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THE NEW KEYNESIAN PHILLIPS CURVE AND THE EFFECTS OF DOMESTIC INFLATION DRIVERS IN THE REPUBLIC OF SERBIA

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This study investigates the validity of the New Keynesian Phillips curve in the Republic of Serbia. By means of empirical analysis, the impact of domestic inflation drivers, i.e. inflation expectations, real marginal costs and the output gap, is quantified. The results reveal that inflation in Serbia responds more intensively to negative rather than positive supply and demand shocks as it decreases more significantly in economic contraction than in expansion. The estimated model of the New Keynesian Phillips curve with marginal costs gives the unambiguous evidence that the growth of cost-push inflation could be reduced by a productivity-enhancing policy. Expected inflation significantly impacts the actual inflation rate, albeit inflation dynamics are dominated by inertia, i.e. past rates affect the current. The empirical estimate of the New Keynesian Phillips curve model with the output gap that indicates monetary expansion in the Republic of Serbia might, inter alia, stimulate the economic activity without causing significant inflationary pressures to occur.

Keywords: inflation rate, output gap, unit labor costs, nonlinear ARDL model, dynamic multiplier, asymmetry

JEL Classification: B22, C13, C32, E31

INTRODUCTION

The contemporary analysis of inflation dynamics is commonly based on the New Keynesian Phillips curve (NKPC). In its original version, the curve represents the effect of domestic inflation drivers in the closed economy model. Actual inflation is determined by expected future inflation and the factors of the real economic activity, such as real marginal costs and the output gap as a deviation of the actual output from the potential. Despite growing interdependence among national economies, a number of recent research studies (Globan, Arčabić & Sorić, 2015; Hałka & Kotłowski, 2016; Abdih, Lin & Paret, 2018) clearly confirm the fact that inflation dynamics in developed and emerging economies are determined by domestic inflation drivers. A study of the European Central Bank indicates that global inflation drivers had a

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statistically significant impact on inflation in the Eurozone only in period from 2008 to 2009, whereas in the period from 2012 to 2015, domestic factors were dominant. In transition countries, the impact of domestic inflation drivers is specific and was commonly determined by the intensity of the reform processes towards the market economy. The relative significance of particular drivers evolves as transition progresses, so that the dominance of the output gap, the fiscal deficit and political cycles in initial phases are subsequently substituted by the impact of food and oil prices, the exchange rate regime, and the current account in mature phases (Petrović, Mladenović & Nojković, 2011).

Compared with other countries, the Republic of Serbia started transition reforms relatively late. Initially, as in other transition economies, a high inflation rate was the corollary of these reforms. During the 2010s, due to the monetary policy regime based on inflation targeting, monetary stability was enhanced, along with inflation volatility reduction (Narodna banka Srbije, 2018). However, the dynamics of the domestic drivers (the output gap, aggregate demand, the productivity rate, inflation expectations) were characterized by large fluctuations in the mention period. Assumed by the NKPC concept, a strong association between these drivers and the inflation rate raises the issue of the validity of this curve in the context of the Republic of Serbia, as well as the exact impact of these inflation drivers.

Not disputing the effect of external factors (the exchange rate, the import/export share in the GDP, the oil price, etc.), this study tries to extract the impact of the domestic inflation drivers in the Republic of Serbia, because a better understanding of the mechanism and the extent of their influence contributes to the designing of more efficient monetary policy measures intended to maintain monetary stability. In addition to the above, the study investigates the nonlinearity of the NKPC in the economy of the Republic of Serbia. Bearing in mind the fact that this relationship assumes a certain extent of the price and wage rigidity in the short run, there is a possibility of the asymmetric (nonlinear) adjustment of the inflation rate to changes in the economy. For instance, if prices are rigid downwards, economic contraction might reduce the inflation rate to a lesser extent in the short run, compared with inflation growth due to economic expansion. By assumption, prices are flexible in the long run, as frictions in their adjustment diminish and the long-term reaction of inflation to the economic activity would be symmetric.

Accordingly, the empirical analysis of the validity of the NKPC in the economy of the Republic of Serbia and the investigation of the role of the domestic inflation drivers are the subject matter of this paper.

The research study is aimed at revealing whether the explanatory variables (the expected inflation rate, real marginal costs and the output gap) in a relationship have a significant impact on the actual inflation rate. Besides, a long-term asymmetry in the manner in which inflation reacts to changes in these variables is also examined. The presence of such asymmetry has important implications for the monetary policy, since the intensity of its measures should be in accord with how inflation responds to different phases of the business cycle.

The main motivation lies in the fact that quantifying the effects of the domestic drivers gave a more complete picture of inflation dynamics in the Republic of Serbia in the last decade. The research is also motivated by the fact that, according to the best of the author's knowledge, there have been no empirical studies of the NKPC nonlinearity in the Republic of Serbia to date, albeit this relationship has become the basis for the contemporary analysis of the inflation and stabilization policy.

In line with the defined subject matter and aim of the research study, the following research hypotheses are tested:

H1: The expected future inflation rate has a statistically significant impact on the actual inflation rate dynamics in the Republic of Serbia.

H2: Real marginal costs have a positive, statistically significant and symmetric long-term effect on the inflation rate in the Republic of Serbia.

H3: The output gap changes in expansionary and contractionary periods are in a positive, statistically significant and symmetric long-term association with the inflation rate in the Republic of Serbia.

As an econometric approach suitable for testing research hypotheses, the Nonlinear Autoregressive Distributive Lag (NARDL) method developed by Y. Shin, B. Yu and M. Grenwood-Nimmo (2014) is employed. This approach allows for a joint analysis of short- and long-term relationships between dependent and explanatory variables and their asymmetric effects. In addition, it enables the presentation of the cumulative intertemporal effects of inflation drivers, as well as adjustment after the initial shock towards a long-term equilibrium (Shin *et al*, 2014). Furthermore, in the context of the research hypotheses, this approach helps investigate not only the direction and statistical significance of the relationships between real marginal costs, the output gap and the inflation rate in the Republic of Serbia, but also the presence of long-term asymmetry in the reaction of inflation to these drivers in expansionary and contractionary periods.

Apart from the Introduction and the Conclusion, the paper consists of the three sections: in the second section, the NKPC theoretical background is discussed and an overview of the reference empirical research studies is given; in the third section, the econometric approach and the data are presented. The results and a discussion on the empirical results are given in the fourth section.

THE THEORETICAL AND EMPIRICAL BACKGROUNDS OF THE NEW KEYNESIAN PHILLIPS CURVE

The Theoretical Framework

The NKPC represents the outcome of convergence between neoclassical and Keynesian theories. By connecting the rational expectation hypothesis, as the "trademark" of New Classical Macroeconomics, with price and wage rigidity models, New Keynesians have made a step closer to the New Consensus Macroeconomics. Inflation dynamics modelling in the New Consensus is dominantly based on the NKPC (Galí, 2008). The actual inflation rate (π_t) is determined by the present expectations of a future inflation rate ($E_t\pi_{(t+1)}$), which is in line with the rational expectation hypothesis. The impact of changes in the real economy on the actual inflation rate is captured by the second component, which basically refers to real marginal costs dynamics (mc_t). Accordingly, the NKPC can be expressed as follows (Galí, 2008):

$$\pi_t = \beta E_t(\pi_{t+1}) + \lambda mc_t, \tag{1}$$

where β measures the impact of the expected future inflation rate on the actual rate, whereas λ represents the frequency of the price change, thus reflecting the impact of real marginal costs on the inflation rate. Marginal cost changes are determined by the productivity and production capacity utilization rate, as well as input prices, which may all lead to cost-push inflation. Beside the NKPC with marginal costs, there is also a version with the output gap (a deviation of the actual output from the potential). Namely, if the following is assumed:

$$mc = \kappa(y_t - y_t^*), \tag{2}$$

which means that the relationship between marginal costs and the output gap ($y_t - y_t^*$) can be expressed by the parameter κ, then it follows:

$$\pi_t = \beta E_t(\pi_{t+1}) + \lambda\kappa(y_t - y_t^*) \tag{3}$$

where y_t and y_t^* refer to the actual and potential outputs, respectively (Galí, 2008). The positive output gap occurs when aggregate demand exceeds potential supply, thus creating inflationary pressure. In contrast, an insufficient level of aggregate demand results in a negative output gap, which decreases the inflation rate (Orphanides & van Norden, 2005).

An Overview of the Empirical Research

Since this study investigates the original form of the NKPC for a closed economy, the current section is

focused on recent research studies dealing with the role of domestic inflation drivers and asymmetries in their effects on inflation.

Using different alternatives for the output gap, S. Oinonen and M. Pallovita (2014) find that the negative output gap in the euro area existent since 2012 has lowered the inflation rate below the policy target and that the Phillips curve has become steeper. C. Friedrich (2016) applies the factor model to estimate the Phillips curve for 25 advanced economies. He concludes that, apart from the output gap, the inclusion of inflation expectations into this relationship improves the explanation of inflation dynamics. Analyzing the NKPC in the USA, Q. Xu, X. Niu, C. Jiang, and X. Huang (2015) document that an increase in the output gap leads to a higher level of inflation and raises its volatility. M. Jarociński and M. Lenza (2018) assess the euro area output gap as a factor of inflation dynamics. They conclude, inter alia, that an increase in aggregate demand may reduce the output gap after 2011, which wouldn't be coupled with an increase in inflation. M. Jašová, R. Moessner and E. Takáts (2018) analyze the impact of domestic output gaps on inflation in 25 developed and 22 emerging economies. Comparing these effects with the impact of the global output gap, they conclude that both of them were and are important inflation drivers before the Great Recession of 2008 and in the post-crisis period as well, respectively.

Whereas the significance of the output gap as a determinant of the dynamics of the inflation rate is mainly confirmed by numerous empirical studies, the findings related to the validity of the NKPC with marginal costs included are diversified and usually depend on the choice of the analyzed economy. For example, S. Lagoa (2014) finds the evidence that nominal unit labour costs, along with a long-term discrepancy between prices and costs, could explain inflation differentials in the euro area. J. Posh and F. Rumler (2014) estimate a hybrid NKPC with the open-economy measure of marginal costs. Their model provides a good explanation of inflation changes in the United Kingdom, but only in the short run. In contrast, S. Mazumder (2012) shows that real unit labour costs cannot explain the inflation dynamics in the European economies; these costs are also a poor proxy for real marginal costs. Similar findings for the USA can be found in E. V. Peneva and J. B. Rudd (2017). These controversies stimulate a certain additional research study based on a different methodology in order to generate more valid and unambiguous conclusions about the impact of these costs on the inflation rate.

Opposite to the research studies dealing with developed economies, the studies of the NKPC in (former) transition countries do not find enough evidence of the importance of inflation expectations and real marginal costs, but rather frequently emphasize a higher extent of price rigidity. Thus, A. Dabušinskas and D. Kulikov (2007) develop the Phillips curve model for the Baltic economies (Estonia, Latvia, and Lithuania) and conclude that actual inflation is mainly determined by past rates and, to a lesser extent, by expected future inflation, whereas the impact of real marginal costs is not significant. B. Vašíček (2011) comes to a similar conclusion for Visegrád Group, A. Vasilev (2015) for Hungary and F. Furuoka (2016) for the Baltic States. In contrast, M. Bouda (2013) finds the evidence of the key impact of expected inflation, along with monetary policy shocks, on the actual inflation rate in the Czech Republic. M. Basarac, B. Škrabić and P. Sorić (2011) analyze the hybrid Phillips curve in nine transition economies and confirm the fact that actual inflation is associated with expected inflation and the output gap in the long run.

In recent years, many empirical studies have investigated nonlinearity (asymmetry) in the relationship between the variables of the Phillips curve and the inflation rate. For instance, P. G. Egan and A. J. Leddin (2017) investigate inflation dynamics in China and conclude that the inflation-output relationship is nonlinear. Analyzing unemployment fluctuations in the New Keynesian model, A. Lepetit (2018) investigates the role of the labor market asymmetries in designing efficient monetary policy measures. He concludes that this asymmetry is the key determinant of the inflation-unemployment relationship and that the monetary policy should be directed towards both inflation and unemployment.

Employing the NARDL model and the methods of causality, M. E. Bildirici and F. Özaksoy Sonustun (2018) investigate the inflation-unemployment nexus in Japan, Turkey, the USA and France. The empirical estimates indicate a negative and asymmetric long-term relationship between these variables. J. Morley and I. B. Panovska (2019) assess the business cycle asymmetry in ten industrialized economies. They reveal that the output gap responds more intensively during recessions than in expansions, thus indicating that the Phillips curve is mainly convex. A research study conducted by S. Ho and B. N. Iyke (2019) also confirms the nonlinearity of the Phillips curve in 11 Eurozone countries and indicates that the inflation-unemployment nexus is negative when the unemployment rate is lower than 5%.

Having in mind the empirical research studies carried out to date, this study aims to supplement the literature dealing with the role and significance of asymmetric effects in the NKPC in transition economies by focusing on the Republic of Serbia's economy. The empirical results may improve the understanding of the inflation process and may serve monetary authorities in setting more efficient measures aimed at achieving and maintaining monetary stability.

RESEARCH METHODOLOGY AND DATA

The Econometric Model

The main problem in the empirical analysis of the validity of the New Phillips curve (Equation 1), reflects a fact that the data about real marginal costs are not available. Instead, J. Galí and M. Gertler (1999) proposed that unit labor costs should be used, which has become the approach commonly used in empirical research studies (Furuoka, 2016; Peneva & Rudd, 2017; Chin, 2018). These authors employ average labor costs instead of real marginal costs, which is defined as the total labor share in the nominal output:

$$mc_t = \frac{w_t n_t}{p_t y_t}, \tag{4}$$

where w_t denotes the nominal wage, n_t stands for employment, p_t is the price level, and y_t represents the output.

The total labor share in the nominal output can be perceived as the real unit labor cost (φ_t), which justifies its use instead of the real marginal cost. Furthermore, for the purpose of the empirical analysis conducted in this paper, Equation (1) can be extended by introducing an intercept (α_0), which indicates the inflation rate consistent with the zero value of the explanatory variables, as well as by adding a random error (ε_t), in order to generate the following equation:

$$\pi_t = \alpha_0 + \beta_1 \pi_t^e + \nu\varphi_t + \varepsilon_t, \tag{5}$$

where π_t^e denotes expected future inflation, whereas the coefficient ν measures the effect of change in the unit labour costs on the inflation rate.

Likewise, Equation (3) can be reformulated so as to generate an NKPC model for empirical estimation as follows:

$$\pi_t = \alpha_1 + \beta_2 \pi_t^e + \gamma x_t + \varepsilon_t, \tag{6}$$

where x_t denotes the output gap ($x_t \equiv y_t - y_t^*$).

The empirical analysis carried out in this study is based on the Autoregressive Distributive Lag (ARDL) approach. Since the lagged values of the dependent and explanatory variables serve as regressors, the model introduces dynamics into their relationship, thus helping eliminate the problem with the autocorrelation of residuals (Moosa, 1997).

Starting from Equation (5), the Autoregressive Distributed Lag (ARDL) model (*m*, *n*) of the NKPC can be expressed as follows:

$$\Delta\pi_t = \alpha_0 + \beta_1\pi_{t-1} + \delta_1\pi_{t-1}^e + v\varphi_{t-1} + \sum_{j=1}^{m} \vartheta_j \Delta\pi_{t-j} + \sum_{j=0}^{n} \tau_j \Delta\varphi_{t-j} + \varepsilon_t \tag{7}$$

where Δ is the first difference operator, β_1, δ_1 and v are the long-term coefficients, ϑ and τ denote the short-

term coefficients, whereas *m* and *n* are the selected lag length.

It is evident that the expected inflation rate (π^e) serves as a fixed regressor, i.e. its impact is modelled without the distributed lags that cover the short-term relationship. This allows the modelling of the long-term relationship between change in actual inflation in the observed quarter and expected inflation in the same quarter of the next year, since the analyzed data are structured in such a way.

In order to test the second research hypothesis, it is necessary to decompose the dynamics of unit labor costs into positive and negative changes, on the one hand, and reveal their impact on the inflation rate, on the other. Changes in real unit labor costs (φ_t) are decomposed into increasing and decreasing partial sums, i.e. $\varphi_t = \varphi + \varphi_t^+ + \varphi_t^-$, where φ_t^+ and φ_t^- represent the partial sums of positive and negative changes in real unit labour costs, generated as follows (Shin *et al*, 2014):

$$\varphi_t^+ = \sum_{j=0}^{t} \Delta\varphi_j^+ = \sum_{j=0}^{t} max(\Delta\varphi_j, 0)$$
$$\varphi_t^- = \sum_{j=0}^{t} \Delta\varphi_j^- = \sum_{j=0}^{t} min(\Delta\varphi_j, 0) \quad (8)$$

By substituting φ_t in Equation (7) by φ_t^+ and φ_t^-, the NARDL model is obtained in the following form:

$$\Delta\pi_t = \alpha_0 + \beta_1\pi_{t-1} + \delta_1\pi_{t-1}^e + v^+\varphi_{t-1}^+ + v^-\varphi_{t-1}^- + \sum_{j=1}^{m} \vartheta_j\Delta\pi_{t-j} + \sum_{j=0}^{n}(\tau_j^+\Delta\varphi_{t-j}^+ + \tau_j^-\Delta\varphi_{t-j}^-) + \varepsilon_t \quad (9)$$

Likewise, starting from Equation (6), the ARDL (*p*, *q*) model of the NKPC can be expressed as follows:

$$\Delta\pi_t = \alpha_1 + \beta_2\pi_{t-1} + \delta_2\pi_{t-1}^e + \gamma x_{t-1} + \sum_{i=1}^{p} \kappa_i\Delta\pi_{t-i} + \sum_{i=0}^{q} \mu_i\Delta x_{t-i} + \varepsilon_t, \quad (10)$$

where β_2, δ_2 and γ denote the long-term coefficients, κ and μ are the short-term coefficients, and *p* and *q* are the selected lag length.

The changes in the output gap (x_t) are decomposed into increasing (x_t^+) and decreasing (x_t^-) partial sums in the following way:

$$x_t^+ = \sum_{i=0}^{t} \Delta x_i^+ = \sum_{i=0}^{t} max(\Delta x_i, 0)$$
$$x_t^- = \sum_{i=0}^{t} \Delta x_i^- = \sum_{i=0}^{t} min(\Delta x_i, 0) \quad (11)$$

In order to test the third research hypothesis, the NARDL model of the NKPC with the output gap is obtained by replacing x_t with x_t^+ and x_t^- in Equation (10):

$$\Delta\pi_t = \alpha_1 + \beta_2\pi_{t-1} + \delta_2\pi_{t-1}^e + \gamma^+x_{t-1}^+ + \gamma^-x_{t-1}^- + \sum_{i=1}^{p} \kappa_i\Delta\pi_{t-i} + \sum_{i=0}^{q}(\mu_i^+\Delta x_{t-i}^+ + \mu_i^-\Delta x_{t-i}^-) + \varepsilon_t \quad (12)$$

The presence of cointegration between the inflation rate and the explanatory variables is investigated by employing the Bounds test, developed by M. H. Pesaran, Y. Smit and R. J. Shin (2001). The null hypotheses of no cointegration in Equations (9) and (12), i.e. H_0: $\beta_1 = \delta_1 = v^+ = v^- = 0$ and H_0: $\beta_2 = \delta_2 = \gamma^+ = \gamma^- = 0$, respectively, are tested in order to obtain the value of the F-statistic. The presence of the long-term asymmetry is checked by testing the null hypothesis of equality between the long-term coefficients of positive and negative changes in unit labor costs, i.e. H_0: $L_\varphi^+ = L_\varphi^-$ (where $L_\varphi^+ = -v^+ / \beta_1$ and $L_\varphi^- = -v^- / \beta_1$) and the null hypothesis of equality between the long-term coefficients of positive and negative changes in the output gap, H_0: $L_x^+ = L_x^-$ (where $L_x^+ = -\gamma^+ / \beta_2$ and $L_x^- = -\gamma^- / \beta_2$). The rejection of the null hypotheses at a given level of statistical significance indicates that the association between the inflation rate and the considered regressors is asymmetric in the long run. The presence of short-term asymmetry is evaluated by testing the null hypotheses of symmetry in Equations (9) and (12), i.e. H_0: $\sum_{j=0}^{n}\tau_j^+ = \sum_{j=0}^{n}\tau_j^-$ and H_0: $\sum_{i=0}^{q}\mu_i^+ = \sum_{i=0}^{q}\mu_i^-$, respectively. To test the hypotheses, the Wald test is employed as a common approach in a number of empirical studies (Shin *et al*, 2014; Bildirici & Özaksoy, 2018).

In order to have the insight into the cumulative impact of short- and long-term changes in the explanatory variables on the inflation rate, dynamic multipliers are applied (Shin *et al*, 2014). They capture the effects of a 1% increase and decrease in unit labor costs and the output gap on the inflation rate.

The Dataset

Quarterly data about the year-on-year actual and expected inflation rates (12 months ahead, enterprises' expectations), the real indices of unit labor costs in industry, and the real Gross Domestic Product (GDP) are used in this empirical study. The data were collected from the National Bank of Serbia and the Eurostat databases. The analysis covers the time span from the first quarter of 2008 to the fourth quarter of 2019 (48 observations). Bearing in mind the fact that the data on the dynamics of the inflation rate, expected inflation and unit labor costs indices are available on a monthly basis, the average observation approach was applied in order to obtain such quarterly data. The output gap was calculated by decomposing the real GDP time series into the trend and cyclical components by means of the Hodrick-Prescott filter (λ = 1600).

The empirical dynamics of the observed variables in the analyzed time period are presented in Figure 1. A common trend between the expected and actual inflation rates is apparent, as well as their approaching after 2014. It could be the initial signal for the statistical significance of their relationship. The positive association between the output gap and the inflation rate after 2014 is also evident, whereas the exact direction of the unit labor costs-inflation rate nexus is not visually apparent. The preliminary analysis of the relationships between the observed variables by means of the scatter diagrams (Figure 2) indicates a positive association between the inflation rate and all the explanatory variables, except for the unit labor costs, which are negatively correlated with the inflation rate. This analysis does not necessarily prejudice the final results, as the dynamics of the explanatory variables are decomposed into positive and negative changes serving as separate regressors.

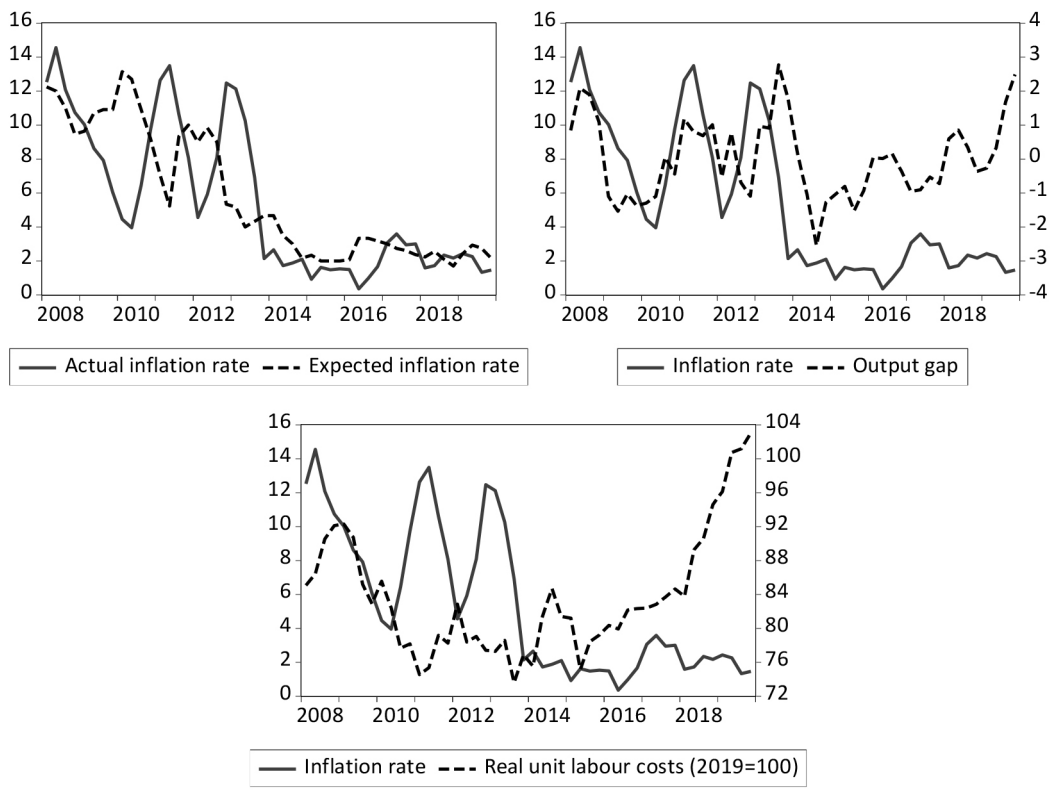


Figure 1 The empirical dynamics of the analyzed variables in the Republic of Serbia

Source: Author, based on the National Bank of Serbia's data

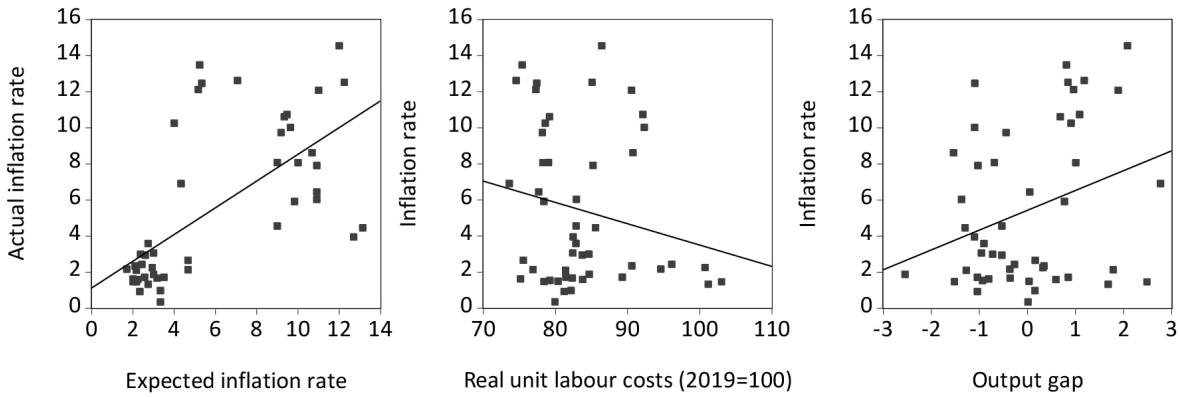


Figure 2 The scatter diagrams of the relationship between the inflation rate and the explanatory variables

Source: Author, based on the National Bank of Serbia's data

RESEARCH RESULTS AND DISCUSSION

A valid implementation of the NARDL model implies that all variables should be stationary at the level and/or first difference, which entails the application of different unit root tests as the first step. The results of the parametric ADF (Augmented Dickey-Fuller) test and the nonparametric PP (Phillips-Perron) test reported in Table 1 confirm that this condition is fulfilled. In order to obtain more robust results, the Zivot-Andrews test (Zivot & Andrews, 1992), which takes into account the presence of structural breaks, is also applied. This test re-confirms the fact that none of the observed time series is I(2). The results of this test also indicate the exact break date (quarter)used as a dummy variable in the further analysis. This variable takes the value 0 before the break date and the value 1 afterwards.

Prior to the final estimation of the NARDL model, the direction of the causality between the analyzed variables should be checked. The inflation rate is set as a dependent variable in all versions of the Phillips curve, including the New Keynesian one. Accordingly, the Granger non-causality test is applied in order to evaluate whether changes in the inflation rate can be explained by past changes in unit labor costs and the output gap. Since unit root tests indicate the fact that the time series integrated are of a different order (I(0) and/or I(1)), the Toda-Yamamoto procedure is applied as well (Toda & Yamamoto, 1995). This procedure checks the causality between time series at levels, thus reducing the risk of the wrong identification of their exact integration order (Wolde-Rufael, 2005). In addition, following A. Hatemi-J (2012), the direction of the causality between positive and negative changes in unit labor costs (the output gap) and the inflation rate is investigated.

The causality test results reported in Table 2 confirm the presence of the unidirectional causality which goes from the real unit labor costs and the output gap to the actual inflation rate. The positive and negative changes in these variables also represent an important determinant of the dynamics of the future inflation rate. The actual inflation rate is led by expected inflation as well. Hence, the postulated relationship between the inflation rate and the explanatory variables in the NKPC is appropriate for Serbia's economy.

The final specification of the NARDL model for both variants of the NKPC is reported in Table 3. It is obtained by the successive trimming of insignificant time lags, starting from four lags. The residual diagnostics tests (for normality, autocorrelation, heteroscedasticity, dynamic stability, and the functional form) all indicate the fact that both models are well specified and stable. The results of the cointegration test in the bottom row of Table 3 confirm

Table 1 The results of the unit root tests

Variable	ADF test		PP test		Zivot-Adrews test	
	Constant	Constant & Trend	Constant	Constant & Trend	t-statistic	Break date
π	-1.66	-2.57	-1.88	-2.49	-4.64***	2014Q2
π^e	-1.28	-2.21	-1.56	-2.21	-4.95***	2012Q4
x	-2.88*	-2.84	-2.97**	-3.01	-3.95***	2014Q2
φ	-1.17	-0.99	-1.17	-0.87	-2.69*	2010Q2
$\Delta\pi$	-2.80*	-2.81	-3.99***	-4.02**	-3.59***	2013Q1
$\Delta\pi^e$	-5.95***	-6.08***	-5.76***	-5.73***	-6.81	2013Q3
Δx	-5.66***	-5.47***	-6.69***	-6.74***	-6.12*	2013Q4
$\Delta\varphi$	-6.94***	-7.31***	-6.93***	-7.81***	-4.83**	2015Q2

Note: The results denoted by *, **, and *** are statistically significant at the levels of 10%, 5%, and 1%, respectively.

Source: Author

the presence of the long-term relationship between the dependent and explanatory variables in both models. The impact of expected inflation on the actual inflation rate is statistically significant in both models, too. In the first model, the long-term coefficient of the negative changes in the unit labor costs (L_{φ}^{-}) is statistically significant and larger than the long-term coefficient of the positive changes (L_{φ}^{+}). More precisely, a 1% increase in the unit labor cost leads to the 0.28% growth of the inflation rate, whereas a 1% decrease in these costs leads to a 0.61% fall in the inflation rate. The results of the Wald test (WLR) confirm the presence of a long-term asymmetry in the relationship between the unit labor costs and the inflation rate. Bearing in mind the fact that the dynamics of these costs are determined by the changes in productivity, it appears that the improvement of productivity might reduce cost-push inflation growth as a component of the total inflation in the Republic of Serbia.

In the second model, the impact of both long-term coefficients is statistically significant, and the

Table 2 The results of the Granger non-causality test (the Toda-Yamamoto procedure)

Symmetric approach		Asymmetric approach - positive changes in the explanatory variables		Asymmetric approach - negative changes in the explanatory variables	
H_0	χ^2	H_0	χ^2	H_0	χ^2
$\varphi \nrightarrow \pi$	7.57*	$\varphi^+ \nrightarrow \pi$	8.06*	$\varphi^- \nrightarrow \pi$	5.89*
$\pi \nrightarrow \varphi$	1.20	$\pi \nrightarrow \varphi^+$	1.29	$\pi \nrightarrow \varphi^-$	3.85
$x \nrightarrow \pi$	2.81*	$x^+ \nrightarrow \pi$	6.09	$x^- \nrightarrow \pi$	5.91*
$\pi \nrightarrow x$	1.12	$\pi \nrightarrow x^+$	3.52	$\pi \nrightarrow x^-$	1.96
$\pi^e \nrightarrow \pi$	6.40**	-	-	-	-
$\pi \nrightarrow \pi^e$	2.13	-	-	-	-

Notes: The symbol $\nrightarrow$ means "do not Granger-cause"; the results denoted by *. **. and *** are statistically significant at the levels of 10%. 5%. and 1%. respectively.

Source: Author

Table 3 The NARDL model specification of the NKPC

Model with unit labor costs			Model with the output gap		
Variable	Coefficient	p-value	Variable	Coefficient	p-value
α_0	2.48	0.26	α_1	2.52	0.28
$\pi_{(t-1)}$	-0.39	0.00	$\pi_{(t-1)}$	-0.64	0.00
$\pi^{e}_{(t-1)}$	0.25	0.05	$\pi^{e}_{(t-1)}$	0.37	0.00
$\varphi^{+}_{(t-1)}$	0.11	0.06	$x^{+}_{(t-1)}$	0.69	0.00
$\varphi^{-}_{(t-1)}$	0.23	0.00	$x^{-}_{(t-1)}$	0.81	0.00
$\Delta\pi_{(t-1)}$	0.57	0.00	$\Delta\pi_{(t-1)}$	0.67	0.00
$\Delta\varphi^{+}_{t}$	-0.22	0.08	$\Delta\pi_{(t-2)}$	0.51	0.00
$\Delta\varphi^{-}_{t}$	0.07	0.62	Δx^{+}_{t}	0.46	0.12
$\Delta\varphi^{-}_{(t-2)}$	-0.27	0.02	$\Delta x^{-}_{(t-1)}$	-1.23	0.00
D	4.19	0.00	D	-	-
L^{+}_{φ}	0.28	0.11	L^{+}_{x}	1.09	0.00
L^{-}_{φ}	0.61	0.00	L^{-}_{x}	1.28	0.00
R^2 (adjusted)	0.65		R^2 (adjusted)	0.68	
JB test	0.80	0.67	JB test	1.13	0.57
BG LM test	1.17	0.32	BG LM test	1.44	0.25
BPG test	0.31	0.97	BPG test	1.98	0.08
Cusum test	Stable		Cusum test	Stable	
Cusum Sq. test	Stable		Cusum Sq. test	Stable	
RESET test	0.74	0.39	RESET test	0.22	0.64
W_{LR}	11.56	0.00	W_{LR}	1.29	0.26
W_{SR}	0.01	0.95	W_{SR}	14.48	0.00
F_{PSS}	11.89	0.00	F_{PSS}	20.06	0.00

Notes: D denotes the dummy variable representing the structural break in the time series; JB, BG LM, and BPG are the Jarque-Bera test for normality, the Breusch-Godfrey test for autocorrelation, and the Breusch-Pagan-Godfrey test for the heteroscedasticity of the residuals, respectively; Cusum (Cusum Squared) refers to the cumulative sum of the residuals (squared residuals) test, which is presented graphically in the appendix; W_{LR} and W_{SR} denote the results of the short- and long-term asymmetry Wald tests, respectively; F_{PSS} refers to the F-statistic of the Bounds test (Pesaran *et al*, 2001).

Source: Author

coefficient of the negative changes (L_x^-) is higher than the coefficient of the positive changes (L_x^+): a 1% decrease in the output gap leads to a 1.28% fall in inflation, whereas a 1% increase leads to the 1.09% growth of the inflation rate. However, the result of the Wald test indicates no statistically significant difference between the two coefficients, i.e. the relationship between the output gap and inflation is symmetric in the long run.

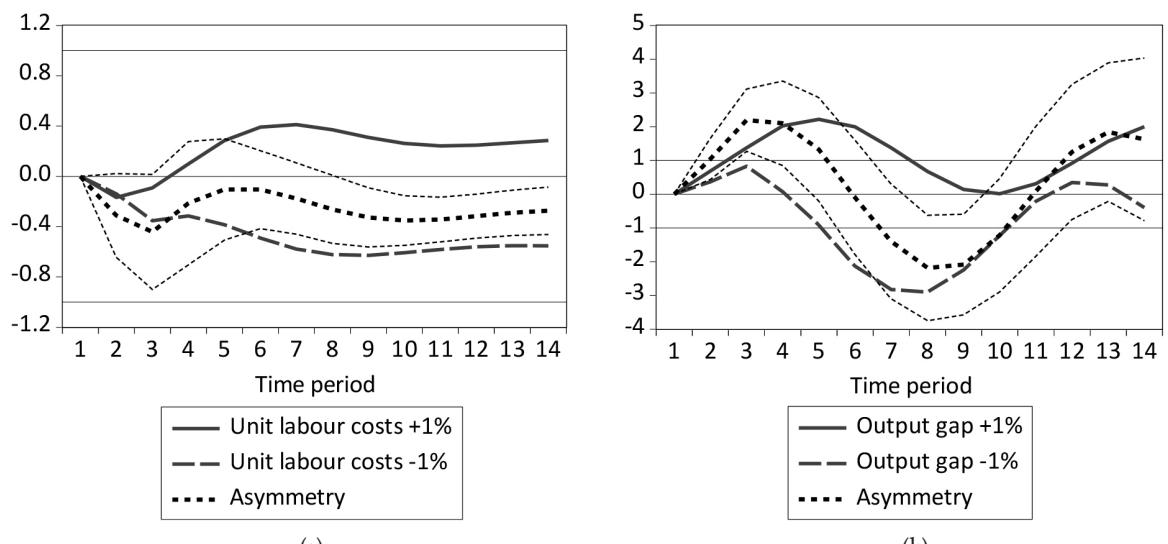
If the fact that unit labor costs represent a good approximation for marginal costs is accepted, then it can be concluded that the results pertaining to the long-term relationship in both models of the Phillips curve are mutually consistent, since the negative changes in the output gap (in economic contraction) coincide with a decrease in the marginal cost due to a decrease in the production capacity utilization rate.

Indeed, these procyclical dynamics of marginal costs are proven in numerous empirical studies (Alexová, 2012; Vasilev, 2015; Furuoka, 2016).

Furthermore, the Wald test for a short-run asymmetry (WSR) reveals the fact that the relationship between the output gap and the inflation rate is asymmetric in the short run, which is opposite to the results for the model with the unit labor costs. The short-term asymmetry in the relationship between the output gap and inflation is a corollary of an incomplete inflation adjustment during economic expansion and contraction due to a certain extent of the price rigidity, which is in accord with the NKPC.

An insight into the cumulative impact of explanatory variables in the NKPC, as well as the adjustment from the initial shock towards a long-term equilibrium, can be gained by means of dynamic multipliers (Shin *et al*, 2014). Figure 3a represents the intertemporal effects of the unit labor costs increases and decreases on the inflation rate. The negative changes in these costs (the dashed grey line) lead to the inflation rate reduction, which is more pronounced in the short run (approximately during five quarters after the initial shock) and gradually decreases towards the long-term equilibrium. The positive changes in the unit labor costs (the continuous grey line) initially lead to the inflation rate reduction, and later to a long-term inflation increase. The dashed black line represents the difference between the effects of the positive and negative changes, i.e. the asymmetry. It is presented along with the black dashed lines denoting the 95% confidence interval. If the zero line is inside the confidence interval, then there is no asymmetry. The dynamic multipliers in Figure 3a indicate a long-term asymmetry, but a short-term symmetry, which is in accord with the results of the Wald test from Table 3. The long-term equilibrium establishes approximately 10 quarters after the initial change in the unit labor costs.

In Figure 3b, the short- and long-term impacts of the changes in the output gap on the inflation rate are presented. The short-term asymmetry is apparent and the dominance of the positive changes in the output gap is followed by the dominance of the negative changes. In the first three quarters, the decrease in the output gap leads to the growth of the inflation rate and then to its fall. Thus, the inflation rate strongly responds in the short run, but much more time is needed for a long-term equilibrium to establish.



(a) (b)

Figure 3 The dynamic impact of the changes in the unit labor costs (a) and the output gap (b) on the inflation rate

Source: Author

The dynamic multipliers confirm the Wald test results pertaining to the presence of a short-term asymmetry.

In the light of the defined research hypotheses, the results of the empirical analysis can be summarized as follows. In both models of the NKPC, the current expectations of the future inflation rate have a statistically significant impact on the actual inflation rate, thus confirming the first research hypothesis. The values of the expected inflation coefficients are relatively low (0.25 in the first, and 0.37 in the second model), thus indicating the fact that the inflation expectations of economic agents in the Republic of Serbia are formed following an adaptive pattern, i.e. they are based on past inflation rates. These results coincide well with the findings for other transition and emerging economies (Dabušinskas & Kulikov, 2007; Vašiček, 2010; Basarac *et al*, 2011; Furuoka, 2016).

The empirical analysis has not provided enough evidence for the second research hypothesis to be accepted. Unit labor costs have a statistically significant and positive long-term impact on the inflation rate in the Republic of Serbia, but only during economic contraction. An increase in these costs during economic expansion has no statistically significant impact on inflation growth. Their long-term effect on the inflation rate in Serbia is asymmetric, which is in contrast with the NKPC.

Changes in the output gap have a statistically significant impact on the inflation rate in the Republic of Serbia, which is also symmetric during expansionary and contractionary periods. This impact is positive, i.e. the inflation rate moves pro-cyclically (it increases in expansion, and decreases in contraction). Thus, the third research hypothesis is confirmed. Given the fact that, in the NKPC model with the output gap, expected future inflation also has a statistically significant impact on the actual inflation rate, it can be concluded that the validity of this variant of the Phillips curve in the context of the Republic of Serbia is confirmed. In other words, this relation of the Phillips curve may serve the Serbian monetary authorities to monitor the impact of changes in the real economy and inflation expectations on the actual inflation rate.

The coefficient of the determination value (R^2) shows that 68% of the variation in inflation rates in Serbia can be explained by changes in both the output gap and expected inflation. This is consistent with the finding in a recent study by the World Bank, which indicates the fact that about the three-quarters of the inflation variation are determined by domestic drivers (Ha, Ayhan Kose, Ohnsorge & Yilmazkuday, 2019). Besides, the difference between the intensity of the long-term impact of the output gap in economic expansion and contraction (the coefficients L_x^+ and L_x^-, respectively) implies that the ongoing accommodative monetary policy conducted by the National Bank of Serbia through lowering the reference interest rate can stimulate the economic activity, without creating significant inflationary pressures. This simultaneously coincides with the findings in an empirical study by P. Petrović, D. Brčerević and M. Gligorić (2017) and their conclusion that the ongoing economic growth of the Republic of Serbia is about two percentage points below a potential annual growth of about 5%, i.e. that the output gap is negative. In that case, the monetary expansion would make the actual output closer to the potential, without causing the occurrence of the significant growth of the inflation rate.

CONCLUSION

This study is aimed at evaluating the validity of the NKPC in the context of the Republic of Serbia and assessing the impact of domestic inflation drivers as well. The results of the estimated NARDL model have indicated the following:

- expected future inflation has a statistically significant impact on the actual inflation rate regardless of the NKPC specification; however, the effect on inflation expectations on the actual inflation rate is less pronounced than the impact of the past inflation;
- real marginal costs, approximated by unit labor costs, exert a statistically significant impact on the inflation rate in the Republic of Serbia, but only during economic contraction. In other words, the

influence of these costs on the inflation rate is asymmetric in the long run, but symmetric in the short run, which is not in accord with the NKPC. However, as suggested by the identified direction of the asymmetry, the improvement of the productivity level in the long run may decrease cost-push inflation growth as a component of the total inflation;

- changes in the output gap during economic expansion and contraction have a positive, statistically significant and symmetric effect on the inflation rate in the Republic of Serbia, which is consistent with the role of the output gap in the NKPC. The empirical results indicate that inflation responds more intensively to negative than positive supply and demand shocks, i.e. it decreases more significantly in economic contraction than in economic expansion.

Based upon the estimated econometric model of the NKPC, the main contribution of this research study reflects in the quantification of the impact of the domestic inflation drivers in the Republic of Serbia (marginal costs and the output gap) in the different phases of the business cycle, as well as the effect of inflation expectations. In the case of positive and negative unit labor costs and output gap shocks, employing dynamic multipliers, the analysis of the inflation rate adjustment mechanism, could improve the understanding of the cumulative short- and long-term impact of economic disorders on the inflation rate. The estimated model of the NKPC with the output gap provides clear argumentation in favor of the expansionary monetary policy which the National Bank of Serbia has been conducting in recent years, since it can stimulate the economic activity without creating significant inflation pressures.

The empirical analysis conducted in the paper, however, is not without limitations. First of all, the value of the output gap (since it is not directly observable) was obtained by means of the Hodrick-Prescott filter. The application of the other decomposing techniques (such as the Kalman filter, the Band-pass filter, etc.) would potentially result in the different values of the output gap, consequently leading to different estimation results. Furthermore, the analysis is based on unit labor costs for industry, not for the whole economy. In addition, these costs are only used as an approximation for real marginal costs, which there are no available data for. Finally, albeit the research study covers a period of twelve years, the sample is still relatively small (48 observations). Undoubtedly, including more observations would enlighten the relationships among the analyzed variables in a more complete manner.

Some future research in the inflation dynamics in the Republic of Serbia might include the so-called Hybrid NKPC, which incorporates the impact of past inflation on the actual inflation rate, along with inflation expectations. In such a way, the impact of inertia in inflation dynamics as an important aspect of an efficient disinflation policy could be quantified. Although, as in the majority of other economies, domestic inflation drivers significantly determine the variation of inflation rates in the Republic of Serbia, a research study based upon the open-economy NKPC (which includes variables such as an import/export share in the GDP, the oil price, etc.) could identify the key external factors of inflation, thus improving the economic policy directed towards the maintenance of monetary stability.

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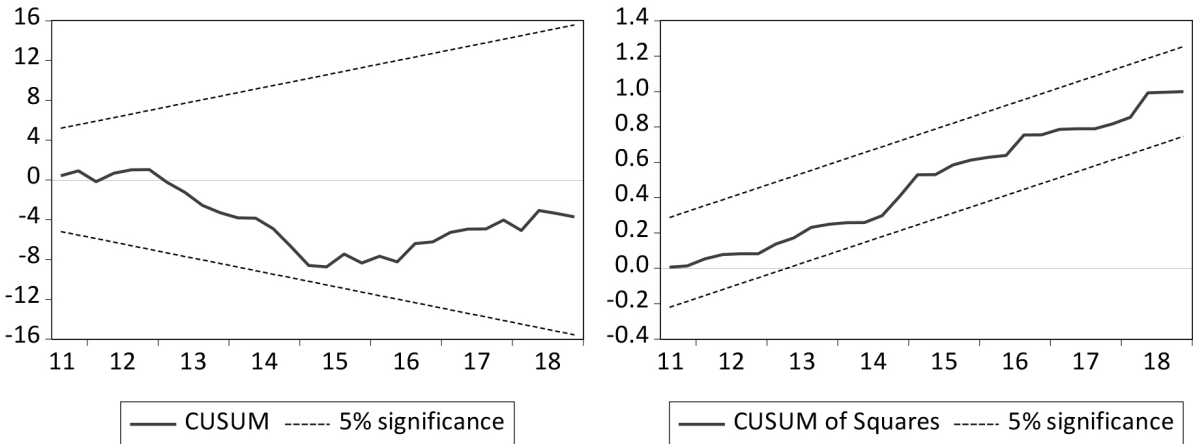
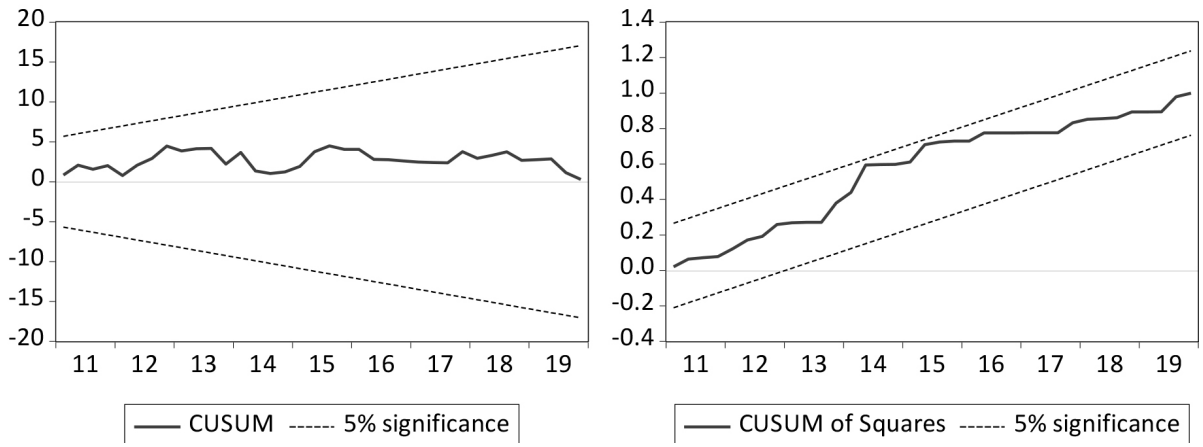
APPENDIX

The graphical presentation of the tests for the dynamic stability of the New Keynesian Phillips curve models



The model with unit labor costs



The model with the output gap

Source: Author