy of the population, i.e. the awareness about the availability of different payment methods and their features. This element also analyses buyer i.e. consumer complaints, unauthorised payment transactions etc.

5.2 Methodology

Previously mentioned areas which significantly impact DPI serve to form index pillars:

Possibility of payments

Payment services infrastructure on the issuance side

Payment services infrastructure on the acquiring side

Payment performances

Consumer experience is considered to be the fifth pillar. It is understood as a descriptive parameter, meaning that the values observed within that pillar will not be taken into account when calculating DPI value, though they make an integral part of DPI analysis. The trust and experience of digital payment service consumers are important factors in the process of

increasing the use of these services in the corporate sector, so this data category is observed as part of the analysis of the state of digital payments in the Republic of Serbia.

For the sake of comparison, India's index contains a pillar processing similar data as the above Consumer Experience pillar and according to their methodology, its calculated value is assigned 5% weight in the index formula. As this area of digital payments is by no means negligible, it is understandable that the Reserve Bank of India decided to incorporate it in index formula. However, a quantitative expression of consumer experience (however measured) included into the calculation which uses elements such as the number of payments (in millions), value of payments (in billions) and other, leads to potentially inadequate representation of such data relative to other data clusters. Also, the 5% share in the index could also excessively reduce the impact of this area on payments digitalisation, given that it could entail a marginal impact on changes in index value.

Based on the above reasons, the data cluster aiming to capture consumer experience in DPI is interpreted along with its value, as an integral part of the index, aiming to descriptively grasp the state of play of Serbia's digital payments.

All of the pillars stand for indispensable and mutually interdependent areas of an economy's payment operations. Based on the features of Serbia's payment operations, each of the pillars/areas observed is assigned an appropriate weight in the final DPI calculation formula.

Prior to assigning weights and explaining the reasons for the designed structure, we need to explain how to obtain the unique DPI value. This index is calculated for each year based on the indicators from the above pillars. Each pillar has its value at the annual level calculated based on its respective indicator values. The obtained pillar value is multiplied with the assigned weight and the resulting products are added up to create DPI. In the base year DPI has value 100 and its values in subsequent years are considered relative to the base year, as this is a base index. DPI calculation formula:

$$DPI = (PILLAR1*Weight1) + (PILLAR2*Weight2) + (PILLAR3*Weight3) + (PILLAR4*Weight4)$$

For example, if we take 2016 to be DPI's base year (value 100), and then calculate that in 2019 DPI climbed to 200, it means that according to this indicator, the state of play and potential of digital payments in the Republic of Serbia was twice better in 2019 relative to 2016. If it reaches value 300 in 2020, it means that that year saw three-fold improvement compared to 2016. However, its value has not doubled relative to the previous year (2019), i.e. increased by 100 percent or percentage points. DPI is designed in such a way so that its value rises almost exponentially in case of expected development of digital payments and this value should always be observed relative to the base year, in order to avoid confusion in the interpretation. The text below presents data which will further clarify this analysis.

As can be observed in the formula, DPI value depends on weights assigned to each pillar, the formula for the calculation of pillar value and elements incorporated under each pillar. The sum of all weights is one (1). The weights are created based on interdependence between the areas and their impact on digital payments, consistent with the state of play of digital services

in the domestic economy. The formulas for calculating the values of individual index pillars are presented in Annex 1, and the following text elaborates on the main reasons behind the selection of particular data and weights which make up the DPI and their accompanying rules.

5.2.1 Possibility of payments

The first pillar concerns possibility of payments and has the least impact on digital payments compared to other pillars. This pillar offers insight into the availability of internet connection, mobile devices, bank accounts and other factors instrumental for executing digital payments by the population. All the elements under this pillar represent potential preconditions for the use of digital payments, but availability of these elements to corporates/households does not automatically imply higher digitisation of payment services. Consequently, the weight assigned to this data cluster is 0.1 or 10%. Taking all the above into account, the pillar elements are as follows:

1. *Internet.* Internet, i.e. the broadband network with its infrastructure, providers and consumers, has a significant impact on digital payments. As such, it is represented by two indicators within DPI calculation: *number of consumers accessing internet each day relative to the total Serbian population and percentage of households owning internet connection.*
2. *Mobile devices*. Mobile devices may be used in a variety of ways within digital payments, which is why their use is important for DPI. The indicator observed is the *percentage of mobile phone use in Serbia.*
3. *Bank accounts*. Bank accounts, as a pillar element, are used as a *ratio of the total number of natural persons owning at least one current account and the number of the population of eligible age for opening a current account with a bank* (16 and above).
4. *ICT use.* ICT use impacts the ability and interest among the population to execute digital payments, i.e. it has a significant impact on the possibility of digitisation of payment services. Given that internet and mobile phones are already covered, this element is observed as *a percentage of persons to have used the computer over the past three months*.
5. *Digital literacy of companies: website and e-commerce*. Depending on whether they own a website and engage in e-commerce, companies are observed in terms of the *percentage of companies offering online orders or booking of products/services via website*. This indicator is observed as it brings added value to DPI which cannot be compensated for by the pillar incorporating online points of sale. It covers companies which allow for effecting payments via cash on delivery, payment order or in some third manner which however does not lead to the website being registered as an online point of sale in the official statistics and records kept by persons dealing with acceptance in our country.

5.2.2 Payment services infrastructure on the issuance side

The second pillar entering DPI formula concerns the payment services infrastructure on the issuance side. This area covers data on digital payments instruments. Owning any one of such instruments enables consumers to effects digital payments. Since this data cluster is one of the two basic preconditions for the execution of digital payments, it is more relevant than the previously considered area in the first pillar and is therefore assigned higher weight in DPI formula. The weight assigned to this pillar is 0.2 – meaning that 20% of the index value depends on the current status of the payment operations infrastructure used by payers to initiate their payments.

This category consists of the following elements:

1. *Cards.* Cards are currently the most widely used instrument for execution of digital payments. For DPI purposes we observe *a total number of active payment cards with the payment function and the number of cards with the e-money function.*
2. *Electronic banking.* E-banking offers a number of financial services and is currently an extremely popular channel for effecting payments, largely used by legal persons and entrepreneurs, thus influencing digitalisation of payments within business processes in Serbia. DPI uses the *number of e-banking applications* as an indicator of e-banking.
3. *Mobile banking.* M-banking, same as e-banking, offers a number of financial services, and the latest trends in payment services market in our country testify to its becoming an extremely important channel for execution of digital payments. An m-banking indicator monitored for DPI purposes is the *number of m-banking applications*.
4. *Direct debit.* This is a separate payment service enabling payment automation, where a payee, based on the payer's consent, initiates a payment transaction to debit the payer's payment account. The payer may give such consent to the payee, its payment service provider or payee's payment service provider. In our country, this service may be executed, inter alia, via direct debit clearing, operated by the Serbian Banking Association. It enters the DPI value via *the number of contracted direct debits*.
5. *Standing order.* While the standing order service may be initiated by submission of a paper form, without the use of digital channels after making an agreement, it enables consumers to automatically execute payments in future, which may be considered to be a digital payment. Therefore, this category is a digital payment service and its prevalence should be captured by the index. For DPI purposes, *the number of standing orders* is monitored.

5.2.3 Payment services infrastructure on the acquiring side

The third DPI pillar encompasses the acquiring side of the payment services infrastructure. Within this area, data are collected about devices on which the payee uses his digital payment instrument to execute digital payments. This area is primarily concerned with the diffusion of the acquiring network and other devices (e.g. ATMs) enabling payment instrument users to effect their digital payments. Given that the current status of payment operations in the Republic of Serbia is such that users own a variety of payment instruments which can be used to make payments, the diffusion of the network of devices accepting those digital payment instruments may be considered more relevant. Enhancing infrastructure on the acquiring side may have a greater impact on the rise in digital payments than enhancements on the issuance side.

However, one should take into account instruments such as for example electronic banking, which may be viewed as not having the acquiring side, as it uses payment systems established in the economy to execute transactions, influencing digital payments in that way. This means that the importance of the payment services infrastructure on the acquiring side should not be overestimated either. This pillar participates in DPI value with 25%, i.e. is assigned 0.25 weight. The difference of 0.05 between the second and third pillar reflects the previously mentioned slightly higher importance of this pillar in effecting digital payments in the economy, taking into account the characteristics of payment operations.

The infrastructure on the acquiring side consists of three elements: physical and online points of sale and ATMs.

1. *Physical points of sale (POS terminals, applications and other hardware and software solutions).* Physical points of sale are facilities where payments can be made via some of the existing digital payment instruments in Serbia. This includes payment cards, IPS, electronic money etc. The diffusion of physical points of sale directly impacts the number of digital payment transactions and within this element the index captures *the number of active POS terminals, applications and other hardware and software solutions in Serbia.* This number includes POS terminals, active mobile applications for payment acceptance, mobile devices accepting digital payment instruments (softPOS) etc.
2. *Online points of sale.* Points of sale taken into consideration are those enabling payment via a certain digital instrument such as e-money, payment card, IPS and similar, which are entered in the NBS records. Let us remind that the data on online points of sale which enable only payments via cash on delivery or transfer orders are covered by the first pillar which analyses possibility of payments.

   This element monitors the *number of online points of sale in Serbia.* For the purpose of DPI calculation, this number is multiplied by weight 10. This weight is used in order for online points of sale to maintain within the DPI the level of significance they carry in the payment services area in general. The number of POS terminals does not correspond to the exact number of physical points of sale. Large merchants may install several devices within a single facility or own a number of facilities, and there even may be two POS terminals at a single cash

register, while merchants generally have one online point of sale. Technically, an ideal weight would be the average number of POS terminals per merchant in Serbia. Since it is impossible to identify this number, the weight 10 is most appropriate for the need of maintaining the relevance of online points of sale within the DPI.

3. *ATMs.* ATMs enable the service of bill payment via a digital payment instrument, which is a digitalised service. New generation ATMs bring varied payment options to consumers, which qualifies them as an element under DPI pillar. Given that DPI does not monitor payment transactions related to paper orders or cash, the ATM indicator in DPI captures a limited number of these devices, i.e. only *the number of ATMs with credit transfer function*.

5.2.4 Payment performances

The last pillar calculated within the DPI are payment performances. Within this area, the results of digitalisation and digitisation of payment services in the Republic of Serbia and/or data on executed digital payments are monitored. Given that these are the records of executed payments which in themselves may show a large part of the change toward digital payment services of money transfer, this pillar is assigned the highest weight. Payment performances are multiplied by 0.45 weight, which means they impact 45% of DPI value.

For the purpose of DPI, all digital payments are considered equal. Bearing in mind that the index is used for observing the state of play of payment services in the Republic of Serbia – which includes infrastructure on the side of issuance and on the side of acquiring, as well as payment possibilities in Serbia – the number and value of payments monitored by the index are based on dinar payments executed in the country.

Payment performances encompass two elements:

1. *Number of executed digital payments.* The number of executed digital payments pertains to the number of transactions in the time period for which DPI is calculated. This number is defined by taking into account the number of payments by card, e- and m-banking, e-money, standing order, direct debit and telephone payments (see footnote 12).
2. *Value of executed digital payments*. The value of executed digital payments is an element showing dinar value of digital payments executed over the time period for which DPI is calculated. The value of digital payments is defined taking into account the value of card-based payments, e- and m-banking, e-money, standing order, direct debit and payments by telephone.

5.2.5 Consumer experience

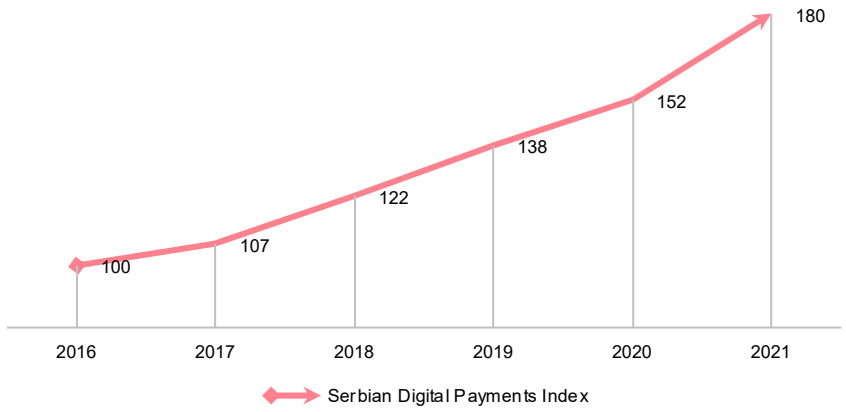
This fifth pillar does not enter DPI calculation, but complements it by shedding light on consumer experience, describing the success and satisfaction of consumers in executing digital payments. An ideal consumer experience would be a digital payment experience with no

barriers, either in the form of internal (systemic) or external factors. In order to measure the degree of positive consumer experience, data are monitored on *i*) *consumer complaints*, given that complaints describe communication with the population and legal persons /entrepreneurs regarding the problems encountered in the use of payment instruments; *ii*) *unauthorised payment transactions occurring due to the loss, theft or abuse of payment instrument data,* which are an integral part of payment and therefore impossible to uproot – but with improvement in technology and education they can be minimised, which is a realisable goal; and, finally *iii*) *consumer preferences,* which may point to different movements in the use of digital payment instruments. While currently there are no data about this element, they could be created in future by using a survey of the population, capturing their wishes, satisfaction and methods of performing digital payments.

5.3 DPI from 2016 to 2021

By using the methodology explained above (pillars, elements and their indicators, mutual interconnectedness of pillars...) we defined DPI value for the prior five-year period. The period observed starts in 2016 which is established as the base year, with index value defined at that point as number 100.

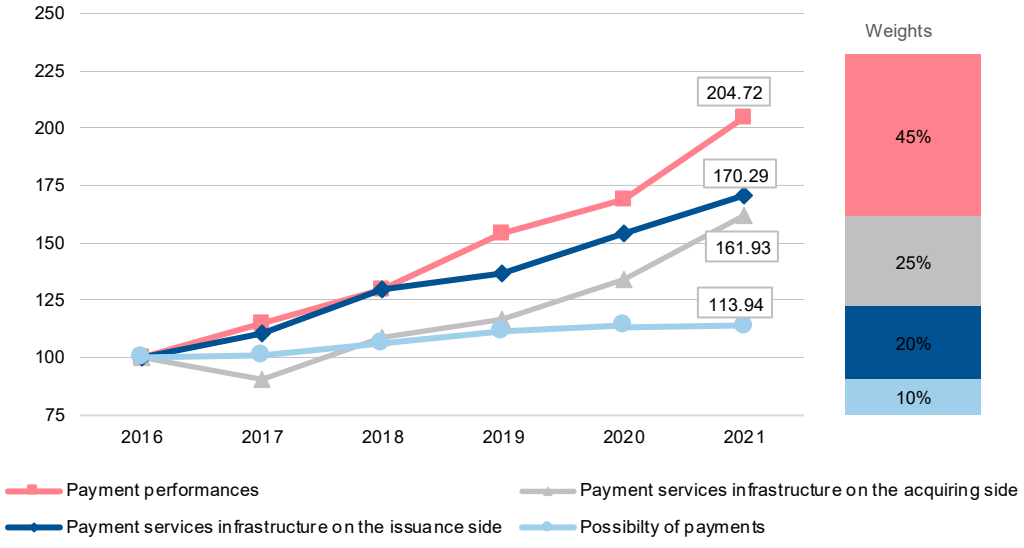
Chart 3 **DPI movement**
(index, 2016 = 100)



Source: NBS.

Chart 3 shows DPI values over time and data in this Chart indicate that the digital payments ecosystem in the Republic of Serbia has recorded constant growth over the past six years. Such trend of development of digital payment services is accompanied by other statistical data collected by the National Bank of Serbia. Given that the index culminates a large cluster of statistical indicators in different payment areas, the constant rise in the index does not imply a constant improvement in all areas which impact it. Data from previous years may show a moderate stagnation in some indicators, and one of the index pillars also declined in value in 2017. Therefore, the index value speaks about the direction of development of the overall digital payments ecosystem and its movement may hide separate movements in individual areas. Given that DPI is based on pillars that capture particular areas, the text below presents the evolution of pillar values since 2016.

Chart 4 **Evolution of DPI pillars and their weights**
(index, 2016 = 100)



Source: NBS.

DPI pillar values have their base in year 2016, when they carried value 100. After 2016, pillar values are observed relative to the base year. Chart 4 and Chart 3 with DPI show the rising trend in the majority of areas which impact the above shown DPI movements. By looking at this visual interpretation we may obtain more detailed information about the reasons behind DPI movements. The text below uses the data from the two charts above to describe the movements in the overall index.

After the base year, the start of the period observed, 2017 saw a decline in the payment services infrastructure of the acquiring side, which had a significant bearing on index result. However, despite this negative movement, DPI experienced growth, though the smallest one recorded in the period observed – of 7 percentage points. The growth stemmed from favourable trends in payment services infrastructure of the issuance side and in payment performances which have the greatest impact of index value. Almost every element on the issuance side contributed to DPI growth, from active payment cards to standing orders, while a negative difference relative to the year before was posted only by the indicator showing a total number of cards with the e-money function. In addition, the number of digital payments in 2017 increased by little less than 43 million transactions, which entailed an increase in the turnover value and these are the key indicators which helped to correct negative movements on the acquiring side primarily reflecting large costs, i.e. fees in this segment of the payment services market.

In the period observed the pillar Possibility of payments had an almost neutral impact, but next year it posted growth which may be considered markable for this pillar. In the period observed this pillar did not undergo major changes, contrary to other pillars, but such movements are expected. The reason lies in the fact that the mobile phone use (the monitored element) has trended high since 2016 and even back then, according to SORS data, 91.8% of the population used mobile phones. Also, the number of current accounts opened in the country

at the beginning of the period observed was high. It should also be kept in mind that it is difficult to abruptly make major changes in basic habits of the population covered by this pillar. The year 2018 saw a more considerable increase in the number of households owning an internet connection and persons who used the computer in the last three months according to SORS data. This is exactly what influenced the pillar movements in Chart 4.

In 2018 these movements were accompanied by the progress in payment services infrastructure on the acquiring side whose growth annulled the fall from 2017 and exceeded the value from the base 2016. The remaining two pillars continued the same, excellent dynamic from the year before, which resulted in a significant increase in DPI, to 122 in 2018. The ecosystem of digital payments services was by one fifth better than in 2016.

After such two-year period, 2019 witnessed a slowed development in the areas observed. This is primarily evident in pillars relating to the payment services infrastructure on the acquiring and issuance side. Such data may be considered an indicator of stable marginal system development. It should be particularly emphasized that the pillar Possibility of payments continues to develop through the element *number of consumers accessing internet each day relative to the total Serbian population and percentage of households owning internet connection,* an indicator posting growth two years in a row. This speaks about the readiness of the Serbian population to accept digital services even before the start of the COVID-19 pandemic. Prior to the pandemic, during the small-scale and stable growth in payment services infrastructure, the number and value of payments in Serbia increased significantly. Payment performances were thus a major driver of the index value. In 2019 it climbed to 138, so DPI proved that digital payments continued up, on the back of the developed infrastructure in existing conditions.

These conditions changed significantly in 2020 and it is very interesting to look at the pillar movements in that period. Namely, the pillar which experienced the most stable and quickest growth until this period, slowed down thereafter. Payment performances increased less vigorously in 2020 due to the COVID-19 pandemic and numerous government measures adopted at the time. Hindered economic activity and shutdowns considerably impacted the evolution of this pillar.

However, as noted in many research papers, the pandemic outbreak had extremely positive effects on payment digitalisation and digitisation. This may be recognised if we observe the pillars related to the payment services infrastructure. There was a large increase in the pillar which monitors the value of payment services infrastructure on the issuance side. The number of active payment cards increased by over 400,000, as well as the number of e-banking users, while the number of m-banking users went up by over 450,000. The acquiring side followed suit by increasing the number of POS terminals and online POS where consumers can make digital payments. In 2020, online POS went up by 77%, i.e. from 1,139 to 2,013 online POS. The pandemic effect is obviously present in the provision of services connected to digital payments, while on the acquiring side this effect was combined with the implementation of the Law on Multilateral Interchange Fees whose implementation in late 2018 triggered a significant decrease in merchant service charges, primarily for the acquiring of payment cards.

The pillar related to possibility of payments posted stable growth in this period, i.e. the consumer base having access to and the ability to use digital services increased even more. As

this pillar did not rise sharply, it may be concluded that the diffusion of digital devices and internet and other elements prerequisite for payment execution was not such a big problem in our country in terms of the further evolution of the digital payments ecosystem. The pandemic outbreak on the other hand induced a change in habits and much greater use of these elements in everyday life which created much better conditions for the development of payment services digitisation and their infrastructure. In other words, the existing potential for digital payment services could be used even better, based on the potential used in 2020 in the form of diffusion of infrastructure and maintaining the growth in the number and value of digital payments. This year's DPI is 152, suggesting that the digital payments ecosystem in the Republic of Serbia improved further in the first year of the pandemic.

The results in terms of the changed consumer habits during the pandemic became evident immediately in 2021, with the number and value of payments posting highest figures on record. The growth rate of the pillar capturing digital payments performances is higher than in other periods observed. Pandemic effects were still felt in 2021, as well as the effects of measures and activities of the NBS, so one observes a further development of payment services market. The increase in value is recorded for both pillars which monitor payment services infrastructure. It is interesting that these two pillars, a kind of base indexes in themselves, are gradually approaching each other. More precisely, the pillar oriented to the acquiring side is catching up with the pillar which covers the issuance side. Given that in Serbia's economy the number of instruments on the issuance side is satisfactory, with a significant base value and faring relatively better compared to acquiring side, such movements are encouraging, speaking about the increasing diffusion of digital payments. The increase in the pillar on the acquiring side means that year after year the population has access to the increasing number of payment instruments. Catching up with and equalisation of the impacts of acquiring and issuance in the economy, i.e. their balance, leads to the maximum utilisation of capacities and even better values within payment performances. DPI has recognised such development of pillars in 2021 as the most optimal, recording the sharpest growth in percentage points. Its value in this period was 180, meaning that the digital payments ecosystem had improved by 80% from 2016. If such pace continues, the results in 2022 could show double improvement from 2016 in terms of the state of play of digital payments.

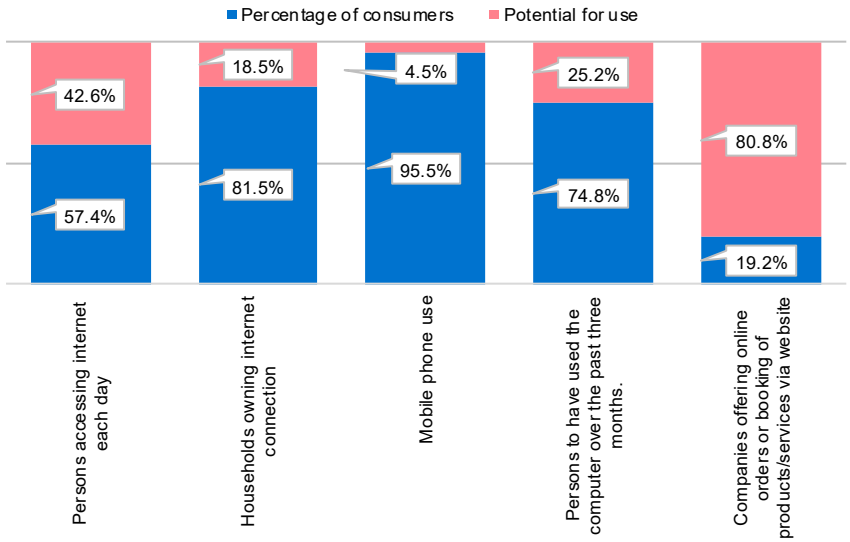
5.4 DPI in 2021

Measured by the DPI, 2021 saw the highest increase in value. This reflects primarily the above positive trends under the pillars Payment performances and Payment services infrastructure on the acquiring side. The areas clustered in such way elucidate the development of digital payments in general, while more information can be obtained by observing individual index pillars and indicators. What follows is an in-depth analysis of the most interesting and most important trends / state of play of elements within pillars for 2021 as this is the last observed year with data that correspond most closely to the current situation in the field of payment services in Serbia.

PILLAR 1 – Possibility of payments

This cluster of indicators was at a satisfactory level for the application of digital payments in 2021. There was a significant percentage of everyday users of the internet, computers and mobile phones, as shown in Chart 5.

Chart 5 **Tapping into and potential of information services user base in Serbia in 2021**



Source: NBS.

Most room for improvement is seen among companies providing the service of online ordering or booking of products/services via their websites. Such potential is important for digital payments given the high value-in-use in online trade. The fact that such potential has not been used even by a fifth, while this year experienced a robust rise in digital payments, stimulates the further development of online trade and encourages all participants who wish to engage in such activity, i.e. provide the relevant services.

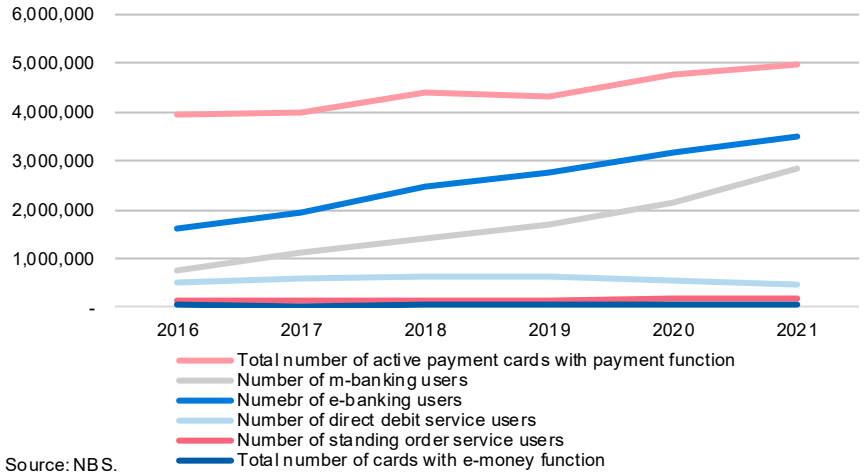
PILLAR 2 – Payment services infrastructure on the issuance side

The issuance of payment instruments was on a rise in 2021. A large number of new m-banking users appeared, and the number of users of e-banking and payment cards continued up at a similar pace as in the past period.

In addition to positive trends, the Serbian payment services market was also marked by negative trends. A decline in users was recorded for payment instruments such as direct debit, standing order and cards with e-money function. Changes in the number of users within the above elements are also shown in Chart 6.

The number of m-banking users rose sharply, from 2,162,362 to 2,840,518, up by 31%. If such trend continues, m-banking users may exceed e-banking users in a few years. In the past three years (2018, 2019 and 2020), the difference between m- and e-banking users equalled constantly one million. In 2021, owing to the above rise, it declined to somewhat more than 650,000 users.

Chart 6 **Movement in the number of payment instrument users by year**



Source: NBS.

The trends of use of digital payments in combination with state-of-the-art technologies in the payment field had an obvious effect on our market. This implies, for instance, the use of contactless card-based payments, which spurred the use of payment cards, also supported by the development of the acquiring network in our market (more details are given under the following pillar). In 2021, the number of active payment cards rose by 202,850. In the past two years, the number of active cards was rising. The use of this instrument indicates the improvement of conditions and positive market trends, which mildly stagnated in some of the earlier observed years. The year 2019 even saw a slight decline in the number of active payment cards compared to 2018 (65,309 active cards less).

PILLAR 3 – Payment services infrastructure on the acquiring side

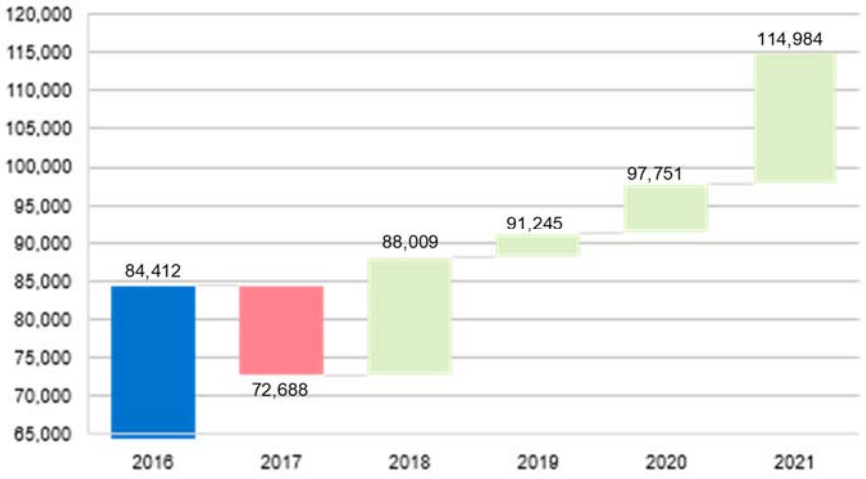
The current period of the development of offer on the issuance side is closely related with the activities concerning the acceptance of payment instruments. In the past several years, the acquiring network in the Republic of Serbia displayed a constant rise, enabling an increasing number of merchants to become part of digital transaction flows.

This rise is reflected primarily in the increase in the number of physical and virtual POS terminals.

The number of POS terminals rose by 17,233 in 2021, which is a significant increase compared to the previous two years. This reflects better market conditions following the adoption of the Law on Multilateral Interchange *Fees and* Special Operating Rules for Card-Based Payment Transactions, owing to which the average fee for the acceptance of payment cards has almost halved compared to the period before the adoption of the Law.

Such movement in the number of POS terminals is also supported by the introduction of a new payment instrument in Serbia within the NBS IPS system. The new method of accepting payments in the market and affordable fees for small merchants also give rise to the increase in the number of payment devices.

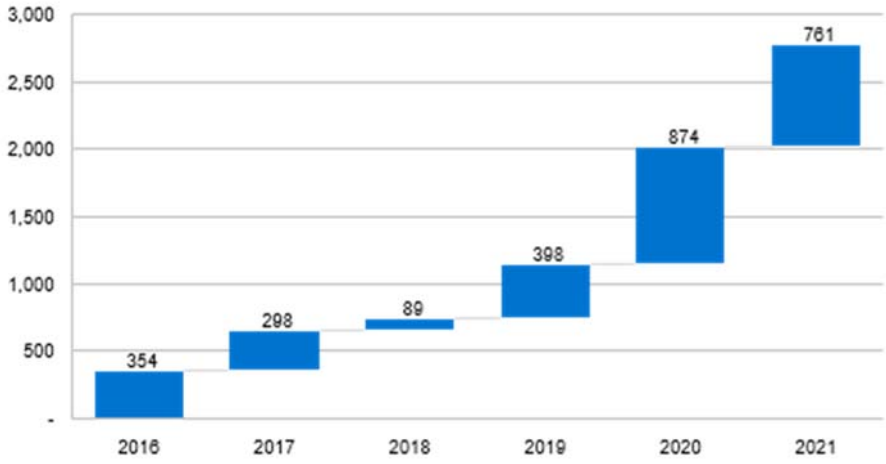
Chart 7 **Number of POS terminals by year**



Source: NBS.

The rise in the number of brick-and-mortar POS is accompanied with an increasing number of virtual, i.e. online POS. This branch of operation underwent major progress in the past two years, in parallel with the development of new habits and needs of the population. This is also reflected in the number of online POS where users can make digital payments by a payment instrument.

Chart 8 **Increase in the number of online POS in Serbia**



Source: NBS.

The number of online POS and the dynamics of their development were impacted by the COVID-19 situation, which was also the case with the entire branch globally, as well as by the above relaxation of the level of fees for payment card acceptance and other activities concerning the promotion and further development of payment methods for online trade. This development also includes the operation of the NBS IPS system, which enables payments without leaving any sensitive data on the buyer on the internet. The effects of such development will be particularly pronounced in the coming years.

In 2021, the number of new online stores rose by 761, which is an excellent result. The rise from 2020 when 874 new online stores appeared in Serbia was almost replicated. Such growth has a strong impact on the number of online payments by payment cards, as illustrated below.

Table 1 **Number of online card-based payments**

Indicator	2016	2017	2018	2019	2020	2021
Number of online card-based payments	867,548	1,227,889	2,395,525	5,505,237	12,545,889	20,492,442

Source: NBS.

More detailed data about payment performances are presented hereinafter.

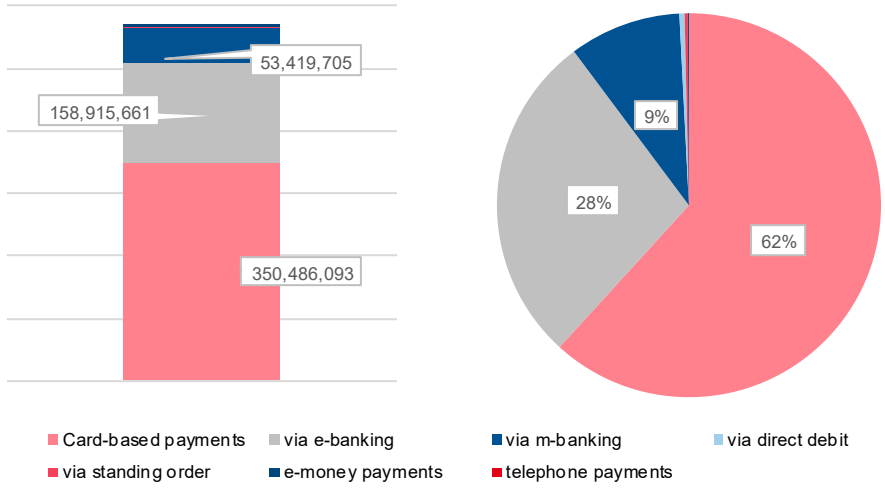
PILLAR 4 – Payment performances

The results of the above situation concerning the acceptance and issuance of payment instruments, including other elements closely related to the increase in digital payments, are reflected in the number and value of digital payments.

Having amounted to 350,486,093, payment card transactions accounted for the major part, i.e. 62% of total digital transactions. E- and m-banking followed suit, with these three categories making up 99% of total digital transactions in 2021.

The constant growth in digital payments in Serbia goes hand in hand with the improvement of the market situation. The above three key categories of digital payments give the main impetus to the growth, compensating for the mild decline in the use of some payment instruments in Serbia. Namely, the number of payments via standing order and direct debit was smaller in 2021 than in 2020 and has a generally mild downward tendency, while telephone payments fell into disuse in 2021 (not a single transaction was recorded). It is worth noting that the number of e-money payment transactions is rising year by year – in 2021 it

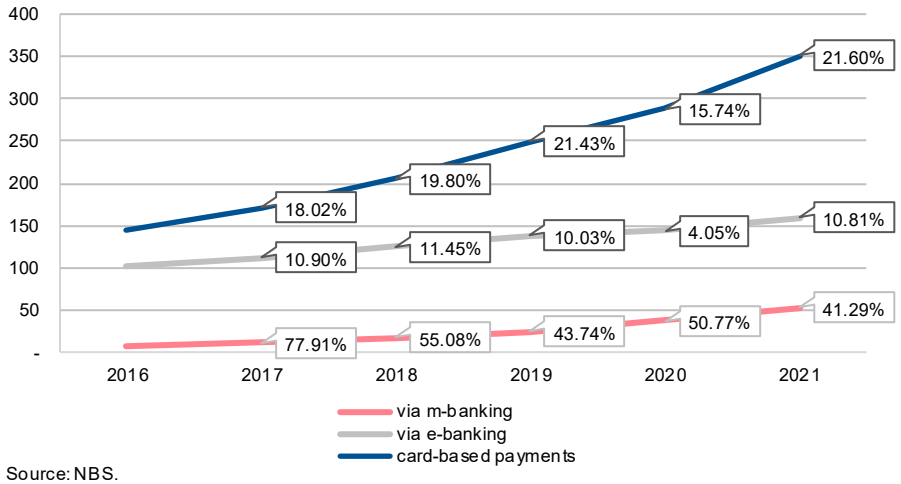
Chart 9 **Share of digital transactions in 2021**



Source: NBS.

increased by over 60% (219,739 up from 2020) although, on the issuance side, the number of cards with the e-money function declined.

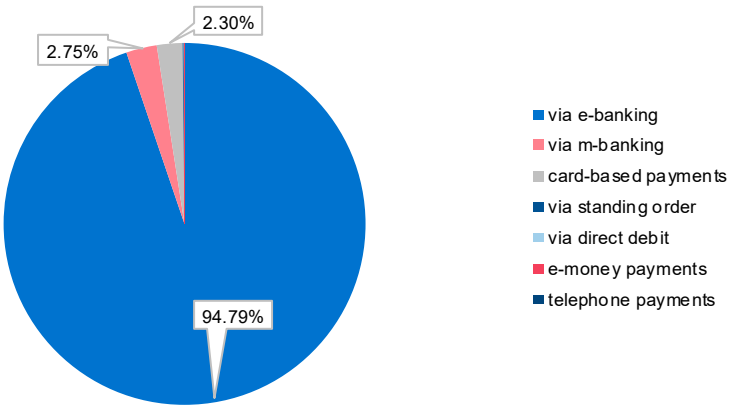
Chart 10 **Rise in the number of payments in three key digital payment categories**
(in mn)



Source: NBS.

Chart 10 also shows percentage increases in the number of transactions recorded each year (compared to the previous year). Data suggest that the highest increase, year after year, has been observed for m-banking transactions. This growth is partly supported by a very small base of the number of m-banking transactions, which equalled only 6,323,088 in 2016. On the other hand, the development of card-based payments and exceptionally high growth percentages suggest that, in terms of the frequency of use of digital payments, card-based payments hold the first place next to other payment instruments, and will probably keep this position over the next few years.

Chart 11 **Share of digital payment categories by value in 2021**



Source: NBS.

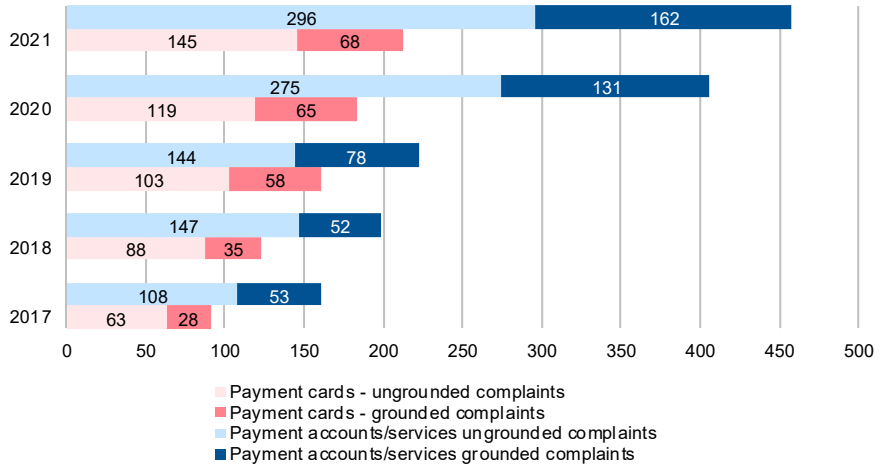
Despite a high share of payment card transactions, the value of digital payment transactions doubtless belongs to e-banking transactions. Given the nature of this instrument and the manner of its use, such statistics is expected. E-banking makes up over 94% of the value of digital payments in our country.

PILLAR 5 – Consumer experience

The use of almost all digital payment instruments implies previous knowledge (very often digital literacy) and largely depends on the simplicity of the process that these instruments provide to their users. To monitor user dis/satisfaction in relation to digital payments, the number of user complaints concerning the use of payment instruments is followed, as well as the number of unauthorised payment transactions in relation to the method of execution.

In 2021, users filed the highest number of complaints relative to previous years. There was also a rise in the number of grounded and ungrounded complaints concerning the use of payment instruments. Such situation is expected given a constant rise in the number of digital payments and users who have access to payment instruments. In 2021, the number of grounded complaints concerning the use of payment cards was only 68, vs. 65 in 2020, which is not a significant increase. The number of complaints concerning payment accounts / other payment services also increased – grounded complaints rose from 131 in 2020 to 162 in 2021.

Chart 12 **Dynamics of grounded and ungrounded complaints concerning the use of payment instruments, by type**

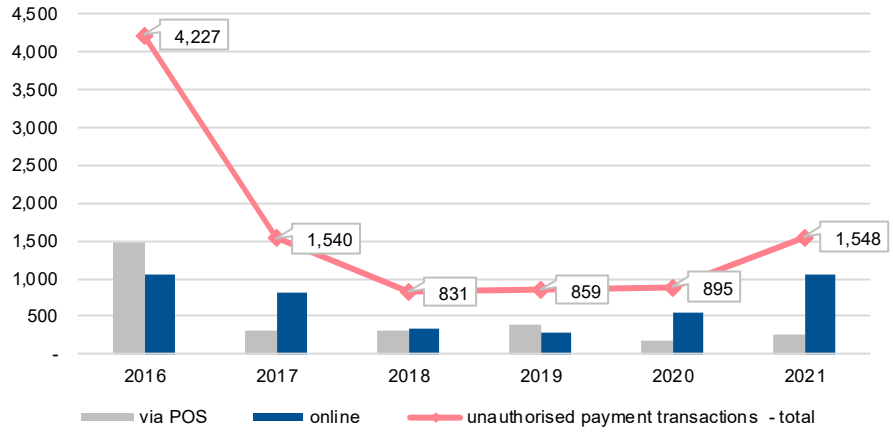


Source: NBS.

Along with the rise in the number of consumer complaints, last year saw an increase in unauthorised payment transactions in Serbia due to a loss, theft or abuse of payment instrument data. According to data submitted to the NBS by banks as part of their regular quarterly reporting, the number of reported unauthorised payment transactions increased from 895 in 2020 to 1548 in 2021. However, this growth was almost three times lower than in 2016 – 4227 unauthorised payment transactions. The DPI follows the number of unauthorised payment transactions related to the internet and POS terminals. The fact that their number on the internet almost doubled indicates the need for greater education of the population in relation to online purchases and use of payment instruments on the internet.

The user experience analysis lacks data from the proposed population survey within defining of DPI elements. In case the survey is carried out in the coming period, the information obtained would complete this DPI area.

Chart 13 **Unauthorised payment transactions at POS terminals and online**



Source: NBS.

Given the above stated, the ecosystem of digital payments in Serbia, presented through the DPI, recorded the highest growth in 2021. This is testified by the positive dynamics of most indicators. Last year, the number of digital payments at online POS increased significantly, and is entirely justified to expect the continuation of such trends in the coming period. The year 2021 also experienced a large, 31% increase in m-banking users, which indicates the prevalence of mobile applications in the ecosystem of cashless payments in our country. This may be an important business signal for many companies/startups in the area of software engineering with a focus on mobile phones. Owing to its constant expansion, the acquiring network enables an increasing number of merchants to join the digital payment flows. In addition to the increase in the number of POS terminals, which are at the same time increasingly state-of-the-art, the rapid development of new online stores in 2021, almost equal to the huge increase in this indicator amid COVID-19 pandemic last year, had an exceptional influence on the DPI value. We expect that online stores, which due to changed consumer habits became one of focal points of the development of digital payments, will in future provide a vigorous impetus to the DPI increase. Finally, although there are payment instruments, i.e. indicators within the index, which in 2021 experienced a decline in popularity (standing order, direct debit...), a significant rise in other instruments and their indicators more than offsets these marginal declines, which is why the total impact of indicators on the DPI value was positive in 2021. The highest rise in the DPI was recorded in 2021 owing to the exceptional results of a large number of indicators.

6 Conclusion

Digital payments are undergoing constant evolution owing to continuous interaction of payment services providers, information technologies and needs of end-users. Owing to such development and embracement by users, the digitalisation and digitisation of payment services are taking place, giving rise to the need to cover and analyse trends, results and final effects of this process on the economy.

Based on the large number of data on various forms of digital payments globally and particularly in our country, which have been analysed in this paper and adequately contextualised, it is possible to confirm a multiple-year progress in the field of digital payments in the Republic of Serbia.

As presented in the paper, digital payments have gone a long way in terms of their development. Starting from 2020, the COVID-19 pandemic also doubtless had a positive impact on the accelerated embracement of digital and contactless forms of payment, and it significantly influenced user preferences. The popularisation of the use of mobile phones and mobile payment applications also results in new business models and improves user experiences during payments, notably online. In parallel with the development of retail payments, e-banking, which is generally used for large-value payments, has been recording positive results in the Serbian market over a number of years already – the number of users and value of e-banking transactions is increasing. For these reasons, card-based payments, e-banking, m-banking and mobile smart devices can be considered primary, market-recognised elements for the spread of digital payments in Serbia.

With the DPI of Serbia, presented in this paper, an attempt was made to measure the success of the spread of digital payments in our country. It is designed in such way that digital payments in the country are followed through five key dimensions, i.e. four pillars included in its calculation (possibility of payments, infrastructure on the issuance side, infrastructure on the acquiring side and payment performances). Being a tool that captures the situation and development of digital payments in a concrete time period, the DPI provides unique value added to all hitherto analyses of this area.

Starting from 2016, which is taken as the base year for the DPI, the measurement and analysis of the results achieved indicate that the digital payment ecosystem has been recording a constant rise in the past six years. The results concerning a change in consumer habits during the pandemic can be observed through the index movements in 2021, in which the number and value of payments were particularly pronounced and recorded the best results in the period under review. Such results are also supported by the introduction of the new payment instrument in Serbia within the NBS IPS system, as well as other innovations and business models encouraged by the system. Market innovations are accompanied with the expansion of the acquiring network with the increase in the number of brick-and-mortar and online POS. In the past two years, online POS have recorded considerable progress, consistent with the development of new habits and needs of the population, which was also recorded within the DPI value. The development of online stores was also backed by the operation of the NBS IPS system, which enables payments without leaving any sensitive data on buyer's payment instrument on the internet, an increased use of payment cards and generally more frequent use of technology and the internet by people – the indicators also followed by the DPI.

The development of the DPI for Serbia marked a new, extensive attempt at covering and analysing all relevant digital payment areas and adequately valuing their mutual relations. This concept doubtless remains modifiable in line with future development trends, potentially non-coverable by the existing methodology, which entails necessary flexibility. Still, this is an all-

encompassing method for the analysis of digital payment development in Serbia through time, which can – by meeting the current information needs of all stakeholders – serve as the method of long-term monitoring and as an autonomous data source for future research.

Appendix

DPI calculation formulas

To calculate the DPI, each of its pillars was assigned a weight based on its importance for the digitalisation and digitisation of payments in Serbia. Based on those weights, the following DPI calculation formula was devised:

0.1*„Possibility of payments“ + 0.2*„Infrastructure-issuance“ + 0.25* „Infrastructure - acquiring“ + 0.45* „ Payment performances “ = DPI

The method of calculation of values of individual DPI pillars is shown below:

Possibility of payments

	(Number of persons accessing internet each day in the past three months of the year /total Serbian population)
+	Percentage of households owning internet connection
+	Mobile phone use
+	(Number of inhabitants (aged 16+) / Number of users owning at least one current account in Serbia)
+	Percentage of persons to have used the computer in the past three months
+	Percentage of companies offering online orders or booking of products/services via websites
=	Possibility of payments

Payment services infrastructure on the issuance side

	Total number of active payment cards with the payment function
+	Total number of cards with the e-money function
+	Number of m-banking users
+	Number of e-banking users
+	Number of users of direct debit service
+	Number of users of standing order service
=	Payment system infrastructure on the issuance side

Payment services infrastructure on the acquiring side

Number of POS devices
\+ Number of online POS * 10
\+ Number of ATMs with the credit transfer function

= Payment system infrastructure on the acquiring side

* In making the calculation for this pillar, the number of online POS is an indicator multiplied with weight ten, given the nature of online POS.

Payment performances

$$\frac{\text{Number of payments (current year) / Number of payments (base year)} + \text{Value of payments (current year) / Value of payments (base year)}}{2} = \text{Payment performances}$$

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Abbreviations

ATM – Automated Teller Machine

GDP – Gross Domestic Product

BIS – Bank for international Settlements

IBM – International Business Machines

DPI – Digital Payments Index

NBS IPS – Instant Payment System of the National Bank of Serbia

NBS – National Bank of Serbia

NFC – Near Field Communication

PIN – Personal Identification Number

POS – Point of Sale

SORS – Serbian Statistical Office

TSR – Total Shareholder Return

COVID-19 – coronavirus

QR code – Quick Response Code

ROLE OF THE BASEL ACCORDS IN PRESERVING FINANCIAL STABILITY

Aleksandra Ristić

Available at www.nbs.rs

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

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Role of the Basel Accords in preserving financial stability

Aleksandra Ristić

Abstract: International convergence and standardisation of general banking terms and conditions are primarily associated with the Basel Committee's activities, which resulted in the adoption of the Capital Adequacy Accords (Basel I, Basel II and Basel III) for the purpose of limiting potentially growing risks in the international banking operations by means of appropriate capitalisation. The purpose of this paper is to point out the importance of the Basel Accords and/or their impact on banking operations and financial stability based on available scientific literature, international standards, the EU acquis, national legislation and other statistical data. Starting from a defined subject matter and a set goal, the paper will first analyse the core principles of Basel I and the transition to the new Basel II Accord. After identifying the shortcomings of Basel II, which were manifested during the global financial crisis, the attention will be focused on the development and implementation of Basel III. Taking into consideration the preservation of financial stability, the National Bank of Serbia pays special attention to improving and harmonising the legislation governing banking operations in accordance with international standards and the EU acquis, while observing distinctive features of the local legal framework and the national market.

Keywords: Basel Committee on Banking Supervision, capital adequacy ratio, financial stability, Basel I, Basel II, Basel III, capital buffers
[JEL Code]: G01, G21, G38, O11

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Non-technical summary

Financial stability gained importance over the last few decades of the 20th century due to frequent crises in the banking sector. Pursuant to the Law on the National Bank of Serbia (RS Official Gazette, Nos 72/2003, 55/2004, 85/2005 – other law, 44/2010, 76/2012, 106/2012, 14/2015, 40/2015 – Decision of the Constitutional Court and 44/2018), the National Bank of Serbia defines and undertakes, within its jurisdiction, measures and actions in order to preserve and strengthen the stability of the financial system. Achieving and preserving financial stability is by no means a simple task and it requires developing an appropriate regulatory framework that includes various institutions, rules and procedures.

The Basel Accords (Basel I, Basel II and Basel III) are a series of guidelines drawn up by the Basel Committee on Banking Supervision, which was established by the governors of the central banks of the G-10 Group in order to limit risks in banking operations by means of adequate capitalisation.

Bank capital symbolises its ability to expand credit and cover losses resulting from deterioration in the asset quality. Due to the importance of capital adequacy, as well as the creation of conditions for equal competition among internationally active banks, the Basel Committee on Banking Supervision has stipulated a minimum capital adequacy ratio, allowing national regulatory bodies and supervisors to impose stricter capital adequacy requirements.

It is extremely important for each bank to maintain a certain level of liquidity, which provides a bank with the ability to respond to sudden needs for liquid assets when performing financial operations, to preserve financial health during financial crises, and take advantage of any opportunity to earn profit by investing liquid assets in above-average profit potential investments.

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1 Introduction

Modern banking development resulted in a higher exposure to various types of operational risks, which in turn requires their identification and appropriate protection measures as a prerequisite for efficient banking operations. Bank capital symbolises a source of funds – it enables bank's growth, provides security in terms of risk management, protects interests of creditors and bank's depositors, and makes it possible to gain trust in the bank and the banking sector in general.

The Basel Accords provide regulatory and incentive measures for more secure banking operations. They are adopted by the Basel Committee on Banking Supervision headquartered in Basel, which, at first, used to issue recommendations and guidelines that were not binding at a global level. These included recommendations on how to properly carry out certain banking activities, how to approach risk management, etc. The role of the Basel Committee is to define general supervision standards and guidelines to be implemented by legislative bodies subject to specific conditions in a specific country. This way common supervision standards are ensured in different countries.

The subject matter of this paper is an analysis of the roles of the Basel Accords in ensuring financial system stability. Since banks' assets are exposed to higher risks than assets of companies, and due to the fact that the banking system can jeopardise the financial stability both at national and international levels, the need for international banking standards arose. An institution that is highly important globally for creating international banking supervision standards is the Basel Committee on Banking Supervision. The years of Committee's work resulted in the adoption of the Basel Accords (Basel I, Basel II and Basel III) aimed at limiting growing risks in international banking operations by means of adequate capitalisation.

Basel Accord I was adopted by the Basel Committee in 1988 with the aim of managing and monitoring credit risk. A set of rules of this accord came into force in January 1993, when uniform capital rates were set against risk-weighted assets for all banks operating internationally.

The Basel Committee responded to Basel I weaknesses by adopting a new accord – Basel II, which primarily concerned international banking. It contributed to better risk management and accordingly to the preservation of financial stability and better financing conditions. The Basel II standard is based on three interrelated sets of rules for governing financial sector operations, i.e. the so-called Basel II pillars, which will be separately described in more detail hereunder. In addition, the weaknesses and limitations of this standard that led to the adoption of Basel II will also be covered.

The global financial crisis only prompted the improvement of the Basel II standard, whose modification resulted in a new Basel III Capital Accord adopted to mitigate the effects of the crisis by striking a balance between the requirements for developing and maintaining stable financial systems, on the one hand, and achieving a necessary credit level, on the other hand, as well as minimising the employment of government and taxpayers' money for covering losses and recovery of private financial institutions. If the aforementioned goals were to be implemented, the Basel III Accord should contribute to long-term financial stability and

prosperity. A major novelty of Basel III is the introduction of capital buffers, liquidity coverage ratios and leverage ratios.

2 Establishment, role and objectives of the Basel Committee

A bank is one the most important entities in the financial market and the overall system of economy financing. For this reason, banks need to be constantly monitored by central monetary authorities that undertake preventive supervision. Such an approach enables timely protection against the collapse of the banking sector and its severe consequences for the stability of the financial system.[1]

The development of financial markets and their interconnectedness at a global level added an additional dimension to efforts invested to preserve the banking system stability. Risk growth on global financial markets is always accompanied by an increase in exposure of globally active and particularly of large banks, and the deterioration of the capital adequacy ratio. One of those severe disturbances on banking foreign exchange markets that occurred at the beginning of the 1970s and resulted in the bankruptcy of some major banking institutions drew attention to the need to establish an international body that would deal with issues and modalities of cooperation in terms of improving the international monitoring network and overcoming its shortcomings.[2]

The Basel Committee on Banking Supervision was founded in 1974 by the central bank governors of the G-10 Group, and is headquartered at the Bank for International Settlements in Basel. Its main objective was to enhance financial stability by improving the quality of banking supervision worldwide, and to serve as a forum for regular cooperation between its member countries on banking supervision matters.[3]

The first meeting of the Committee was held in February 1975 and since then meetings have been regularly held three or four times a year. The Basel Committee members have been expanded since the establishment from G-10 to 45 institutions and 28 jurisdictions. At first, the Committee's primary objective was to bridge the gaps in the international banking supervision, so that no banking institution would escape supervision and that supervision would be adequate and consistent across member jurisdictions. Starting with the Basel Concordat, which was first issued in 1975 and has been revised a few times since then, the Committee introduced a number of international banking standards, most notably its landmark publication of capital adequacy accords commonly known as Basel I, Basel II and Basel III.[4]

Decisions made by the Basel Committee are the result of consultations with financial experts and representatives of regulatory and supervisory bodies from the most developed countries. It should be noted that the Basel Committee does not have controlling powers and its conclusions have no legal force. Its recommendations and adopted documents only become

[1] Matić, V. (2009). Prudential supervision, *Banking*, vol. 38, no. 3-4, Association of Serbian Banks, 108.

[2] *Ibid.*

[3] *History of the Basel Committee*, https://www.bis.org/bcbs/history.htm

[4] *Ibid.*

binding when they are adopted as a law or a by-law by competent authorities. Those are recommendations and advice on how to appropriately implement certain activities in banks, how to approach risk management, etc. Each national regulator should adapt the given recommendations to specific circumstances in a specific country.[5]

One of the main issues of preventive supervision since the end of the 1980s is the capital adequacy issue. In 1988 the Basel Committee decided to introduce a common capital adequacy measurement system named the Basel Capital Accord (Basel I Accord).[6] Its main objectives were to ensure an adequate capital level in the international banking system in order to strengthen financial stability, so that no bank is able to operate if it has not met the necessary capital requirements.[7]

3 Basel I

The response to the global debt crisis during the 1980s was the adoption of the Basel Capital Accord in July 1988, better known as the International Convergence of Capital Measurement and Capital Standards. The standard was signed by the representatives of the USA and leading industrial countries (Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, Sweden, Switzerland, Great Britain and Luxembourg) as an accord on banking standards for capital adequacy measurement and minimum standards that supervisory bodies need to implement in their countries. In order to ensure the uniformity of conditions for banking operations on the global financial market, the Basel Committee on Banking Supervision published a set of rules for calculating capital adequacy and minimum standards that supervisory bodies need to implement in their countries.[8]

Basel I achieved particular success after prudential regulations were accepted in more than 100 countries, to a greater or lesser extent, thus becoming the global standard for bank solvency measurement and risk management in banking. The Basel Committee's report from 1993 indicates that all banks from the G10 Group members operating internationally met minimum capital requirements listed in the Basel I Accord.[9]

Basel I sets out components of bank capital – core and supplementary (Tier 2) capital, credit risk assessment weights per balance sheet assets and credit conversion factors for credit risk assessment per balance sheet assets, as well as a relation between equity capital and total

[5] Božović, J. Božović, I. (2009). The role of Basel principles in banking operations and financial stability, *Ekonomika,* Niš, no. 5, 248.

[6] Matić, V. *op. cit.* 112.

[7] Stojković, M. Jeremijev, V. (2017). The importance of implementing the Basel Standards in the banking sector of the Republic of Serbia, *European legislation*, no. 61-62, 240.

[8] Božović, J. (2009). *Main principles of the banking management process,* first edition, Faculty of Economics in Priština, Kosovska Mitrovica, 66.

[9] Jocić Radenković, D. Stanković, J. Pešić Anđelković, M. (2012). Harmonisation of the risk management legislation in the Serbian banking sector, *Faculty of Economics of the University of Niš*, Niš, vol. 36, no. 3, 1196.

credit risk weighted assets in order to assess the capital adequacy ratio.[10] The Accord also specifies bank capital tiers:

Primary (core) capital has a key role in calculating the profit rate and assessing bank's risk absorption capacity and ability to maintain competitive relationships. It comprises ordinary shares, a surplus above the nominal value of shares paid by shareholders, non-cumulative preference shares and retained earnings.[11]

Tier II includes convertible preference shares, cumulative preferred stocks, loan loss reserves, convertible loans and other debt instruments. These components are included in the bank capital base in order to assess capital adequacy even though they do not have the stability characteristics of core capital.[12]

Tier III is a term introduced by the Basel Committee on Banking Supervision by adopting an amendment in 1996, with market risk as an additional risk that banks were exposed to when dealing with financial derivatives, for which they are supposed to ensure supplementary capital. This type of capital may be used only to cover market risks arising from shares and interest-sensitive instruments of trade portfolios, foreign exchange risk and commodity risk. Additionally, tier III has to have maturity of at least two years and has to be subject to the provisions stipulating that neither interest nor principal may be paid if such payment means that the bank falls below or remains below its minimum capital requirement.

Basel I stipulated the following minimum capital requirements: a minimum 4% ratio of tier I capital to the total risk-weighted assets and a minimum 8% ratio of tier I and tier II and tier III to the total risk-weighted assets, whereby the sum of tier II and tier III is limited to a 10% of the tier I.

The main focus of Basel I is the obligation to assess banks' capital adequacy using the proposed standards, the introduction of minimum capital adequacy of 8% and the highest coverage for banks within jurisdictions, i.e. the obligation to apply these standards if they implement them at national level.

$$\text{CAPITAL ADEQUACY RATIO} = \frac{\text{TOTAL EQUITY CAPITAL}}{\text{TOTAL RISK} - \text{WEIGHTED ASSETS}}$$

i.e.

$$\text{CAR} = \frac{\text{AVAILABLE CAPITAL}}{\text{RISK} - \text{WEIGHTED ASSETS}} * 100$$

This ratio denotes a proportion between net capital and net risk-weighted assets, and it constitutes the main component for reaching a conclusion on whether capital may support a bank's risk profile, i.e. whether a bank's operations are acceptably secure for depositors and creditors and whether they are a threat to the overall stability.[13]

[10] Bozovic J. *op. cit.* 66.

[11] Nikic D. (2012). Interest rate risk performances and Basel procedures, *Ekonomika, Niš,* no. 4, 165.

[12] Bozovic J. *op. cit.* 66.

[13] Božović J. *op. cit.* 67.

One of the shortcomings of Basel I was that it related to credit risk, whereas market risk was taken into consideration to a lesser extent. In addition, when applied to all banks in a certain jurisdiction (not only to internationally active banks, but to local ones as well), its weakness was that the same standard, i.e. a minimum capital adequacy ratio of 8%, was used for all types of banks. This percentage has to be higher for local banks in countries with higher risk exposure. National supervisory bodies are the ones that decide on prescribing a higher amount of regulatory capital for local banks.[14] Having taken country risk into consideration, the National Bank of Serbia (hereinafter: the NBS) stipulated a minimum regulatory capital requirement of 12% by adopting a Decision on Capital Adequacy of Banks in 2007.[15]

Basel I helped increase the stability of global banking systems. The number of banks on larger financial markets was considerably reduced through liquidation and bankruptcy or acquisitions and mergers with larger banks that did not have any difficulties in adjusting their operations to changed business conditions thanks to capital, their risk management approach or market position. The implementation of this standard was overcome by further developing banking products, connecting markets and strengthening competitiveness.[16]

3.1 Weaknesses of Basel I

Numerous weaknesses of Basel I were identified due to the development of banking systems over time. Risk management practice and technology advanced and thus the assumptions contained in the applicable accord became too simplified for banking business practice. Therefore, it could no longer provide a reliable basis for assessing an adequate capital amount against total risks as it only covered credit risk and partly market risks, while excluding other risks. Being divided into OECD (Organisation for Economic Co-operation and Development) members and non-member countries (for credit risk exposure assessment purposes), it is evident that Basel I did not properly identify and assess country risk, which means it unjustifiably favoured OECD member countries. Moreover, the method of applying risk weights according to Basel I may have encouraged banks to allocate or securitize assets. In this way, banks could present a nominally high capital adequacy ratio, which is realistically insufficient to cover assumed risks.[17]

As mentioned earlier, the main weakness of Basel I is the fact that it was almost exclusively related to credit risk. Banks, particularly large ones, were displeased with the fact that it applied the same standard to all loan types and sizes – a minimum capital adequacy ratio

[14] Jocić Radenković, D. Stanković, J. Pešić Anđelković, M. *op.cit*. 1197.

[15] Section 2 of the Decision on Capital Adequacy of Banks (RS Official Gazette, Nos 129/2007, 63/2008);

[16] Božović, J. *op. cit.,* 68.

[17] Todorović, V. Tomić, N. (2020). The Basel Accords and the stability of the banking system, *Current Macroeconomic and Microeconomic Aspects of European Integrations of the Republic of Serbia,* Faculty of Economics in Kragujevac, Kragujevac, 369.

of 8% (in the EU and USA), while it was higher in countries with higher risk exposures (e.g. it was 10% in Croatia and 12% in Serbia).[18]

In order to eliminate this weakness, the Basel Committee formulated a set of non-binding market risk principles after adopting the main document. The next important step in the evolution resulting in the adoption of the Basel II Standard were principles that were published as proposals in 1993. This approach was based on the stand that, in addition to credit risk, the bank's portfolio is also exposed to other risks: interest rate risk, foreign exchange risk, commodity and price risks. This model was incorporated into Basel II and named the Standard Model. In 1995 the Basel Committee expanded the concept of market risk and permitted the use of market risk models, allowing banks to set their capital requirements on their own using these models, and developed sophisticated risk assessment models. This risk is recognised in Basel II as the internal risk assessment model. A few years later, as of 1998, banks have been required to have regulatory capital as a hedge against market risks.[19]

4 Basel Capital Accord (Basel II)

A draft of a new accord was drawn up at the beginning of 1999, and its final version published in June 2004, titled *International Convergence of Capital Measurement and Capital Standards,* or generally accepted as the Basel II Standard *(Basel Committee on Banking Supervision, 2006, International Convergence of Capital Measurement and Capital Standards).* The document came into force in December 2006, whereby its implementation by EU member states began in January 2007.*[20]*

The objectives of the new Basel Capital Accord are:[21]

1) creating a better correlation between regulatory capital rules and risks that banks are faced with, which contribute to strengthening financial stability;
2) creating conditions to ensure competitive equality of banks;
3) an integrated risk exposure approach (credit, market and operational risks);
4) developing own and appropriate approaches to determining capital adequacy, which reflect risk level sensitivity.

The Basel Capital Accord (Basel II) is a new measurement concept of banks' capital adequacy, which offers new rules for managing and assessing risks that banks are faced with in their ordinary course of business. Since capital is the basis of each bank's growth and a hedge against unexpected losses, this accord set the equity amount that is sufficient to cover those losses. Equity is a bank's primary hedge against the insolvency risk. Hence, its value has to be adjusted to the bank's risk exposure. As such, capital has an important role in preserving

[18] Basel Committee on Banking Supervision, (2007). Basel II – International Convergence of Capital Measurement, *Yugoslav Survey,* Belgrade, 10.

[19] *Ibid.*

[20] Jocić Radenković, D. Stanković, J. Pešić Anđelković, M. *op.cit*. 1199.

[21] Nikić, D. *op. cit.* 167.

the stability of any bank. A low capital value would result in incapacity to absorb risks. However, a high capital value would jeopardise business profitability.[22]

The Basel II standard is based on three interrelated sets of rules for governing financial sector operations, i.e. the so-called Basel II pillars.

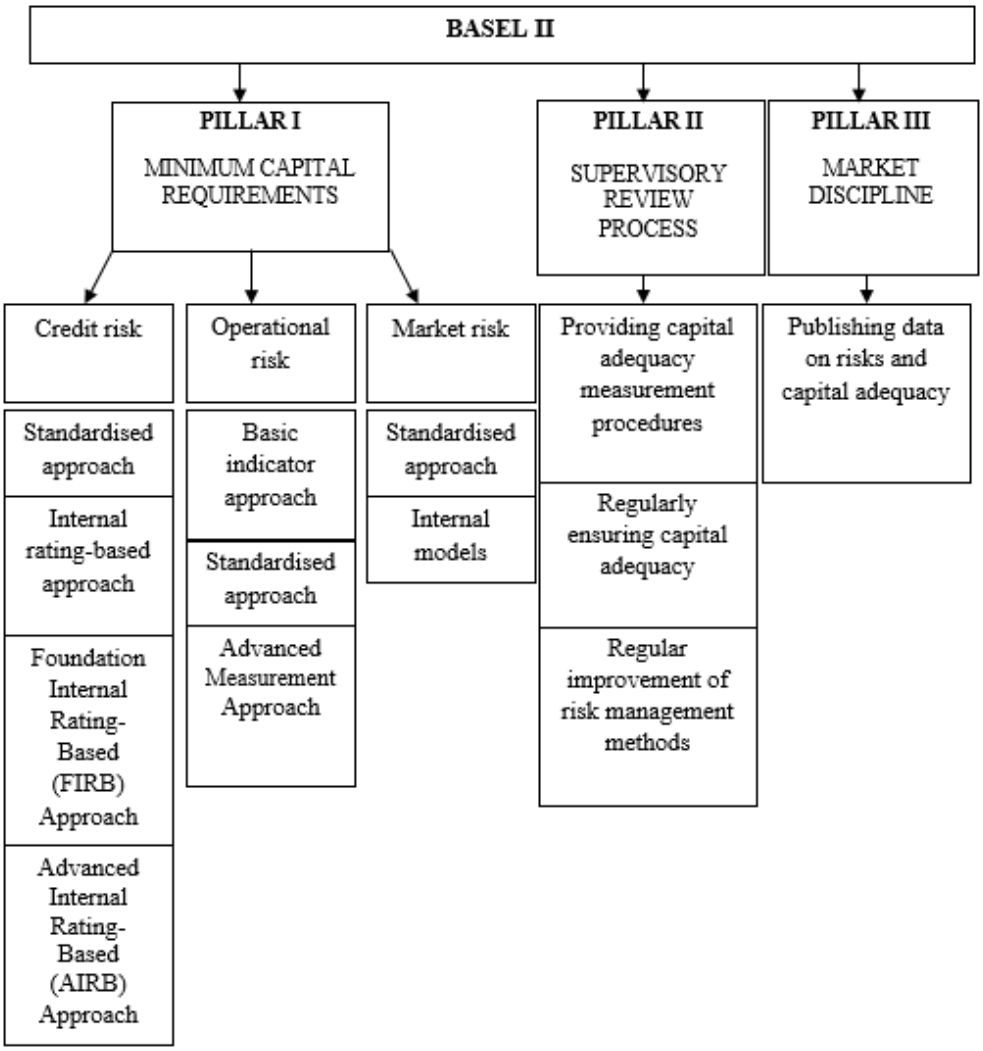

Figure 1 **Three pillars of Basel II**

Source: Milojević, N. (2008). Basel II and forecasts of the effects of its implementation, Industry, No 1, 54.

[22] *Ibid.*

4.1 The first pillar – minimum capital requirements

A minimum capital requirement is used to define capital adequacy ratio measurement and it represents a ratio between equity and a risk level that a bank is exposed to and/or risk-weighted assets.[23]

$$\frac{\text{Core capital} + \text{supplementary capital}}{\text{Weighted assets}} = \text{Minimum equity quota of } 8\%$$
$$(\text{Credit risk} + \text{Market risk} + \text{Operational risk})$$

The upper part of the fraction is the same as in the Basel I Standard, whereas operational risk was introduced into the calculation in the bottom part of the fraction, and the following credit risk measurement models are available to banks:[24]

1) Standardised approach;
2) Internal ratings-based approach – IRB;
    1) Foundation internal ratings-based approach – FIRB;
    2) Advanced internal ratings-based approach – AIRB.

4.1.1 Credit risk

Risk is an inseparable component of every average or "normal" credit transaction, which is why a bank, as a credit institution, has to perform a due diligence review of a borrower in order to protect itself from any credit risks, both preventively and consequently.[25] Credit risk is a risk of potential occurrence of adverse effects on a bank's financial result and capital due to a debtor's default on their obligations to the bank.[26]

Credit risk measurement is one of the credit risk management functions. Credit risk measurement is in fact used to determine the credit quality of each bank's transaction and overall portfolio, as well as the probability and amount of losses that might occur due to other contractual party's default.[27]

The standard approach to credit risk measurement is similar to the credit risk measurement according to Basel I. Banks assign prescribed risk weights to their accounts receivable depending on the characteristics of receivables (corporate, retail or banks). Weights are assigned depending on a rating assigned to a debtor by a credit rating agency. If a debtor has

[23] Milojević, N. (2008). Basel II and forecasts of the effects of its implementation, Industry, No 1, 54.

[24] Neogradi, S. (2014). "Credit risk assessment and management models", *Hypo-Alpe-Adria a.d. Belgrade*, 22 - 23.

[25] Vunjak, N. Antonijević, T. (2008). "Bank Portfolio Management Strategy", *Montenegrin Journal of Economics, No. 7,* 52.

[26] Risk management, https://nbs.rs/sr/finansijske-institucije/banke/upravljanje-rizicima/

[27] Stojanovski, Đ. (2007). *Internal models for credit risk measurement*, *value-at-risk model,* First Edition, *Centre for Publishing Activities* of the Faculty of Economics, Belgrade, 8.

not been assigned a credit rating by a recognised rating agency, a receivable is assigned a weight of 100%.[28]

There are still no credit rating agencies in Serbia, therefore, the implementation of this standard may encounter certain difficulties. Corporate risk weights are given as rating examples according to Basel II.

Table 1 **Corporate risk weights**

Credit rating	AAA to AA-	A+ to A-	BBB+ to BB	Below BB	No rating
Risk weight	20%	50%	100%	150%	100%

Source: Milojević, N. (2008). Basel II and forecasts of the effects of its implementation, Industry, No 1, 55.

Basel II enables banks that have available funds for more accurate risk measurement to measure credit risk using their internal models. IRB approaches enable banks to use their internal ratings for borrowers' creditworthiness in order to assess credit risk in their portfolios. Risk weights assigned to each bank's exposure are based on the rating. Therefore, those exposures that are more favourably rated have lower risk weights and consequently lower capital requirements.[29]

The use of IRB approaches is approved by a supervisor based on stipulated eligibility standards. In order to obtain permission to use an IRB approach, a bank has to prove that it has in place reliable risk measurement and management processes. IRB approaches cannot be used without the prior supervisor's approval, whereas the Basel Committee points out that supervisor's monitoring of the application of any IRB approach is crucial in order for the risk supervision results to be credible. There have to be separate systems for measuring risk parameters, strict formal control and appropriate documentation on using models and data.[30]

When using IRB models, receivables have to be divided into at least eight different groups, while risk components are as follows:[31]

1) Probability of Default (PD);
2) Loss Given Default (LGD);
3) Exposure at Default (EAD);
4) Maturity (M).

As already mentioned, banks can use the foundation approach or FIRB and the advanced approach or AIRB. The difference between these two approaches is that FIRB is based on supervisor's assessments of risk components, whereby LGD, EAD and M (PD) are calculated by banks themselves, while all four risk components in the AIRB approach are calculated by

[28] Milojević, N. *op. cit.* 55.

[29] Janković, M. (2018). *Credit risk parameters*, Master thesis, University of Niš, Faculty of Sciences, Department for Mathematics, Niš, 14-15.

[30] *Ibid.*

[31] Stojanovski, Đ. *op.cit*. 159.

the bank alone. The AIRB approach is much more flexible, but also more demanding, and it can be used only by large banks that have developed software and trained staff.[32]

4.1.2 Operational risk

Operational risk is a specific type of financial risk. It refers to potential losses due to inadequate organisation, mismanagement, incorrect control, fraud, theft and human error. Operational risk often entails deliberate fraud when, for instance, a seller or another authorised employee intentionally falsifies or understates transaction values.[33]

As regards the occurrence of operational risk as "a risk that will cause a loss event", banks do not differentiate between companies from the industry and companies from other industries. It can be:[34]

1) human factor;
2) technical factor
3) process actions;
4) information technology.

Basel II introduced operational risk as a part of capital requirements. Little was known about this risk and its measurement method, which is why its management was poor and banks were faced with big losses. Therefore, the Basel Committee paid special attention to this risk using Basel II and offered three methods for its measurement:[35]

1) The *basic indicator approach* is the most simplified method for calculating a minimum capital requirement. A three-year average of net operating income is multiplied by a 15-fixed-alpha percentage. However, this method is not accurate and is therefore not recommended for large international banks.
2) The *standardised approach* implies that operational risk is measured by dividing overall bank activity by eight business segments, and then net operating income of each business segment is multiplied by the beta factor prescribed for each business segment. The total capital requirement is obtained by adding eight capital requirements.
3) The *advanced measurement approach* is the most complex method, which implies that a bank alone develops internal models for monitoring operational risk provided that it meets all qualitative and quantitative requirements prescribed by a supervisor.

[32] Milojević, N. *op. cit.* 56.

[33] Janković, M. *op. cit*. 7.

[34] Đukić, Đ. (2018). *Risk and capital management in banks,* Expanded fourth edition, Faculty of Economics, Belgrade, 45.

[35] Milojević, N. *op. cit.* 57.

4.1.3 Market risk

Market risk is defined as the risk of losses in on- and off-balance sheet items arising from movements in market prices.[36]

Market risk is associated with the variability of financial products and services on a market, and it exists independently of financial capabilities of the debtor and the nature of a separately concluded agreement. Market risk means facing a decline in a share price and associated losses and all losses caused by systemic factors. It is determined by factors that are common for all companies, e.g. changes in the gross domestic product.[37]

Since banks now trade on the financial market more frequently and use increasingly complex instruments, such as futures, swaps and shares, the Basel Committee increased the importance of credit risk management.[38]

We are familiar with two models for measuring this risk: the standardised approach, prescribed by a supervisor, and the internal model, approved by a supervisor. Emphasis is placed on trading control, mark to market models, VaR (Value at Risk), scenario and stress-test models.[39]

Stress tests are an important tool used by banks to manage risks under Basel II. Apart from the risk management process, stress test principles require that banks envisage an economic shock (scenario), test the internal model and assessment procedures, whereas they require that supervisors consider how banks assess unexpected events when calculating the amount of capital. In order for a bank to conduct a stress test, it has to project and apply some of the following scenarios: economy functioning in difficult situations, market risks, banks should use their own data for a rating assessment and conduct a stress test in a potentially deteriorated credit environment.[40]

4.2 The second pillar –– supervisory review process

The second pillar is an addition to the first one and it is supposed to cover the control and provision of capital adequacy and risk management, which were not included in the first pillar. It introduced assessments performed by supervisors, who have a high level of authority when setting a bank's capital requirement.[41] Namely, it requires that supervisors ensure that each

[36] Basel Committee on Banking Supervision, Basel II – International Convergence of Capital Measurement, *op. cit.* 157.

[37] Todorović, T. (2009). Credit risk management in banks, *Economic Horizons*, 11 (2), 90.

[38] Milojević, N. *op. cit.* 58.

[39] *Ibid.*

[40] Englelmann, B. Rauchmeier, R. (2011). *The Basel II: risk parameters, estimation, validation and stress testing,* expanded second edition: part XVI Gundlach V., Development of Stress Tests for Credit Portfolios, 352.

[41] Milojević, N. *op. cit.* 59.

bank has in place acceptable capital adequacy assessments, which are based on their own, thorough assessment of the risks they are exposed to.[42]

Four main principles of supervisor's oversight are the following:[43]

1) Banks should have a process for assessing their overall capital adequacy in relation to their risk profileand a strategy for maintaining their capital levels;
2) Supervisors should encourage risk modelling and control by means of internal models, and they should monitor their usage;
3) Supervisors should expect banks to operate above the minimum capital ratios;
4) The supervisor's role has to be preventative and performed at an early stage to prevent bank capital from falling below the minimum levels required for riskhedging.

These principles are based on the belief that there is a strong connection between the amount of capital held by a bank and its risk exposure, on the one hand, and quality of risk management and internal control processes, on the other. The importance of supervision comes to the fore in terms of business activities of large international banking groups, which operate in different jurisdictions and use different organisational principles.[44]

4.3 The third pillar – market discipline

The third pillar combines the first two, contributing to stronger market discipline through better disclosure of information. Market discipline may produce considerable benefits by helping banks and supervisory bodies to manage risks and improve stability. The bottom line is that banks are supposed to publish sufficient and quality information on their operations, and market entities can then make decisions based on the principle of sound business practice and selection. If a market is sufficiently developed, it will be able to reward banks that operate well and maintain their capital adequacy in line with the risks assumed, and vice versa.[45]

Basel II contributed to a reduction in the minimum regulatory capital requirement of largest banks, which depended on their ability to efficiently exploit the IRB approach. Banks were exposed to the costs of introducing and developing internal models over the short run, but in the long run they made profit.[46]

Basel II strongly promoted the use of internal models for capital adequacy measurement as a tool for covering credit, market and operational risks that a bank is exposed to, since banks developed sophisticated risk measurement models during the 1990s, enabling them to assess

[42] Zelenović, V. Vunjak, N. (2014). Capital adequacy of the banking sector, *Annals of the Faculty of Economics in Subotica,* Vol. 50. no. 31, 8.

[43] Jocić Radenković, D. Stanković, J. Pešić Anđelković, M. *op.cit*. 1200.

[44] Barjaktarović, L. (2010). Harmonisation of the Serbian banking sector with EU legislation, *Singidunum Journal,* 6 (2), 146.

[45] Božović J. *op. cit.* 69.

[46] Todorović, V. Tomić, N. *op. cit.* 372.

risks and determine the required capital level much better than simply weighting assets using standard risk weights defined by Basel I.[47]

Basel II allows banks to improve their risk and capital adequacy measurement systems and hence determine an optimal capital level, which simultaneously protects them from the assumed risks and ensures high profitability.[48]

4.4 Weaknesses and limits of Basel II

The application of Basel II encouraged banks to assess credit and market risks more carefully. However, an issue arose in terms of operational risk measurement due to a lack of comparative data on default rates. Basel categories of operational risk are formulated in a descriptive manner, without using tests to determine differences among them, which gives national regulatory bodies great freedom in making decisions when applying the given guidelines. Even insurance undertakings that cooperate with the largest banks used to adapt their policies to Basel II requirements.[49]

Those banks that assumed high risks in relation to the capital they owned were faced with the necessity to increase the amount of capital, while on the other hand, they faced an increase in total costs.[50] While it was still in its adoption stage in 2004, institutions tried to estimate the actual costs of implementing this standard, which entail the costs of introducing information technologies, developing and introducing a rating system, educational costs and the costs of developing a reporting system.[51] Estimates of actual costs varied, and were higher in countries with many banks (Germany) or countries with large and internationally active banks (England). Based on the aforesaid, it can be concluded that the costs of implementing Basel II differed between countries, depending on the development of a country's banking system, risk management level and the current method of capital adequacy measurement.[52]

Moreover, one of the weaknesses and limitations of Basel II is indirect costs (Figure 2) associated with the procyclical effects that this standard can produce at the macroeconomic level. Basel II increases the cyclicity of minimum capital requirements by increasing the sensitivity to credit risks.[53] For this reason, banks are faced with a big problem in managing capital. However, the procyclical effects on macroeconomic fluctuations vary between

[47] Stojanovski, Đ. *op. cit.* 164 - 165.

[48] *Ibid,* 165.

[49] Todorović, V. Tomić, N. *op. cit.* 373.

[50] Milojević, N. *op. cit.* 61.

[51] *Ibid,* 61.

[52] Todorović, V. (2015). *Managing banking crises,* Faculty of Economics of the University of Kragujevac, 146.

[53] So-called capital buffers, which are held by banks above the required minimum and which will be discussed in more detail in the fifth chapter, play a key role in reducing cyclical effects and mitigating the volatility impact of capital requirements.

countries, and different factors may impact the procyclical effects of this standard: inflows of foreign capital, company size, bank sectoral specialisation, banking competition, etc.[54]

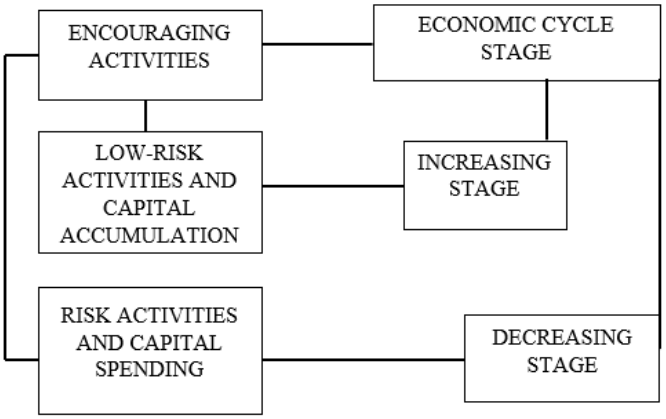

Figure 2 **The procyclical effects of Basel II**

Source: Todorović, V. Tomić, N. (2020). The Basel Accords and banking system stability, *Current Macroeconomic and Microeconomic Aspects of the European Integrations of the Republic of Serbia*, Faculty of Economics, Kragujevac, 374.

The problem of cyclicality of the Basel II capital requirements was the subject of discussions in both financial and regulatory circles. Requests to reduce the minimum capital requirement from 8% to 6% in recession periods, in order to ensure credit expansion, were taken into consideration. However, the Basel Committee stood its ground, indicating that the minimum capital rate needs to be uniform and fixed. If a more flexible capital rate was introduced, the main idea of the Basel Committee underlying the creation of a strong capital requirement regime in the context of higher risks and uncertainty of banking operations might be rendered meaningless. The question is who would decide on a capital rate reduction – the Basel Committee or a supervisor? Finally, the third argument against a lower capital rate was that there were no sufficient macroeconomic reasons to reduce the capital requirement rate.[55]

The global financial crisis showed that there was a discrepancy between the Basel II regulatory framework and its primary objective to preserve financial stability, due to the neglect of systemic risk dimensions and the ease of its transmission. The crisis revealed an obvious omission in the Basel regulation, which consisted of inadequate establishment of dynamic connections between monetary and prudential policies. Central banks were tasked with ensuring macro stability and providing lending services, while supervisors were in charge of prudential regulation and preservation of financial stability. However, the regulation did not oblige them to cooperate closely, which is one of the main causes of the aforesaid crisis.[56]

[54] Heid, F. (2007). The cyclical effects of the Basel II capital requirements, *Journal of Banking & Finance*, 31 (2), 3898.

[55] Todorović, V. Jakšić, M. Tomić, N. (2017). Bank regulations in modern financial environment, *Facta Universitatis, Series, Economics and Organization,* 14 (3), 226.

[56] Todorović, V. Tomić, N. *op. cit.* 375.

5 Development and implementation of Basel III

The global financial crisis that originated in the US began with the collapse of the housing market and credit difficulties. Banks offered favourable mortgage loans to real estate buyers, which resulted in a surge in real estate prices and high profit in the real estate industry. Mortgage loans were granted to customers with low creditworthiness, which increased the number of those who could not pay their mortgage liabilities on time. With mortgages being activated, a large number of real estate was suddenly on offer, but due to reduced credit potential of banks as a consequence of payment delays in outstanding loan instalments, real estate prices dropped drastically. Due to the fact that the estimated mortgage value was higher than the market value of real estate, banks were forced into solvency, which became a mass phenomenon and turned into a financial crisis.[57]

The global financial crisis revealed that the application of rules and measures defined under the Basel II Accord failed to meet the expectations of eliminating adverse effects on the stability of the banking system. In order to improve the ability of the banking system to cushion the adverse effects of the financial and economic crisis and prevent the crisis spillover from the financial sector into the real sector, the Basel Committee on Banking Supervision introduced a new Basel III accord.[58]

Basel III is a key regulatory response to the global financial crisis. It comprises a set of reform measures adopted by the Basel Committee on Banking Supervision for the purpose of strengthening the banking system resilience to a systemic crisis and improving the transparency of banking operations.[59]

The Basel III standard was adopted in EU countries in July 2012 based on the Capital Requirements Directive (CRD IV)[60] and the Capital Requirements Regulation (CRR),[61] while its implementation was planned to begin on 1 January 2013, with gradual application and a transitional period by 2019 inclusive, when the standard was expected to have been fully implemented.

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[57] Stevanović, V. S. Đorđević, T. M. Milanović, R. M. (2010). "Global financial crisis and its effects on the Serbian economy", *Agricultural Economics*, vol. 57, no. 3, 353 – 368.

[58] Đerić, S. (2014). "The role of Basel III Accord in strengthening the stability of the global banking system", *Proceedings of the Faculty of Economics in East Sarajevo*, 8, 296.

[59] Annual Financial Sstability Report, NBS, 2011, 75.

https://www.nbs.rs/export/sites/NBS_site/documents-eng/publikacije/fs/fsr_2011.pdf

[60] Directive 2013/36/EU of the European Parliament and of the Council of 26 June 2013 on access to the activity of credit institutions and the prudential supervision of credit institutions and investment firms, amending Directive 2002/87/EC and repealing Directives 2006/48/EC and 2006/49/EC, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32013L0036

[61] Capital Requirements Regulation (CRR): Regulation (EU) No. 575/2013 of the European Parliament and of the Council of 26 June 2013 on prudential requirements for credit institutions and investment firms and amending Regulation (EU) No. 648/2012, https://www.eba.europa.eu/regulation-and-policy/single-rulebook/interactive-single-rulebook/504

5.1 The purpose of introducing Basel III

As already mentioned, the climax of the global financial crisis resulted in a lack of liquidity on financial markets, slowed down lending to the real sector and a decline in the global economic activity. However, an effective and prompt response of fiscal authorities of major global economies managed to stabilise the market and fully normalise the funding of the real sector. The Basel Committee developed a comprehensive plan, based on which measures for improving the deposit insurance scheme were adopted, which in turn resulted in capital strengthening and preservation of financial system stability. Basel III is a document on capital strengthening and the regulation of the banking sector liquidity.[62]

The objective of the adopted Basel III rules is to improve the ability of the banking sector to absorb shocks arising from both financial and economic stress, and consequently reduce the risk of the crisis spillover from the financial sector onto the real economy.[63]

The purpose of introducing Basel III is as follows:[64]

1) increasing the ability of the banking sector to respond to the shocks arising from financial and economic stress regardless of its cause;
2) risk management monitoring;
3) increasing the transparency of banking operations.

At a micro level, the goal is to increase the resilience of financial institutions in stress periods, and at a macro level, the goal is to identify and monitor risks that can cause disruptions to the overall economic system through the banking sector.[65]

The Basel III standards are more demanding. Their adoption contributes to a higher and better banking base, more adequate risk management, introduction of a new parameter that represents the ratio between capital and total exposure (leverage ratio), and determining its maximum level, defining measures based on which banks will have to set aside more funds to be used in crisis periods and introducing liquidity requirements.[66]

5.2 The first pillar – capital requirements

As already mentioned, the main objective of Basel III is to ensure that banks have more layers of capital that can absorb losses. That is why it introduced higher minimum standards for quantity, quality and risk coverage of capital requirements.[67]

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[62] Ivančević, J. Radaković, M. (2014). "Distinctiveness of the Basel Accords in terms of competitiveness and economic efficiency", *Annals of the Faculty of Economics in Subotica,* Vol. 50. no. 31, 182.

[63] Ljubić, M. (2015). "The implementation of the Basel III capital standards and challenges of the global economic crisis", *Megatrend Journal,* Vol. 12, No. 1, 74.

[64] Jocić Radenković D. Stanković, J. Pešić Anđelković, M. *op. cit.* 1203.

[65] *Ibid.*

[66] Ljubić, M. *op. cit.* 74.

[67] Ingves, S. "Finalising Basel III"", speech, *Sveriges Riksbank*, 2017, 3-4.

5.2.1 Capital buffers

A macroprudential policy is a policy aimed at limiting risks that the overall financial system is exposed to (the so-called system risks) for the purpose of preserving financial stability. A systemic risk is most often defined as a risk of disruption in the provision of financial services, caused by a failure in the overall financial system or one of its components, which might result in severe adverse effects on the real sector.[68]

One of the crucial Basel III novelties is capital buffers, i.e. instruments of the macroprudential policy, which have been applied by the NBS since 30 June 2017.

Capital buffers are additional common equity Tier 1 capital that banks have to maintain above the prescribed regulatory minimum. The advantages of their introduction are reflected in the fact that they increase bank's resilience to losses, reduce excessive or understated exposures and limit capital distribution.[69] These macroprudential instruments should limit systemic risks in the financial system that may be cyclical (capital conservation buffer and countercyclical capital buffer) or structural (capital buffer for systemically important banks and capital buffer for a structural systemic risk).

5.2.2 Capital conservation buffer (CCB)

Capital conservation buffer is a macroprudential instrument stipulating the obligation of banks to maintain additional common equity Tier 1 capital in the amount of 2.5% of their risk-weighted assets.[70]

Banks have to maintain the capital conservation buffer on both individual and consolidated bases in the amount of 2.5% of their risk-weighted assets, calculated in accordance with the Decision on Capital Adequacy of Banks.[71]

Capital conservation buffer may only include the components of common equity Tier 1 capital and cannot be used to maintain capital adequacy ratios,[72] i.e. bank's increased capital adequacy ratio.[73]

Those banks that do not maintain a capital conservation buffer cannot distribute common equity Tier 1 capital in the amount that would reduce common equity Tier 1 capital to the level

[68] Macroprudential framework, NBS, 2015, 3-4. https://nbs.rs/en/ciljevi-i-funkcije/finansijska-stabilnost/finansijska-stabilnost/

[69] Capital buffers, https://nbs.rs/en/ciljevi-i-funkcije/finansijska-stabilnost/zastitni_slojevi_kapitala/index.html

[70] Capital conservation buffer, https://nbs.rs/en/ciljevi-i-funkcije/finansijska-stabilnost/zastitni_slojevi_kapitala/index.html

[71] Section 3, paragraph 2, of the Decision on Capital Adequacy of Banks (RS Official Gazette, Nos 103/2016, 103/2018, 88/2019, 67/2020, 98/2020, 137/2020, 59/2021 and 67/2022);

[72] Section 3, paragraph 3, of the Decision on Capital Adequacy of Banks

[73] Section 5 of the Decision on Capital Adequacy of Banks

indicating that the bank can no longer meet the combined buffer requirement. In fact, banks have to calculate the maximum distributable amount and inform the NBS about it.[74]

In addition, banks that do not meet the combined buffer requirement have to develop a capital conservation plan and deliver it to the NBS not later than five business days after they discovered they did not meet the said requirement.[75]

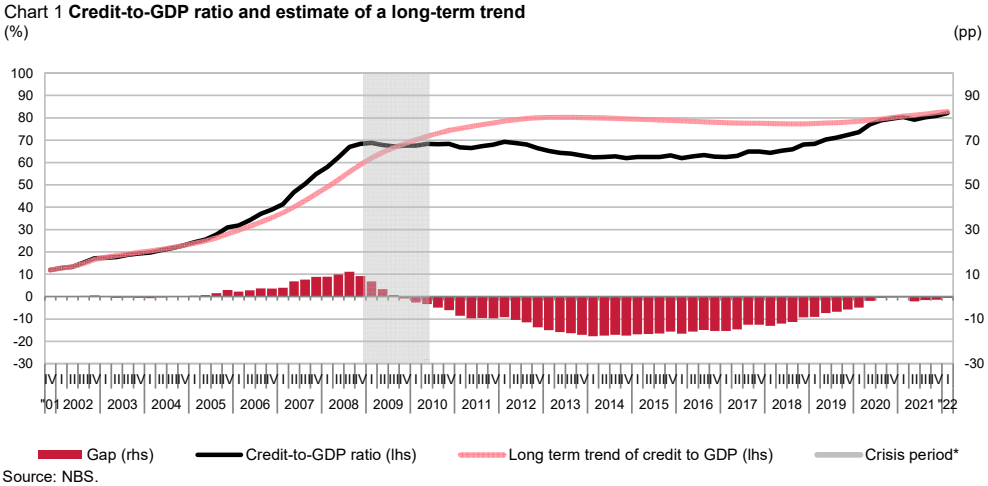
This instrument has also been used to boost economic growth and prevent potential adverse effects of the coronavirus pandemic. Banks are allowed to exclude certain exposures from their risk-weighted assets when calculating the CCB in the period from August 2020 until end-2022.[76] The objective of this measure is to facilitate citizens' access to housing loans and thus provide support to the real sector, namely the construction industry.

5.2.3 Countercyclical capital buffer (CCyB)

Countercyclical capital buffer (CCyB) is additional common equity Tier 1 capital that banks have to maintain above the prescribed regulatory minimum in the amount equal to the result of their risk-weighted assets and a specific countercyclical capital buffer rate. Additional common equity Tier 1 capital is created during a period of pronounced credit growth when this instrument is applied, which increases the resilience of the banking sector and reduces the possibility of a financial crisis.[77]

The NBS sets a CCyB rate for the Republic of Serbia on a quarterly basis taking into consideration the reference guide, applicable guidelines and recommendations of the European Systemic Risk Board (ESRB) and other variables it considers relevant for monitoring the

Chart 1 **Credit-to-GDP ratio and estimate of a long-term trend**



Source: NBS.
*Based on SSI.

[74] Section 455 of the Decision on Capital Adequacy of Banks

[75] Section 458 of the Decision on Capital Adequacy of Banks

[76] Section 2 of the Decision on Temporary Measures for Banks to Facilitate the Access to Financing for Natural Persons (RS Official Gazette, Nos 108/2020 and 119/2021);

[77] Explanation for the countercyclical capital buffer rate for the Republic of Serbia, NBS, June 2022 https://www.nbs.rs/export/sites/NBS_site/documents-eng/finansijska-stabilnost/Explanation_CCB_20220609.pdf

cyclical dimension of systemic risk. Pursuant to the Decision on Capital Adequacy,[78] the basis for determining the reference guide for setting the CCyB rate is a deviation of the credit-to-GDP ratio from its long-term trend.[79]

Chart 1 shows the total non-government sector credit-to-GDP ratio, a long-term trend and the estimated credit-to-GDP deviation from its long-term trend in Serbia. After a period of credit expansion from 2000 to 2008, the credit-to-GDP gap entered a negative territory at the end of 2009. Credit activity has been on the rise since 2014 and, as a result, the share of total loans in GDP came closer to its long-term trend. According to data from March 2022, the ratio of real credit activity to real GDP was below its long-term trend (the gap is -0.6 pp). At the end of Q1 of 2022, the gap increased by 16.9 pp compared to end-2014, and by 0.8 pp relative to the previous quarter. Taking into consideration that the estimated ratio of real credit activity to real GDP was below its long-term trend, accompanied by global uncertainty, intensified geopolitical tensions and the outbreak of the Ukraine conflict, setting the CCyB rate above 0% might result in potentially lower growth in credit activity.[80]

Basel II envisages that the CCyB should be introduced (or increased) as a macroprudential policy instrument during a period of pronounced credit growth, which would contribute to creating an additional capital buffer that can be released if systemic risk materialises, and enable sustainable lending.[81]

5.2.4 Capital buffer for systemically important banks

Capital buffer for systemically important banks is a macroprudential instrument stipulating that banks identified as systemically important for the local economy need to maintain additional common equity Tier 1 capital. Disruption in operations or a collapse of a systemically important financial institution may result in considerable disruptions in the functioning of the overall financial system, thereby jeopardising economic activity. This instrument reduces the probability of such an event occurring. The use of this instrument neutralises comparative advantages that such institutions have due to the "too big to fail" status (moral hazard). Systemically important banks in Serbia have been identified on the basis of the same criteria and mandatory indicators prescribed by the European Banking Agency Guidelines. The NBS reviews the capital buffer for systemically important banks and the methodology for identifying systemically important banks at least once a year, and a list of systemically important banks is published on the NBS web page.

According to the Decision on Compiling a List of Systemically Important Banks in the Republic of Serbia and Their Capital Buffer Rates, dated 16 June 2022, the following

[78] Section 436, paragraphs 2 and 3 of the Decision on Capital Adequacy of Banks

[79] Explanation for the countercyclical capital buffer rate for the Republic of Serbia, NBS, June 2022 https://www.nbs.rs/export/sites/NBS_site/documents-eng/finansijska-stabilnost/Explanation_CCB_20220609.pdf

[80] *Ibid.*

[81] Basel Committee, (2010). "Guidance for national authorities operating the countercyclical capital buffer", *Bank for International Settlements,* Basel, Switzerland, 6 – 7, https://www.bis.org/publ/bcbs187.pdf

systemically important banks have been identified, as well as their capital buffer rates that they have to maintain as of 30 June 2022.[82]

Table 2 **List of systemically important banks in Serbia with capital buffer rates for systemically important banks**

Bank	Capital buffer rate for systemically important banks
BANCA INTESA AKCIONARSKO DRUŠTVO (NOVI BEOGRAD)	2%
OTP BANKA SRBIJA AKCIONARSKO DRUŠTVO NOVI SAD	2%
RAIFFEISEN BANKA AD BELGRADE	2%
NLB KOMERCIJALNA BANKA AD BELGRADE	2%
AGROINDUSTRIJSKO KOMERCIJALNA BANKA AIK BANKA AKCIONARSKO DRUŠTVO, BELGRADE	2%
UNICREDIT BANK SRBIJA A.D. BELGRADE (STARI GRAD)	1%
BANKA POŠTANSKA ŠTEDIONICA AKCIONARSKO DRUŠTVO, BELGRADE (PALILULA)	1%
ERSTE BANK AKCIONARSKO DRUŠTVO, NOVI SAD	1%
EUROBANK DIREKTNA AKCIONARSKO DRUŠTVO BELGRADE	1%

Source: NBS

5.2.5 Systemic risk buffer (SRB)

Systemic risk buffer (SRB) is additional capital expressed as a percentage of risk-weighted assets. It is introduced to limit the euroisation risk as one of crucial structural and non-cyclical systemic risks to the stability of the Serbian financial system.

The systemic risk buffer rate is set at 3% of total daily and foreign currency indexed receivables that banks approve to corporates and households in Serbia.[83]

The Serbian banking sector is still highly euroised[84] and characterised by a high level of deposit euroisation (in June 2022, 63.5% of total corporate and retail deposits were FX and

[82] Capital buffers, https://nbs.rs/en/ciljevi-i-funkcije/finansijska-stabilnost/zastitni_slojevi_kapitala/index.html

[83] Section 3 of the Decision on the Rate and Manner of Maintaining the Systemic Risk Buffer (RS Official Gazette, Nos 58/2017 and 3/2018).

[84] According to the ECB working paper: *Windischbauer U. Strengthening the role of local currencies in EU candidate and potential candidate countries,* http://www.ecb.europa.eu/pub/pdf/scpops/ecbop170.en.pdf?8ca594f1a1391f72a33d05aca6a0405c and the working paper published on the BIS web page: *Alvarez-Plata P.* and *García-Herrero A. To dollarize or de-dollarize, Consequences for Monetary Policy*, http://www.bis.org/repofficepubl/arpresearch200709.1.pdf, countries with a euroization level above 40% are classified as highly euroized countries. Additionally, according to the latter working paper, a level of euroisation between 10% and 40% is considered moderate, whereas it is deemed to be low if it is below 10%.

FX-indexed deposits) and credit euroisation (FX and FX-indexed receivables accounted for 62.8% of total corporate and household receivables in June 2022).[85]

5.3 The second pillar – liquidity standard

Liquidity entails a bank's ability to increase its liquid assets and settle outstanding liabilities when they fall due, without incurring considerable losses. A bank is a financial institution that mediates between parties that have a surplus of funds and parties that have a deficit of funds (i.e. household segment). Liquidity risk management is one of bank's functions that is crucial to its efficient and successful performance.[86]

The global financial crisis revealed that a large number of well-capitalised banks had liquidity problems during the crisis. A problem arises when banks allocate capital in order to have a higher level of capital adequacy without paying attention to possible consequences to their liquidity. In 2008 the Basel Committee on Banking Supervision issued a document titled *The principles for sound liquidity risk management and supervision*. Its purpose was to point to the need to improve the approach to the liquidity risk management process.[87]

In order to improve the stability and resilience of financial systems to unexpected and unforeseeable events, the Basel III legislation entails the application of new liquidity measures, such as the liquidity coverage ratio (LCR) and the net stable funding ratio (NSFR).

An additional macroprudential liquidity requirement (liquidity coverage ratio – LCR) implies that banks maintain an adequate level of unencumbered and highly liquid assets that can be converted into cash within a month if unforeseeable market events occur. The primary objective of LCR is to regulate short-term liquidity and banks' increased resilience to stress situations during a one-month period. According to the LCR, the amount of bank's unencumbered and highly liquid assets during a 30-day period should be higher than the forecast net cash outflows. The LCR is obtained as follows:[88]

$$LCR = \frac{Total\ highly\ liquid\ assets}{\begin{matrix} Total\ net\ cash\ outflow \\ in\ a\ 30-day\ period \end{matrix}} \geq 1$$

Highly liquid assets are classified under two categories:[89]

Level 1 liquid assets that include cash and cash equivalents, a surplus above the minimum reserve requirement with the central bank, government securities with a risk weight of 0% according to the Basel II legislation;

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[85] Report on Dinarization of the Serbian Financial System, First Quarter 2022, NBS, July 2022. https://www.nbs.rs/export/sites/NBS_site/documents-eng/publikacije/dinarizacija/izvestaji/din_I_22.pdf

[86] Mirković, V. "The application of liquidity ratios in risk management in banks", *Finance management in modern business circumstances, Finiz 2015 - Invited papers,* 13.

[87] S. Đerić, *op. cit.* 299.

[88] V. Mirković, *op. cit.* 14 – 15.

[89] *Ibid.*

Level 2 liquid assets that comprise government securities with a risk weight of 20% according to the Basel II legislation, covered and non-financial corporate bonds with an investment grade (of at least AA-);

The total net cash outflow contained in the LCR denominator represents a difference between total expected cash outflows and total expected cash inflows in the next 30 days.[90]

The net stable funding ratio (NSFR) requires a minimum amount of bank's stable funding sources in relation to the liquid profile of assets, as well as the potential for a set of liquid needs arising from off-balance sheet liabilities in a period longer than one year. This ratio is modelled in order to ensure a sustainable maturity structure of assets and liabilities in the bank's balance sheet.[91]

The main objective of introducing the NSFR is to reduce a maturity mismatch between the items of assets and liabilities, whose residual maturity is at least one year. The idea is that the NSFR should be higher than 1, i.e. 100%, since the amount of available stable funding needs to exceed the required funding assets in the observed period. The NSFR is obtained as follows:[92]

$$NSFR = \frac{Available\ stable\ funding}{Required\ stable\ funding} \geq 1$$

Available stable funding includes total bank capital, total preference shares with maturities of one or more years, liabilities with an effective maturity longer than one year, demand deposits and/or term deposits with maturities of up to one year and economy sector funding with a maturity of up to one year. Required stable funding is defined as a weighted sum of assets multiplied by a specific factor of required stable funding assets assigned to each balance sheet item separately.[93]

5.4 The third pillar – leverage ratio

The leverage ratio is a general measure of risk. It was introduced under Basel III as an addition to a risk measure that is based on capital adequacy. Namely, the global financial crisis of 2007/2008 revealed a deficiency in the use of the capital adequacy ratio as a bank's general risk ratio. For this reason, it was concluded that a simple relationship between a bank's capital and exposure, without applying weights, may considerably contribute to understanding assumed risks. Its application is particularly evident during economic and financial crises, which produce high financial risk rates at a macro level, as was the case during the most recent crisis which was the subject matter of an analysis conducted by the Basel Committee. The leverage ratio was introduced under Basel III as a solvency indicator, which should be an obstacle to uncontrolled distortion of the relationship between the capital requirement and its

[90] *Ibid.*

[91] Matić, V. (2011). "Banking risk 22: Basel III – introducing liquidity standard", *Banking,* 3-4, 160.

[92] Mirković, V. *op. cit.* 15

[93] *Ibid.*

exposure to risk, whose ratio serves as an additional measure for determining the capital requirement.[94]

The leverage ratio is also defined as a ratio between the capital measure (capital definition) and bank's exposure measure (total bank's exposure), which is calculated as an average monthly leverage ratio during one quarter.[95]

The Basel Committee proposed that the minimum level 1 of the leverage ratio should be 3%, with the Basel Committee monitoring it on a semi-annual basis.[96]

A capital measure for the leverage ratio is Tier 1 capital, as defined under Basel III. Deductible items from Tier 1 capital, as defined by Basel III provisions, are deductible items when determining bank's total exposure and other components for calculating the leverage ratio. Such an approach is necessary in order to consistently measure capital and exposure, and avoid double calculation. Banks' investments in the capital of financial institutions (banks, insurance undertakings and other financial institutions) that are outside the regulatory consolidation framework are treated as deductible capital items for the purpose of estimating a leverage ratio to the extent to which these investments exceed certain thresholds.[97]

The exposure measure, as well as the other leverage ratio component, usually accompany the accounting exposure measure, which implies the following:[98]

1) balance-sheet, non-derivative exposures do not have specific reserves or value settings;
2) the amount of exposure per balance sheet item is taken into account before using risk mitigation instruments (guarantees, physical and financial collaterals, etc.)
3) the impact of the balance sheet netting of loans and deposits on the amount of exposure for the purpose of estimating this ratio is not allowed.

Apart from common requirements, some specific ones are also prescribed for the purpose of estimating the exposure measure as a component of the leverage ratio.

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[94] Đeric. S. *op. cit.* 300.

[95] Matić, V. "Banking risk 27: Basel III – Leverage Ratio", Banking, 1/2012, 132.

[96] Ivanova, P. B. Barjaktarović, L. Ivanov, Đ. I. "Leverage ratio as a Basel standard in the financial management of the petroleum industry", *Vojno delo,* 7/2018, 346.

[97] Matić, V. Basel III – Leverage Ratio, *op. cit.* 132.

[98] *Ibid.*

6 Conclusion

Modern banking trends take place in complex conditions and are exposed to a wide range of risks, which disrupt financial stability to a lesser or a greater extent. Hence, a need for more thorough supervision of banks and international convergence of national legislation arose. An appropriate regulatory framework needs to be in place in order to make informed decisions, although it cannot completely eliminate risks.

International convergence and standardisation of general banking terms and conditions are associated with the Basel Committee's activities, which resulted in the adoption of the Capital Adequacy Accords (Basel I, Basel II and Basel III). Basel I managed to introduce discipline in global banking sectors and make a positive impact on the amount of bank capital. However, its main weakness lies in the fact that it only dealt with credit risk. Another weakness was that the same standard, i.e. a minimum capital adequacy ratio of 8%, applied to all types of banks. The shortcomings of the Basel I Accord were the reason for adopting Basel II, which addressed operational risk in addition to credit and market risks. It was based on the increased sensitivity of banks and other financial institutions to risks. However, it neglected the liquidity issue as a key factor of banking system instability, which only came to light thanks to Basel III.

The global financial crisis revealed some major weaknesses of the Basel Accords and the inability to prevent the collapse of the banking and financial systems. Afterwards, reforms were initiated to harmonise monetary and prudential policies, which resulted in the adoption of the Basel III Accord. Its main purpose is to ensure the stability of the financial system and capital adequacy and liquidity of banks, and to reduce systemic risk. A major novelty of Basel III is the introduction of capital buffers, liquidity coverage ratios and the leverage ratio.

To conclude, we can say that it is necessary for legislation to keep up with new risks as, even though financial novelties do bring some advantages, they can certainly jeopardise financial stability if they are not adequately managed. Additionally, the role of supervisors is crucial since they ensure rules that have to be applied, while their cooperation with banks and banking associations, supervisors from other countries and other institutions for the purpose of properly managing banking risks is also highly significant. Taking into consideration the aforesaid, it is necessary to regularly upgrade banking regulations and ensure professional development of employees who will be able to adequately respond to challenges ahead.

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