Argumenta Oeconomica
Year 2024, Vol. 52, No. 1
ISSN 2720-5088

Inflation targeting, exchange rate and output gap in Central and Eastern European countries

Victor Shevchuk
College of Social Sciences, Cracow University of Technology, Poland
e-mail: vshevchuk@pk.edu.pl
ORCID 0000-0002-7125-1267

Roman Kopych
Department of International Economic Relations and Computer Sciences, Lviv University of Trade and Economics, Ukraine
e-mail: kopych_r@bigmir.net
ORCID 0000-0002-3986-7694

Quote as: Shevchuk, V., & Kopych, R. (2024). Inflation targeting, exchange rate and output gap in Central and Eastern European countries. *Argumenta Oeconomica*, 1(52), 188-206.

DOI: 10.15611/aoe.2024.1.11

JEL Classification: E31, E47, E52

Abstract: This paper aims at empirical assessment of monetary policy relationships in Central and Eastern European countries (Czechia, Hungary, Poland, Romania), which practise the monetary regime of inflation targeting. Using quarterly data for the period of 2004-2019, the authors examined the relationship between the output gap, nominal and real exchange rate misalignment, consumer price inflation and the central bank policy rate, using the panel vector autoregression (PVAR) model. According to estimates, the central banks of the CEE-4 countries react with an increase of their policy rate to the output gap and inflation, as implied by the Taylor rule. At the same time, a monetary reaction to nominal (real) exchange rate misalignment is lost in the estimates for the post-crisis period of 2010-2019. An increase of the central bank rates does not seem to have unfavourable output effects, while the nominal exchange rate is likely to depreciate with three to five quarter lags. However, there is evidence of the price puzzle when monetary tightening is followed by a counterintuitive increase in the inflation rate. In full accordance with the New Keynesian framework, inflation depends on the output gap, while being expansionary in the real sector. Evidence of the exchange rate pass-through (ERPT) to inflation is mixed. This article provides insights into the average monetary policy reaction function and its macroeconomic effects in the CEE-4 countries, with the value added in that following the Taylor rule does not guarantee effectiveness in tackling inflation in the presence of the price puzzle. Based on the estimated exchange rate effects on the output gap and inflation, deliberate currency appreciation resulting from the central bank foreign exchange interventions and/or fiscal austerity measures can be helpful for such a disinflation that minimises output losses.

Keywords: inflation targeting, output gap, consumer price inflation, exchange rate, Central and Eastern European (CEE) countries

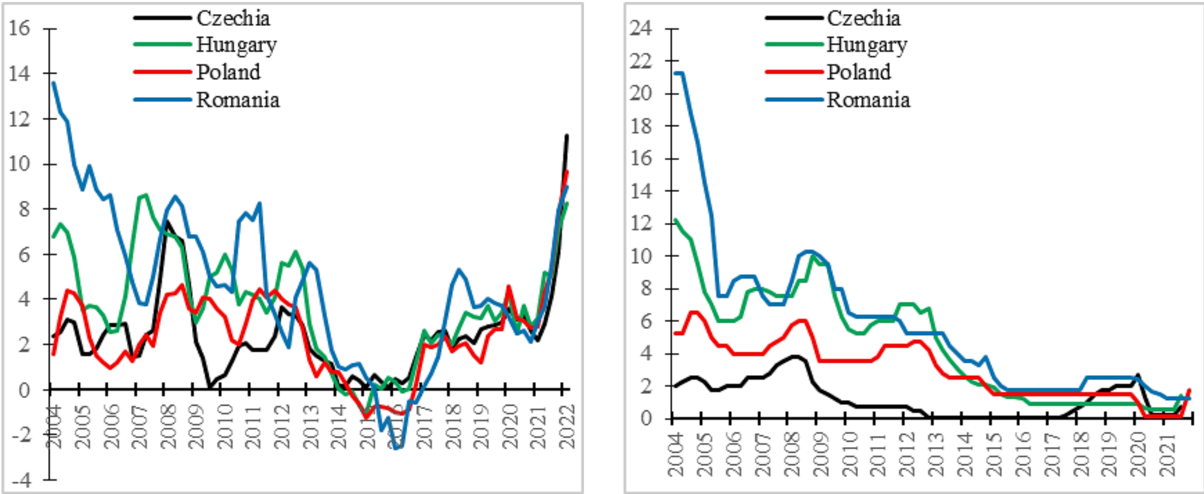
1. Introduction

In general, the monetary policies of the CEE countries which applied the inflation targeting strategy are considered as quite successful ones (Clinton et al., 2017). This corresponds with the recent international evidence in favour of inflation targeting for both emerging and industrial economies, in the context of shock absorbing properties (Fratscher, Grosse-Steffen and Rieth, 2020), favourable conditions for capital inflows (Mollick, Torres and Carneiro, 2011), and stability of the banking system in countries with average quality of institutions (Fazio et al., 2018). However, there are empirical studies showing a very weak or non-existent support for inflation targeting (Petreski, 2014; Ryczkowski and Ręklewski, 2021). Among several disadvantages of inflation targeting, unfavourable output effects, inability to influence inflation expectations and ignorance of exchange rate levels are frequently mentioned (Ayres, Belasen and Kutan, 2014). Consequently, more flexible regimes are proposed, with more weight attached to the stabilisation of output (Svensson, 2009). Moreover, it is suggested that the central bank's assumptions on the long-term levels of the real interest rate, output and even the inflation target should be revised periodically (Vradin, 2015). However, older regimes with a narrow tolerance band and inflation close to the target can be more efficient in the context of monetary policy transmission mechanism, since they are associated with a lower ERPT (López-Villavicencio and Pourroy, 2019). Specific arguments in favour of hard inflation targeting were raised with respect to stabilisation policies (Fratscher, Grosse-Steffen and Rieth, 2020).

In contrast to advanced economies, price dynamics in the CEE countries retain a close relation to the business cycle and this is an argument in favour of the monetary policies that account for domestic and external factors of inflation (Zobl and Ertl, 2021). However, the recent acceleration of inflation in the period of 2021-2022 cannot but strengthen earlier critical arguments that inflation targeting is responsible for the accumulation of imbalances and the outbreak of the global financial crisis of 2008-2009 (Ciżkowicz-Pękała et al., 2019). While consumer price dynamics over the last few years does not seem to support price stability, it must be noted that the inflation targeting policy has been helpful in stabilising the inflation rate all around the target since 2004, especially in Romania (Figure 1a). What is important, any significant deviations from the inflation target, as in Czechia (2007-2008), Hungary (2006-2008, 2012) and Romania (2007-2008, 2010-2011, 2013), were successfully corrected over a short span of time. Moreover, central banks of the CEE-4 countries have managed to achieve a low level of their policy rates, suggesting that a decrease in the inflation rate has not been achieved at the cost of output losses due to more expensive loans to the private sector (Figure 1b). Against such a backdrop, inflation targeting policies seem to be successful – and not without reason.

This study aimed at an empirical assessment of monetary reaction function and its macroeconomic effects for the panel of four CEE countries (Czechia, Hungary, Poland and Romania), which follow the inflation targeting policy. As the CEE-4 countries are quite homogenous with respect to the level of economic development and institutional background, the use of panel vector autoregression (PVAR) model offers a few advantages such as: (i) the construction of average effects (useful for the analysis of country specific differences relative to the average), (ii) the evaluation of interdependencies, (iii) the identification of stylised facts which can improve predictions of models with full specification of economic structures (Canova and Ciccarelli, 2013).

Several research questions should be answered: How does the central bank's (CB) rate policy influence inflation and output gap (plus exchange rate)? What are the CB policy rate effects on inflation and output gap (plus exchange rate)? In particular, is there a price puzzle when contractionary monetary policy increases the rate of inflation instead of decreasing it? How relevant is the standard New Keynesian framework for the explanation of short-term macroeconomic relations in the CEE-4 countries?



a) inflation rate (%)

b) central bank policy rate (%)

Fig. 1. Inflation rate and central bank rate in the CEE-4 countries, 2004-2022

Source: IMF International Financial Statistics online database (www. https://data.imf.org/), BIS online database (https://www.bis.org/statistics/).

The main contribution of this paper is its empirical analysis of the monetary policy reaction in the CEE-4 countries and its outcomes with the PVAR model that includes the output gap, nominal (real) exchange rate misalignment, consumer price inflation and the CB policy rate. The main results imply that (i) the central banks of the CEE-4 countries react to both inflation and the output gap in line with the Taylor rule, (ii) the monetary policy effects on prices are rather weak, with neutrality with respect to output and exchange rate, (iii) the output gap is inflationary and contributes to a short-term exchange rate appreciation, (iv) inflation has an expansionary effect on output.

The rest of the paper is structured as follows. Section 2 offers a review of related literature, with a focus on the monetary policy effects in the CEE-4 countries. Section 3 presents an analytical framework. Section 4 outlines data and statistical methodology. Sections 5 and 6 present empirical results and details of sensitivity analysis, respectively. The conclusions are summarised in the final section.

2. Literature review

The majority of empirical studies of the CEE countries indicate that the central banks respond to both inflation and the output gap, as implied by the Taylor rule (Wang et al., 2015; Klose, 2019). The same result was obtained for Poland (Haug et al., 2019), but another study claims that the central bank seems to follow a pure inflation targeting strategy and does not respond to output (Ryczkowski, 2016). Similarly, Vašiček (2014) found that the monetary policy rules of Hungary, Poland and Romania focus solely on domestic prices and the Taylor rule does not always hold. For the CEE-4 countries, as suggested by Dobešová and Hampel (2014), reaction of the CB policy rate to inflation has become stronger in the post-crisis period since 2010, quite the opposite for the reverse causation running from the CB rate to inflation.

There are studies in support of the exchange rate as an important variable in the monetary response function for the CEE countries (Drygalla, 2015; Feldkircher, Huber and Moder, 2016). However, such a conclusion is not supported by Frömmel, Garabedian and Schobert (2011) and Vašiček (2014). The possible explanations mentioned, include a complete ERPT to domestic prices, a close response of domestic interest rates to the foreign interest rate, and also cancelling out of asymmetric efforts to support exporters and suppress the imported inflation. An expected increase in the CB rate in response to the RER undervaluation was found for Czechia, but not for Hungary, Poland and Romania (Shevchuk, 2020). Recently, Fabris and Lazić (2022) suggested that the central bank reaction to the exchange rate changes is characteristic of the emerging market economies only, not developed ones.

The effectiveness of monetary policy in control of inflation is not uniform across the CEE countries (Table 1), in accordance with the earlier survey by Coricelli, Égert and MacDonald (2006) that all kinds of results can be found for a given country due to different samples, different identification of monetary shocks or the use of a distinct set of variables. It is still quite common to obtain the price puzzle which can be a result of the omission of some information variables that signal inflation, such as commodity prices (Sims, 1992), openness of the economy, cost of price adjustments, interest elasticity of aggregate demand (Ali and Anwar, 2018), output gap or financial constraints in the production sector (Coricelli, Égert and MacDonald, 2006), as well as attempts for smoothing of the CB policy rate (Woodford, 2003) or the inability of economic agents to distinguish between temporary and persistent interest rate shocks (Lukmanova and Rabitsch, 2022).

Table 1. Key findings of monetary policy effects

Author	Country	Method	Sample	Price puzzle	Other results for monetary tightening
Myšková, Hampel and Dobešová (2013)	CEE-4	VAR	2002M1:2012M8	yes/no	A uniform decrease in inflation in the short run, reversed for Czechia and Slovakia
Petreski (2014)	21 CEE and CIS states	OLS, FE, RE	2009Q1:2012Q1		Decline in output
Horká (2015)	CEE-8	VAR	2000Q1: 2014Q4	yes	Decrease in output in all countries and exchange rate appreciation in Czechia, Hungary and Poland
Wlodarczyk (2017)	CEE-3	SVAR	2000M1:2014M2	yes	Decrease in output and employment, with a higher unemployment rate
Shevchuk (2020)	CEE-4	SVAR	2001Q1: 2017Q3	yes	No output effects, with the RER appreciation in Czechia and depreciation in Romania
Stakėnas and Stasiukynaitė (2017)	Baltic states	PVAR	2002Q1: 2014Q4	no	Decrease in output and inflation (excluding energy prices)
Borys and Horváth (2008)	Czechia	SVAR	1998M1:2006M5	no	Decrease in output and price level, with a peak response after a year
Franta, Horváth and Rusnák (2012)	Czechia	TVP VAR	1996Q1: 2010Q4	no	Decrease in output and exchange rate appreciation
Bartóková and Ďurčová (2015)	Czechia	VAR	1999Q1: 2013Q3	yes	Decrease in output and exchange rate depreciation
Kapuścinski et al. (2014)	Poland	SVAR	1998Q1: 2013Q1	yes/no	Decrease in output, inflation increases on impact and then falls
Ulrichs (2018)	Poland	VAR	1998Q1: 2016Q4		Decrease in industrial production
Haug, Jedrzejowicz and Sznajderska (2019)	Poland	SVAR	1998Q1: 2013Q3	no	Decrease in output and inflation. There is price puzzle if the fiscal variables are not included
Popescu (2018)	Romania	SVAR	2005Q3:2012Q1	no	Decrease in output and inflation, depreciation of the exchange rate

Source: authors' compilation of selected empirical literature.

The majority of the surveyed studies report a decrease in output resulting from monetary policy tightening, but this effect should be considered in the context of exchange rate effects, as it is common for the CEE countries that the bilateral RERs are affected by the interest rate, along with the output gap and inflation (Su et al., 2018). The effect of monetary policy on the exchange rate can be different on impact and with a lag. For Czechia, it was found that monetary tightening results in a persistent exchange rate appreciation with a gradual depreciation afterwards (Borys and Horváth, 2008), but a more recent study reported the opposite sequence of exchange rate changes (Shevchuk, 2020), whereas no support for causality running from interest rate to exchange rate was found for Hungary, Romania, and Poland (Shevchuk, 2020; Ulrichs, 2018).

Following the exchange rate depreciation, there was a decrease in output for Czechia, Hungary and Poland while the effect was expansionary for Latvia, Slovakia and Slovenia (Horká, 2015). A weak indication of an expansionary effect on output was found for Romania (Shevchuk, 2020) and Poland (Kapuścinski, 2014), while the opposite outcome was obtained for the other CEE countries (Shevchuk, 2020; Haug, Jedrzejowicz and Sznajderska, 2019; Nene, Damilola Ilesanmi and Sekome, 2022); exchange rate depreciation was contractionary for Czechia (Franta, Horváth and Rusnák, 2012; Nene, Damilola Ilesanmi and Sekome, 2022). Earlier studies suggest that the introduction of floating exchange rate regimes caused the disappearance of the exchange rate effects (Frömmel and Schobert, 2006).

It is worth noting that the earlier survey of monetary transmission channels in the CEE countries by Coricelli, Égert and MacDonald (2006) reports weakness of the interest rate channel and the possibility of the interest rate puzzle when an increase in the central bank interest rate is followed by the exchange rate depreciation. A later study by Égert and MacDonald (2009) concluded that the interest rate pass-through improved, while the link with exchange rate is weak, and disinflation resulted in the weakening of the ERPT over time. While the incomplete ERPT is a standard result in empirical studies for the CEE countries (Haug, Jedrzejowicz and Sznajderska, 2019), it was not ruled out that an exchange rate depreciation can lead to a decrease in inflation, as indicated for Czechia, Hungary and Poland (Horká, 2015). The empirical studies for Czechia (Franta, Horváth and Rusnák, 2012) and Poland (Kapuściński, 2014) reported a small and declining ERPT.

3. Analytical framework

In the spirit of New Keynesian models, the basic features of the monetary transmission mechanism include the expectational IS curve, the New Keynesian Phillips curve and the Taylor interest rate rule for monetary policy (Ireland, 2006). They assume that administrative costs or other rigidities disable full and immediate adjustment to various macroeconomic shocks. Recent studies also argued in favour of accounting for the exchange rate in the monetary reaction function (Engel, 2019).

Based on proposals in the literature, for example Engel (2019), it is possible to consider such a modelling framework for the monetary transmission under inflation targeting:

$$y_t = E_t y_{t+1} - \sigma(i_t - \pi_t) + \theta(q_t - \bar{q}_t), \tag{1}$$

$$\pi_t = \beta E_t \pi_{t+1} + \gamma(y_t - \bar{y}_t) + \delta(q_t - \bar{q}_t), \tag{2}$$

$$i_t = \rho i_{t-1} + \alpha \pi_t + \kappa(y_t - \bar{y}_t) + \psi(q_t - \bar{q}_t), \tag{3}$$

where y_t and $\bar{y}_t$, q_t and $\bar{q}_t$ are actual and equilibrium values for output and nominal (real) exchange rate, respectively, i_t is the short-term interest rate, π_t is the inflation rate, E_t is the operator of expectations.

In Equation (1), output growth is dependent on the expectations of its future dynamics, the decline in the real interest rate and the RER undervaluation measured as the difference between the actual and equilibrium values of the exchange rate. Assuming a fall in the inflation rate resulting from an increase in the CB interest rate, a steep increase in the real interest rate becomes a dominant transmission channel of monetary policy. However, there are theoretical arguments that challenge this conventional view. As stated by Rupert and Šustek (2019), contractionary monetary policy shocks can be associated with an increase, decline, or no change in the real rate, whose role is reduced to the feasibility of consumption smoothing.

In the New Keynesian Phillips curve framework (Equation (2)), inflation increases by its expectations, the output gap and the RER undervaluation. The recent concept of a hybrid New Keynesian Phillips curve implies accounting for backward-looking approaches (inflationary inertia), marginal costs of companies, and openness of the economy. In the post-crisis economic environment, weakening of the relationship between inflation and output gap (or flattening of the Phillips curve) can result from stronger price and wage rigidities in a low inflationary setting, wage deflation during recession, or inflow of labour migrants (Szafranek, 2017). If so, the monetary policy effect on inflation may be weaker and more prolonged.

In Equation (3), the central bank reaction function implies response to inflation, output gap and the RER undervaluation. Policy rule i_t is inertial as it can reflect the policy objective of the central bank (Woodford, 2003). Although there is evidence for the CEE-4 countries that inflation expectations are more important than backward-looking price-setting (Zobl and Ertl, 2021), other studies do not support such an assumption, e.g. Borys and Horváth (2008). Even though in the wider context the effectiveness of the Taylor rule depends on the measure of the output gap and the natural rate of interest, as well as on the way that expectations are formed, it can bring about an optimal pattern of equilibrium responses to real disturbances (Woodford, 2001). Despite proposals to substitute the time inconsistent Taylor rule with the Friedman rule (Neumeyer and Nicolini, 2022), the former is still considered as an important analytical tool. For example, it is proposed to combine in the modelling framework the Taylor rule with the fiscal theory of the price level (FTPL) in order to address the New Keynesian models indeterminacy problem (Angeletos and Lion, 2021). For several industrial countries (Australia, the euro area countries, Canada, New Zealand, Sweden, Switzerland, the UK and the USA), it was found recently that smaller deviations from the Taylor rule accelerate convergence to the exchange rate parities and also improve credibility of the central banks (Anderl and Caporale, 2022).

Other studies argue in favour of accounting for the exchange rate in the monetary reaction function as well, e.g. Engel (2019) proposed to account for the RER misalignment. However, the use of a nominal effective exchange rate is preferable in empirical studies because the RER variability incorporates price fluctuations, which represents another type of uncertainty for private agents (Barguellil, Ben Salha and Zmami, 2018).

4. Data and methodology

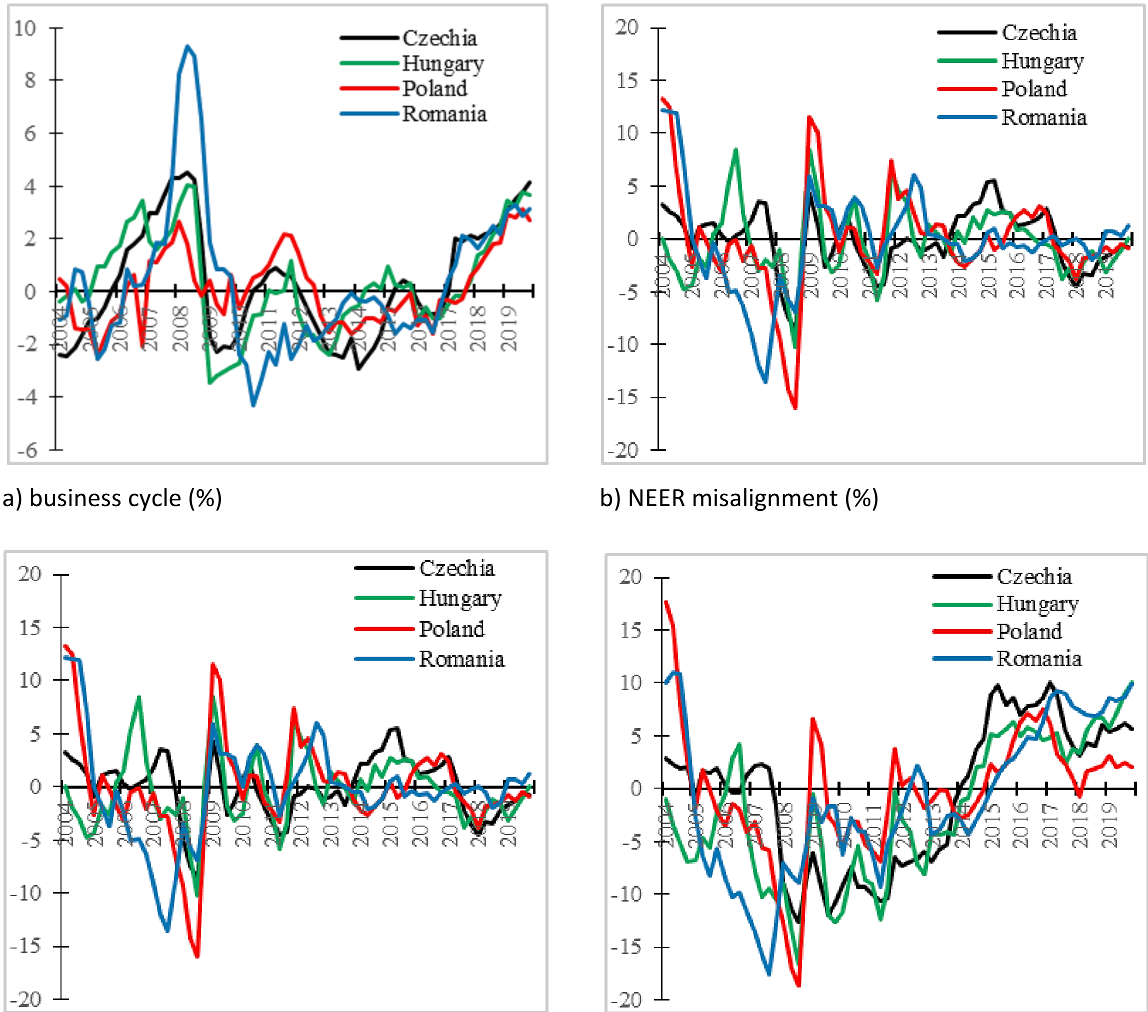
4.1. Data

This dataset includes quarterly series for the period ranging from 2004Q1 to 2019Q4 for Czechia, Hungary, Poland, and Romania. The main data source was the IMF International Financial Statistics. The authors used the following variables, as described in the section above: deviations of both nominal and real effective exchange rates from their long-term level (%), e_{it} and q_{it}, respectively, consumer price inflation (%), π_{it}, CB policy rate (%), i_{it}, business cycle (%), y_{it}; misalignment of the GDP-adjusted real effective exchange rate (%) qp_{it} was also applied. Following suggestions by Rodrik (2008), this measure of RER misalignment was based on the relative prices' indicator obtained as the difference between the RER and residuals from a regression of this variable on the log of the GDP. The Census X-11 method was used to adjust the GDP data periodically, while the Hodrick-Prescott filter provided the long-term trends of output and nominal (real) exchange.

Apart from four endogenous variables, the obtained PVAR model also includes changes in the measure of monetary freedom according to the Index of Economic Freedom by the Washington-based Heritage Foundation and the dummy for time span from 2010Q1 to 2019Q4, aimed at capturing specific effects of the post-crisis period of extremely low interest rates.

The rationale for using the real-time output gap instead of GDP growth rate was that the former allows for much more precise estimates (Borys and Horváth, 2008). Business cycles for the CEE-4 countries seem to be well synchronised, especially over the 2005-2008 and 2016-2019 periods, though not without country-specific features (Figure 2a). The pre-crisis boom had been extremely strong in Romania, followed by a prolonged recovery in the wake of the global financial crisis, whilst Poland avoided the recession in 2008-2009. Nevertheless, it was not possible to avoid a cyclical slowdown in 2013-2014, as in Czechia and Hungary.

The misalignment of nominal and real exchange rates in the CEE-4 countries looks very similar (Figures 2b and 2c). The coefficient of correlation between e_{it} and q_{it} ranges from 0.95 (Hungary, Romania) and 0.97 (Czechia) to 0.98 (Poland). Except for Hungary, other CEE countries undervalued currencies at the beginning of 2004, and then capital inflows and higher confidence in local currencies contributed to their strengthening. All the currencies were overvalued in 2008, with a reverse to undervaluation in 2009 as there was a wave of steep depreciations in the region. Another time span of undervaluation was observed in 2012, except for Czechia, however the Czech *koruna* devalued over the period of 2014-2016. At the beginning of 2018, overvaluation of 5% was observed for the currencies of Czechia, Hungary, and Poland, with a gradual correction until the end of 2019. The Romanian *lei* has been fluctuating close to equilibrium since 2013. If adjusted for the GDP level, the RER overvaluation became more protracted for the time span from 2006 until 2014 (Figure 2d). In contrast to a standard measure of the RER misalignment (Figure 2c), the GDP-adjusted measure revealed undervaluation since 2017 (even though to a lesser extent for Poland). As expected, the coefficient of correlation between both measures of the RER misalignment was substantially lower for Hungary (0.48) and Czechia (0.60), while much higher in Romania (0.71) and Poland (0.88).



a) business cycle (%)

b) NEER misalignment (%)

c) RER misalignment (%)

d) GDP-adjusted RER misalignment (%)

Fig. 2. Business cycle and nominal (real) exchange rate misalignment (%), 2004-2019

Note: trend values of output and nominal (real) exchange rate are obtained with the Hodrick-Prescott filter.

Source: authors' calculations.

The descriptive statistics are shown in Table 2. The business cycle peaks are higher in comparison to the depth of troughs. On average, the central bank rate is positive in real terms (minus the rate of inflation). Nominal exchange rate misalignment ranges between 13.3% and –15.9%, which is comparable with the misalignment of real effective rate. As for the GDP-adjusted RER misalignment, it is of larger magnitude and points towards a slight overvaluation over the period of 2004-2019. All four tests indicate the strong presence of cross-sectional dependency in the panel set (Table 3).

Table 2. Descriptive statistics

Variable	Mean	Max	Min	SD	Skewness	Kurtosis
Gross domestic product (y_{it})	0.300	9.302	–4.290	2.097	0.969	4.972
Consumer price inflation (π_{it})	3.104	13.567	–2.593	2.651	0.848	4.116
Central bank reference rate (i_{it})	3.803	21.250	0.050	3.489	1.786	7.896
NEER misalignment (e_{it})	–0.154	13.323	–15.941	3.981	–0.004	6.124
RER misalignment (q_{it})	0.006	14.860	–14.284	3.898	0.230	5.414
GDP-adjusted RER misalignment (qp_{it})	–0.986	17.743	–18.689	6.673	–0.144	2.518

Note: SD stands for standard deviation.

Source: authors' calculations.

Table 3. Pesaran's cross-sectional independence test results

Tests	Variables					
	y_{it}	π_{it}	i_{it}	e_{it}	q_{it}	qp_{it}
Breusch-Pagan LM	149.37***	145.14***	224.20***	86.22***	67.11***	161.60***
Pesaran scaled LM	41.39***	40.17***	62.99***	23.16***	17.64***	44.92***
Bias-corrected scaled LM	41.36***	40.13***	62.96***	23.13***	17.61***	44.88***
Pesaran CD	11.96***	11.96***	14.71***	8.36***	6.75***	12.56***

Note: ***, ** and * mean rejection of null hypotheses of cross-sectional independence at 1%, 5% and 10% level.

Source: authors' calculations in EViews 10.

Based on the Pesaran's covariate-augmented Dickey-Fuller (CADF) test and cross-sectional augmented Im, Pesaran and Shin (CIPS) test (Table 4), stationarity in levels was confirmed for all variables. Consequently, there was no need to de-trend the central bank interest rate, as in other studies (Lesuisse, 2017).

Table 4. Panel unit roots test results

Test	Option	Variables					
		y_{it}	π_{it}	i_{it}	e_{it}	rer_{it}	$rerp_{it}$
CADF	Level	–2.12**	–1.79**	–1.50*	–7.09***	–6.78***	–3.53***
	Δ	–9.16***	–9.11***	–6.41***	–10.05***	–9.78***	–8.61***
CIPS	Level	–2.03**	–1.77**	–1.75**	–7.72***	–7.38***	–3.77***
	Δ	–11.23***	–10.38***	–7.17***	–11.80***	–11.38***	–3.77***

Note: ***, ** and * mean rejection of null hypotheses of non-stationarity at 1%, 5% and 10% level; for both CADF and CIPS tests a specification with a constant and one lag is chosen.

Source: authors' calculations in EViews 10.

4.2. Specification of the PVAR model

In the most general form, the PVAR model is represented as follows:

$$Y_{it} = A_0 + A(L)Y_{it-1} + B(L)X_{it} + \eta_i + d_t + \varepsilon_{it}, \quad i = 1, \dots, N \quad t = 1, \dots, T \tag{4}$$

where Y_{it} is a four-variable vector of the endogenous variables (output, exchange rate, inflation, central bank policy rate), X_{it} is a vector of exogenous variables, $A(L)$ and $B(L)$ are matrices polynomial in lag operator L, η_i denotes fixed effects, d_t denotes the forward mean-differencing, ε_{it} is a vector of normally distributed, serially uncorrelated and mutually orthogonal white noise disturbances, *i* represents countries in the sample and *t* is the time dimension (2004Q1:2019Q4).

Similar to other studies (Lesuisse, 2017), the Helmert procedure is used for time demeaning and forward mean-differencing of the data as follows:

$$\tilde{y}_{ij}^{p} = \sqrt{\frac{T_i - t}{T_i - t + 1}} \left(y_{it}^{p} - \frac{1}{T_i - t} \sum_{j=t+1}^{T_i} y_{ij} \right), \tag{5}$$

where T_i refers to the last available period for country *i*.

Besides the CB policy rate, the PVAR model includes such variables as cyclical changes in output (output gap), consumer price inflation and nominal (real) exchange *r*. As argued by Lukmanova and Rabisch (2022), this kind of a four-variable set-up allows to maintain the interpretation of the PVAR model dynamics as being driven by standard aggregate demand, aggregate supply and nominal interest rate shocks plus transmission of an era shock, i.e. an exchange rate shock in this case.

Specification of the contemporaneous restrictions for $Au_{it} = B\varepsilon_{it}$. is as follows:

$$y = u_1 + a_1 e, \tag{6}$$

$$e = u_2, \tag{7}$$

$$\pi = b_1 y + b_2 e + u_3, \tag{8}$$

$$i = c_1 y + c_2 e + c_3 p + u_4, \tag{9}$$

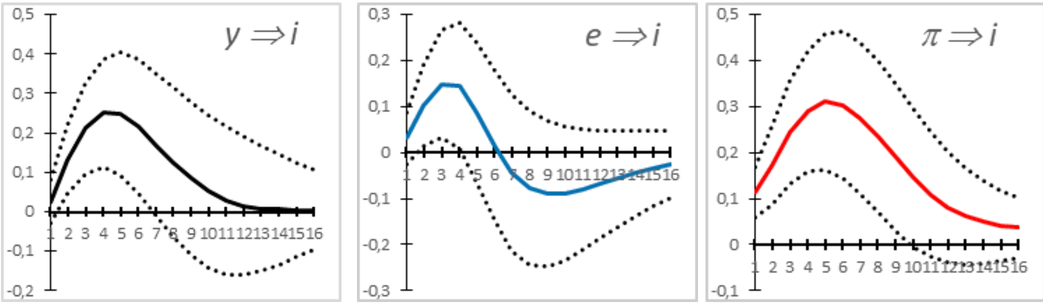
where *y* is the output gap, *e* is the nominal exchange rate misalignment, π the consumer price inflation, and *i* the CB policy rate. For sensitivity analysis, two measures of the RER misalignment were used, that is, real effective exchange rate *q* and GDP-adjusted real exchange rate *qp*.

All the variables in equations (6) to(9) represent the first stage PVAR residuals. It was assumed that domestic business cycle innovations were contemporaneously influenced by the exchange rate fluctuations (Equation (6)), which is quite natural for small open economies. In turn, deviations of the nominal (real) exchange rate from its long-term equilibrium were influenced by cyclical changes in output in the current period (Equation (7)). Then inflation is a function of either output gap, or nominal (real) exchange rate misalignment (Equation (8)). Finally, there was a monetary policy response to the output gap, inflation, and nominal (real) exchange rate misalignment (Equation (9)). As with Borys and Horváth (2008), it is possible to argue that exchange rate fluctuations can influence the inflation forecast if they are considered not to be transitory, yet the exchange rate is not affected by the interest rate in the current period. In other studies, they allow for a simultaneous reaction of the exchange rate and interest rate (Kapuściński et al., 2014).

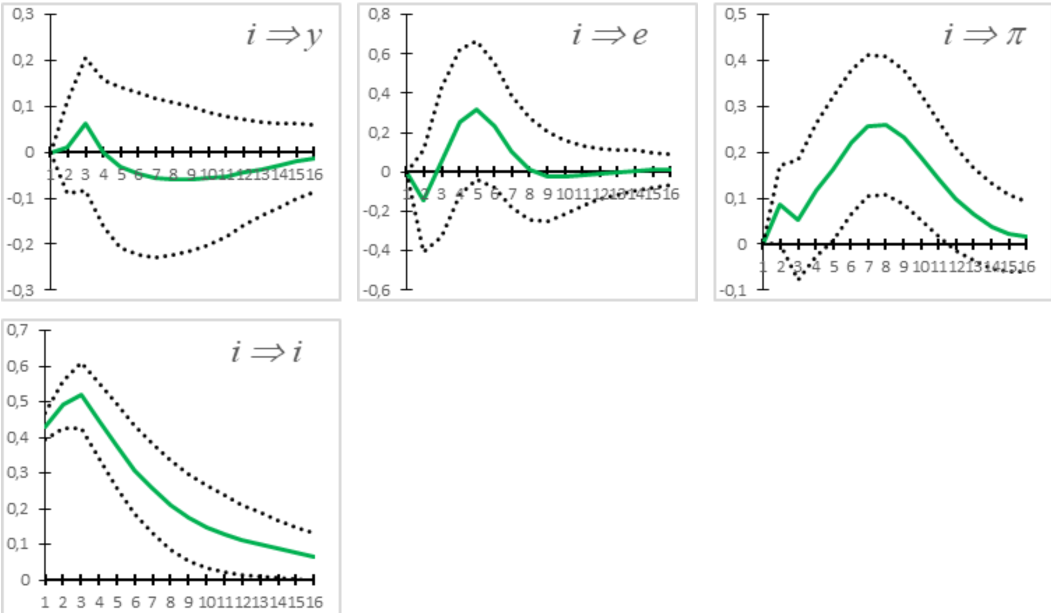
The three benchmark models differ in the measure of exchange rate misalignment, namely e_{it} (PVAR-I), q_{it} (PVAR-II), and qp_{it} (PVAR-III). The system was estimated using four lags, which is a reasonable compromise between several criteria (as the LR test indicates eight lags, the FPE and the AIC tests are in favour of six lags, the SC and the HQ tests indicated just two lags). The absence of autocorrelation of the residuals was supported by the portmanteau test and the LM autocorrelation test. The estimated impulse response functions (IRFs) are presented in the next section, followed by a sensitivity analysis.

5. Empirical results and discussion

The IRFs for monetary policy shocks are presented in Figures 3 to 5. Regardless of the exchange rate variable used, there is a uniform countercyclical central bank reaction to both higher inflation (significant up to twelve quarters after the impact) and a wider output gap (this effect is rather short-lived). For a shorter period from 2010 to 2019, the central bank response to output gap and inflation shocks became weaker, especially for the former (results are available on request). As there was an increase in the CB policy rate in response to a nominal (real) exchange rate shock, this meant that central banks tried to smooth the amplitude of exchange rate depreciation.



a) central bank responses to endogenous shocks



b) central bank policy rate effects

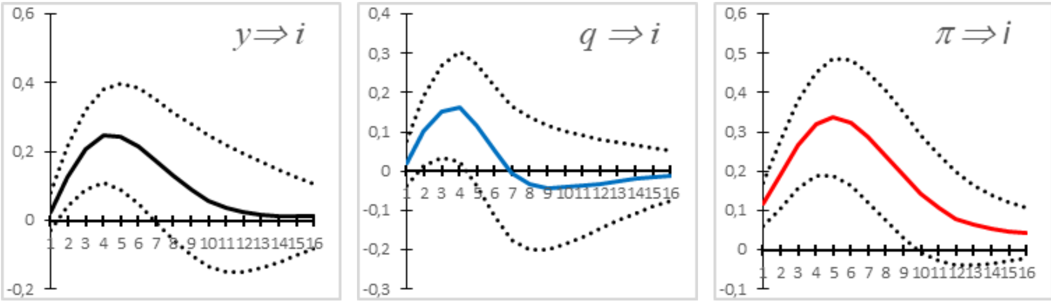
Fig. 3. Selected monetary policy relationships (PVAR-I with nominal exchange rate)

Note: endogenous shocks of one standard deviation size are shown in the confidence bands of ± two standard errors.

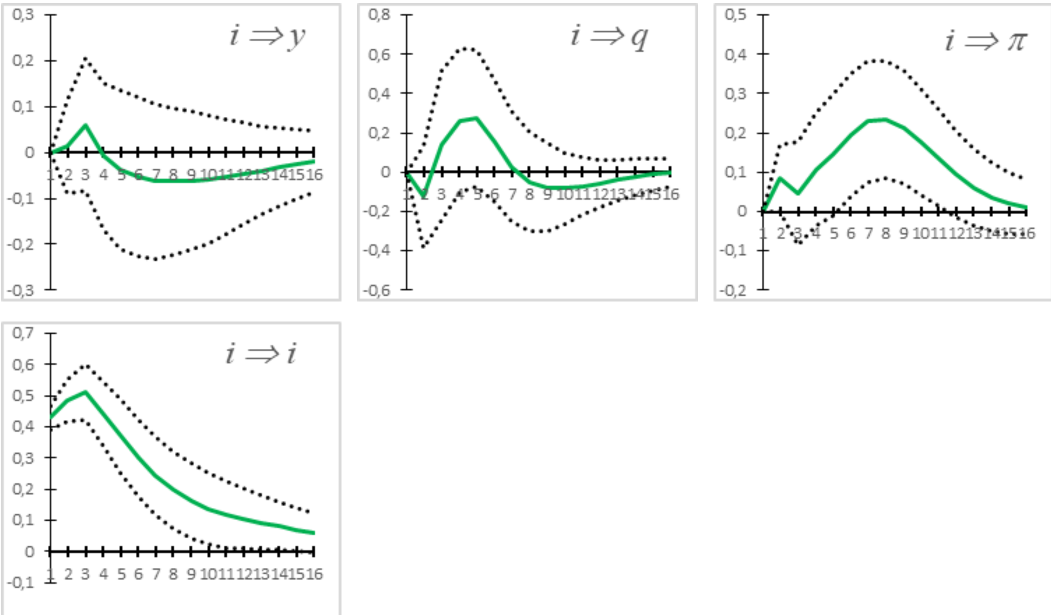
Source: authors' estimations in EViews 10.

The obtained IRFs imply that the coefficients on inflation at 1.1 to 1.2 and the coefficients on the output gap at 0.6 to 0.8 satisfy both the first and second Taylor principles. It is standard to assume that the first Taylor principle is satisfied if the coefficient on inflation is greater than and significantly different from one, while the second Taylor principle is satisfied if the coefficient on the output gap is greater than zero, less than one, and significantly different from both zero and one (Nikolsko-Rzhevskyy, Papell and Prodan, 2019). For a shorter 2010-2019 sample, the reaction of central banks to inflation and the output gap shocks became somewhat weaker, with both Taylor principles satisfied in the estimates of the PVAR-I model only. Unfortunately, a robust monetary reaction in the Taylor rule style did not bring about a much-sought decrease in the inflation rate. Similarly to other studies, there is the price puzzle with a lag from four to ten quarters. Among possible explanations (Ali and Anwar, 2018; Lukmanova and Rabitsch, 2022), the higher openness of the economy and the stability of interest rate shocks are worth noting. As suggested by its own impulse response, the CB policy rate became somewhat more inertial over the 2010-2019 period.

Following an increase in the CB policy rate, the monetary contraction had no statistically significant effect on the output gap. Consequently, the results do not support the findings from previous studies of the almost universal contractionary effect of monetary tightening (Table 1). However, it should be noted that there was a tendency for strengthening the inverse relation between the CB policy rate and the output gap in the estimates for the 2010-2019 period. In addition to the price puzzle, there is weak evidence of both nominal and real exchange rate depreciation (or the exchange rate puzzle) resulting from monetary tightening with a 4-quarter lag (Figures 3 and 4), although just the opposite outcome is suggested by the estimates of the PVAR-III model with the GDP-adjusted measure of the RER (Figure 5). Monetary policy effects on the exchange rates stayed intact in the post-crisis period of 2010-2019.



a) central bank responses to endogenous shocks



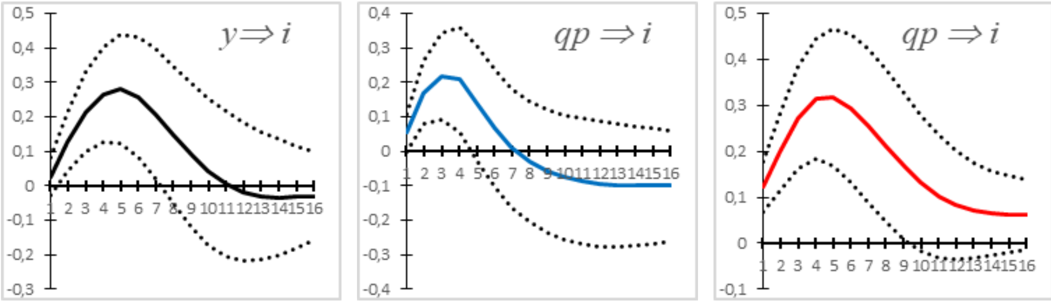
b) central bank policy rate effects

Fig. 4. Selected monetary policy relationships (PVAR-II)

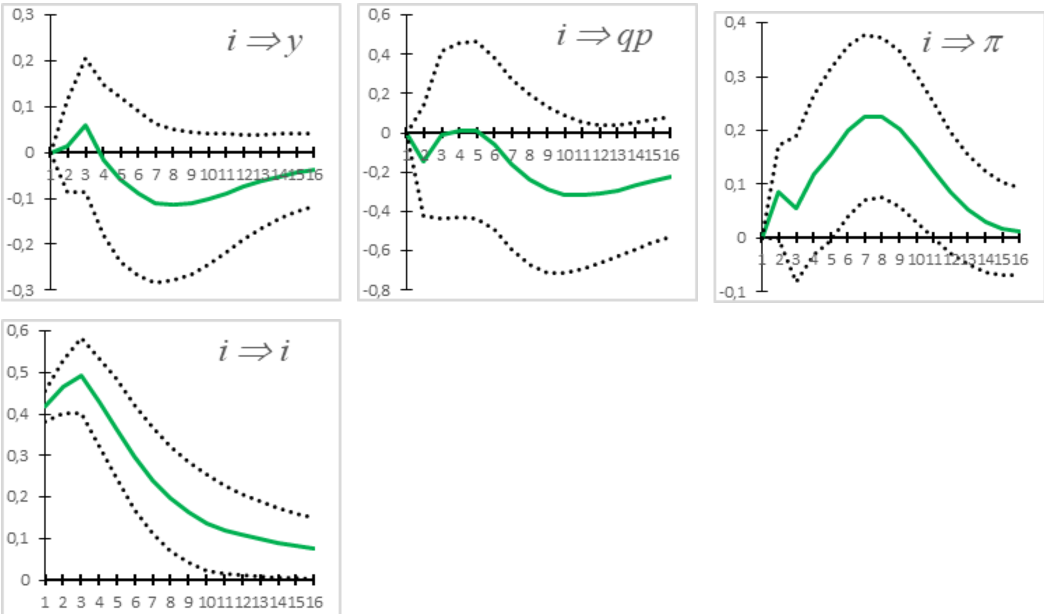
Source: authors' estimations in EViews 10.

Along with monetary policy relationships, Figure 6 presents IRFs for other important macroeconomic shocks. The exchange rate undervaluation in both nominal and real terms was followed by a decrease in output with 6 to 10-quarter lags, which is consistent with many of the previous studies for the CEE-4 countries (Franta, Horváth and Rusnák, 2012; Horká, 2015; Haug, Jedrzejowicz and

Sznajderska, 2019; Shevchuk, 2020) and contradicts some suggestions dating back to the middle of the 2000s that the exchange rate changes become neutral with respect to output in economies with a floating currency (Frömmel and Schobert, 2006). In contrast, the use of the GDP-adjusted RER variable in this study indicates an expansionary effect on the output gap on impact. Regardless of the PVAR model, there was no difference in the exchange rate effects on output in the estimates for the 2010-2019 period.



a) central bank responses to endogenous shocks



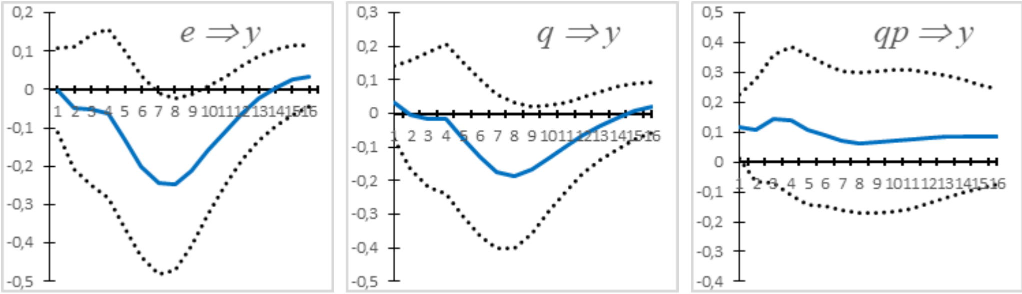
b) central bank rate effects

Fig. 5. Selected monetary policy relationships (PVAR-III)

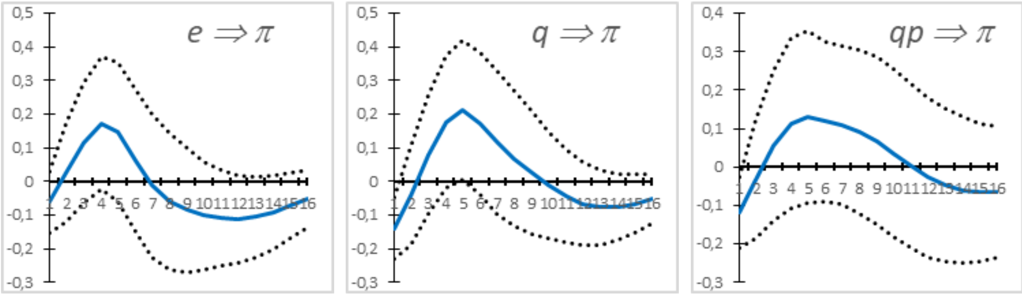
Source: authors' estimations in EViews 10.

Despite a short-lived positive ERPT, a non-conventional inverse relation between the exchange rate and inflation was obtained for a longer horizon in PVAR-I and PVAR-II (Figure 6b). As consumer prices decline with a 10-quarter lag, it can be interpreted by weakening of the domestic demand that could outweigh an opposite effect of higher import prices (Ha, Stocker and Yilmazkuday, 2019). It is worth mentioning that the same inverse relationship between exchange rate depreciation and inflation was found for Czechia, Hungary, and Poland (Horká, 2015), however the estimates for the 2010-2019 period indicate a somewhat stronger ERPT.

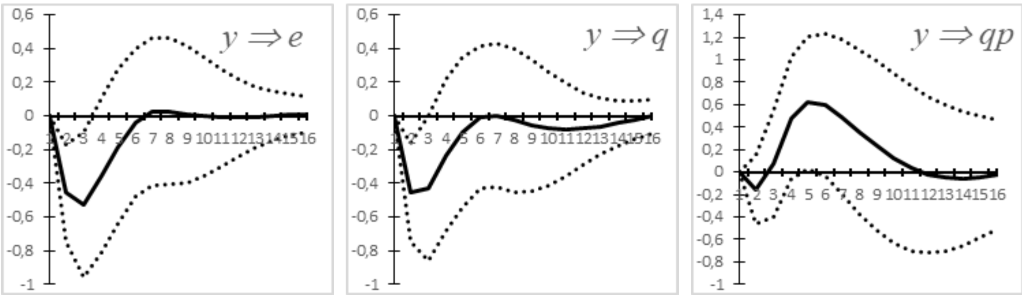
Following a cyclical boom in output, one can observe an exchange rate appreciation on impact in both the PVAR-I and PVAR-II models (Figure 6c), however the possibility of the RER undervaluation was suggested by the PVAR-III model. Such findings draw attention to the fact that some of the exchange rate effects can be dependent on the choice of the exchange rate variable.



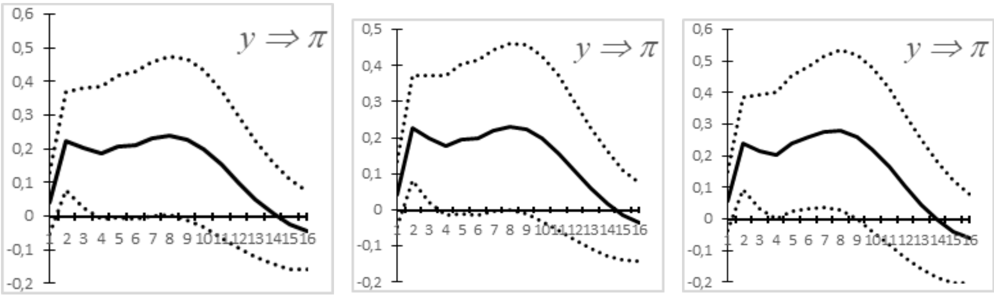
a) nominal (real) exchange rate effects on output



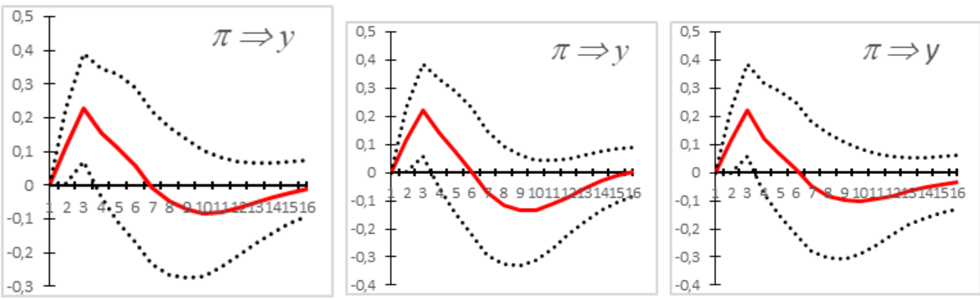
b) nominal (real) exchange rate effects on inflation



c) output effects on nominal (real) exchange rate



d) output effects on inflation



e) inflation effects on the output gap

Fig. 6. Other important relationships

Note: IRFs from the PVAR-I, PVAR-II and PVAR-III models are shown from the left to the right panel.

Source: authors' estimations in EViews 10.

Regardless of the specification and the sample chosen, it was confirmed that there is a strong two-way causality between output gap and inflation in the CEE-4 countries. In full accordance with the new Keynesian Phillips curve framework of Equation (2), inflation is positively influenced by the output gap. Ultimately, it is an argument in favour of the flexible inflation targeting, as stabilising inflation around the inflation target requires a decrease in the output gap which means stabilising resource utilisation around a normal level (Svensson, 2009). The effect of the output gap on consumer prices became somewhat stronger in the post-crisis period, with a shift of the impulse peak towards higher horizons. The same holds for the reverse causality running from inflation to output, regardless of the PVAR model used. This study's estimates do not indicate that there has been weakening of the relation between inflation and output gap since the beginning of the past decade, as suggested by Szafranek (2017). The only difference between the IRFs for the 2004-2019 and the 2010-2019 sample was that the peak of output effect on inflation shifted to the higher horizons while being insignificant on impact.

To assess the importance of impulse responses, the authors used the forecast error variance decomposition (FEVD) (Table 5). Among other endogenous variables, inflation was the strongest factor behind the CB policy rate changes followed by the output gap. For the PVAR-I model, the fraction of inflation in the FEVD of i_t gradually increased from 9% to 29% in the estimates for the years 2004-2019, and from 25% to 42% in the estimates for the post-crisis period. Similar FEVD estimates were provided by the PVAR-II and PVAR-III models. The output gap was much less influential in the determination of the CB policy rate. The fraction of the CB policy rate changes explained by both the nominal and real exchange rates seemed marginal. The price puzzle also appeared not to be very significant, especially in the post-crisis environment of low interest rates, as the fraction of π_t explained by changes in i_t did not exceed 10%. Both IRFs and FEVDs support the results from the previous studies that the central banks of the CEE countries respond to both inflation and output gap (Wang et al., 2015; Haug, Jedrzejowicz and Sznajderska, 2019; Klose, 2019). This study also confirmed that the response to inflation became stronger in the post-crisis period (Dobešová and Hampel, 2014), whereas the monetary reaction to the exchange rate misalignment disappeared, as reported by Frömmel, Garabedian and Schobert (2011) and Vašiček (2014).

Among other results, there is support for a significant link between the output gap and inflation at longer horizons (up to 21% of variance). The ERPT from both the nominal and real exchange rates was not influential to any extent, as the fraction of inflation explained by e_t, q_t and qp_t was below 10%; as in other studies (Vašiček, 2014), the inflation was highly inertial. The same persistence was observed in the deviations of the nominal and real exchange rate from their trend. In the post-crisis period, the expansionary effect of inflation on the output gap continued to be weak. At the same time, the fraction of y_t explained by changes in e_t increased to 12%, compared to 8% in the estimates for the 2004-2019 period. Similar developments were observed with respect to changes in both measures of the RER misalignment. As suggested by the FEVD, the importance of the output gap and the CB policy rate in the nominal and real exchange rate changes was rather marginal. Inflation was not significant in the changes of nominal exchange rate, but became more influential in the post-crisis period changes of q_t and qp_t, up to 10% and 16% of variance respectively.

Table 5. Forecast error variance decomposition

Forecast horizon	2	4	8	12	16	Forecast horizon	2	4	8	12	16
Variation in output gap (y) due to innovation in						Variation in inflation (π) due to innovation in					
y	99 (96)	97 (94)	93 (84)	90 (77)	90 (73)	y	0 (1)	5 (1)	10 (3)	12 (12)	12 (15)
y	99 (95)	97 (94)	95 (89)	92 (83)	92 (79)	y	4 (1)	5 (0)	9 (3)	12 (12)	12 (15)
y	98 (91)	96 (93)	95 (88)	93 (80)	92 (73)	y	4 (1)	6 (0)	12 (7)	15 (19)	15 (21)
e	0 (1)	0 (2)	5 (8)	6 (12)	6 (12)	e	1 (3)	2 (5)	2 (5)	3 (6)	4 (7)
q	0 (3)	0 (1)	2 (4)	4 (7)	4 (7)	q	2 (2)	2 (7)	5 (10)	4 (9)	5 (9)
qp	2 (8)	2 (5)	2 (8)	3 (12)	3 (13)	qp	1 (1)	1 (2)	2 (2)	2 (2)	3 (2)
π	1 (1)	3 (3)	3 (4)	3 (4)	3 (5)	π	95 (96)	92 (94)	81 (89)	75 (78)	74 (73)
π	1 (1)	3 (3)	3 (4)	4 (4)	4 (5)	π	94 (97)	92 (92)	81 (83)	76 (74)	75 (71)

π	1 (1)	2 (2)	2 (2)	3 (4)	3 (8)	π	94 (98)	92 (97)	80 (88)	75 (75)	74 (72)
i	0 (1)	0 (2)	0 (4)	1 (7)	1 (10)	*i*	1 (0)	1 (1)	7 (3)	10 (4)	10 (4)
i	0 (1)	0 (1)	0 (3)	1 (6)	1 (9)	*i*	1 (0)	1 (1)	6 (3)	8 (5)	8 (5)
i	0 (1)	0 (1)	1 (2)	2 (4)	2 (6)	*i*	1 (0)	1 (1)	5 (3)	7 (4)	7 (4)
Variation in nominal (real) exchange rate (*e, q, qp*) due to innovation in						Variation in the CB policy rate (*i*) due to innovation in					
y	2 (4)	4 (7)	4 (7)	4 (7)	4 (7)	*y*	4 (4)	10 (5)	13 (6)	13 (7)	12 (7)
y	2 (4)	3 (5)	3 (5)	3 (7)	3 (8)	*y*	3 (5)	9 (7)	13 (9)	12 (10)	12 (10)
y	0 (1)	1 (2)	4 (7)	4 (7)	4 (6)	*y*	3 (5)	10 (7)	16 (10)	15 (11)	15 (10)
e	97 (95)	93 (89)	92 (86)	92 (85)	92 (84)	*e*	2 (1)	4 (1)	3 (1)	4 (2)	4 (3)
q	97 (94)	94 (89)	93 (83)	92 (81)	92 (80)	*q*	2 (1)	5 (2)	4 (2)	4 (2)	4 (1)
qp	99 (98)	97 (94)	92 (82)	90 (78)	89 (73)	*qp*	7 (1)	10 (1)	7 (0)	7 (0)	9 (0)
π	1 (1)	2 (2)	2 (4)	2 (4)	2 (4)	π	8 (23)	15 (30)	24 (38)	25 (40)	25 (41)
π	1 (1)	2 (4)	3 (9)	3 (10)	3 (10)	π	10 (23)	17 (30)	27 (37)	28 (38)	28 (39)
π	1 (1)	2 (4)	3 (10)	4 (13)	5 (16)	π	11 (24)	17 (31)	24 (35)	25 (36)	25 (36)
i	0 (0)	1 (2)	2 (3)	2 (4)	2 (5)	*i*	86 (72)	71 (64)	59 (55)	58 (51)	58 (50)
i	0 (0)	1 (2)	1 (2)	2 (2)	2 (2)	*i*	85 (71)	69 (61)	56 (52)	55 (50)	56 (50)
i	0 (0)	0 (0)	0 (1)	1 (2)	2 (5)	*i*	79 (70)	63 (62)	53 (54)	52 (53)	51 (54)

Note: the variance decomposition (in percent) is presented over a 16-quarter post-shock horizon; values for the estimates of 2010-2019 period are in brackets; for *y*, π and *i*, the first row represents FEVD from the PVAR-I model, with the second and third rows referring to the FEVD from the PVAR-II and PVAR-III models.

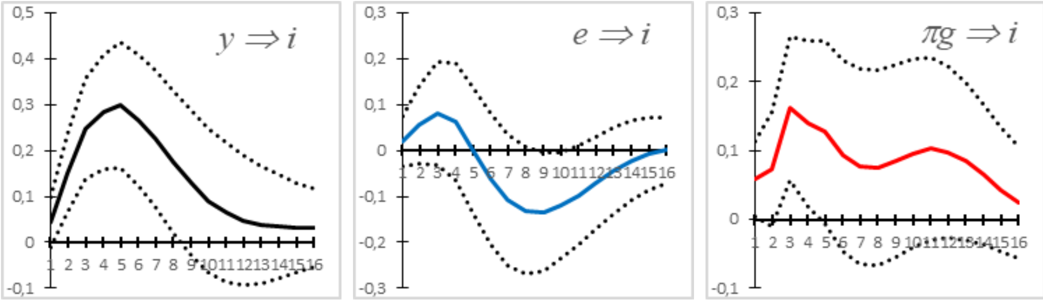
Source: authors' estimations in EViews 10.

6. Sensitivity analysis

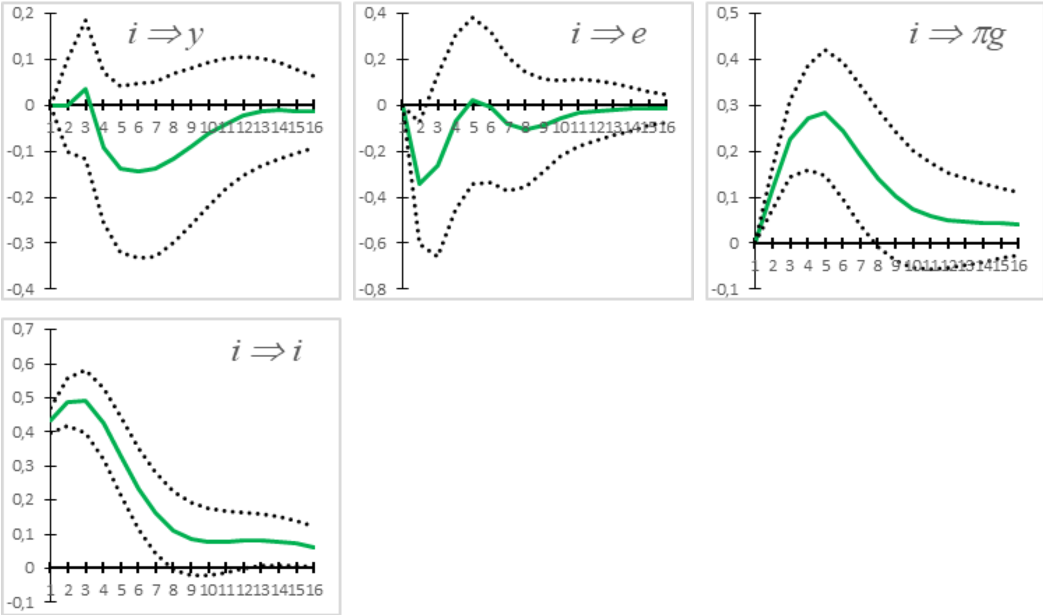
The sensitivity of the benchmark models was analysed by: (i) estimating the recursive PVAR model instead of the structural PVAR model, (ii) estimating both models without exogenous variables, (iii) using the difference between inflation rate and its target rate (or the inflation gap) instead of the actual inflation rate. The recursive PVAR model typically generates the IRFs close to those of the baseline PVAR model and with the same confidence intervals. The only exception was the lack of a short-lived expansionary effect of the GDP-adjusted RER shock and a weaker inflationary effect of the output gap in the estimates of the PVAR-III model. On dropping exogenous variables, monetary reaction to the output gap and the nominal exchange rate misalignment shocks becomes stronger over the longer-term horizon, but any differences disappear for the 2010-2019 period, and the output gap becomes neutral in respect to the GDP-adjusted RER shocks. The response to the nominal (real) exchange rate misalignment was quite uniform across all the specifications, regardless of the exogenous variables and specifications used.

Regardless of the changes in monetary shock effects for the 2010-2019 period, the core results of this study – in particular regarding the monetary policy reaction to inflation and output gap – remain unchanged. It was confirmed that nominal (real) exchange rate undervaluation and deflation are contractionary with respect to output while the output gap is inflationary.

If one substitutes the inflation rate with the inflationary gap, a monetary reaction to the output gap and nominal exchange rate shocks looks very similar (Figure 7a). The same results are obtained by the PVARs with the RER misalignment. Thus, it was confirmed that monetary reaction to output gap and exchange rate shocks becomes somewhat weaker in the post-crisis environment. However, there was a much weaker monetary reaction to the inflation gap compared to the reaction to the actual inflation rate developments (Figure 3a). A deviation from the inflation target rate was followed by a short-lived response (its fraction in the FEVD of i_t declined to just 5-6%). There was no difference in that the IRFs demonstrated a weaker (though more persistent) response to inflationary shocks for the 2010-2019 period.



a) central bank responses to endogenous shocks



b) central bank rate effects

Fig. 7. Selected monetary policy relationships (PVAR-I with the inflation gap)

Source: authors' calculations.

Taking into account the deviations from the inflation target rate, one can confirm that a contractionary monetary stance is neutral in respect to an output gap. In contrast to the estimates with the actual inflation rate (Figure 3b), there was an exchange rate appreciation on impact, although this was not the case for the 2010-2019 period (no sign of the exchange rate puzzle). On the contrary, the price puzzle was observed regardless of the PVAR model specification and the sample used, with the fraction of i_t in the FEVD of the inflation gap increasing above 20% (much higher in comparison to the FEVD of the inflation rate in Table 5). Similarly to the estimates with the actual inflation rate, exchange rate depreciation was contractionary in PVAR-I and PVAR-II, but a positive and significant ERPT was found only in the estimates of PVAR-II and became stronger in the estimates for the 2010-2019 period.

7. Conclusions

Due to the recent acceleration of price dynamics in the CEE-4 countries (Czechia, Hungary, Poland, and Romania), it is of particular interest to provide empirical assessment of the monetary policy effectiveness in keeping inflation close to the established target while not harming economic performance. For this purpose, the authors used the panel VAR estimates for quarterly data of the 2004-2019 period. The four-variable PVAR model include output gap, exchange rate misalignment, inflation, and central bank policy rate, and accounts for the contemporaneous nominal (real) exchange rate effects on output. It was found that there is a time-invariant strong monetary reaction to both the actual inflation rate (not deviations from its target) and the output gap, in full accordance with the Taylor rule. There was no reaction to nominal (real) exchange rate misalignment in the post-crisis period of 2010-2019, while the estimates for a longer sample of 2004-2019 suggest a short-term depreciation in response to a higher CB policy rate. As the CB policy rate is quite inertial, it suggests the presence of backward-looking policy approaches. Regarding monetary policy effects, an increase in the CB policy rate seems to be neutral with respect to both the nominal (real) exchange rate and the output gap, even though there was a tendency for strengthening the inverse relationship between the CB policy rate and the latter in the estimates for the 2010-2019 period. Unfortunately, there is evidence of the price puzzle when monetary tightening is followed by a counterintuitive increase in the inflation rate.

Among other results, the output gap is a factor behind the acceleration of inflation, while in turn inflationary developments contribute positively to the business cycle – both outcomes are time-invariant and in line with the New Keynesian theoretical framework. Except for the specification with the GDP-adjusted RER, the exchange rate undervaluation became contractionary with six to nine lags. The evidence of the ERPT to consumer inflation is also mixed. Finally, an economic boom is associated with a short-lived nominal exchange rate appreciation, while the impact of the real exchange rate misalignment depends on the choice of the RER variable.

The findings of this study have a few important policy implications. First, the central bank's relation to the consumer price developments (although significant) is inertial, which suggests a reorientation towards a forward-looking approach for the policy rate setting. Second, in the presence of the price and exchange rate puzzles, it is quite natural to argue in favour of using non-monetary policy tools as anti-inflationary measures, for example, improvements in the budget balance in the first instance. Third, deliberate currency appreciation resulting from the central bank's foreign exchange interventions and/or fiscal austerity measures can be helpful for such a disinflation that minimises output losses. Moreover, it is worth noting that the exchange rate of all the CEE countries was overvalued up to 2015 if adjusted for the GDP level (Figure 2d), and this feature could explain (at least partially) the weakness of the ERPT. As the exchange rates of the CEE-4 countries have become undervalued recently, this also suggests a stronger contractionary effect on output and ERPT to consumer prices.

References

Ali, S. Z., & Anwar, S. (2018). Price puzzle in a small open New Keynesian model. *The Quarterly Review of Economics and Finance*, 69(C), 29-42. https://doi.org/10.1016/j.qref.2017.12.001

Anderl, C., & Caporale, G. M. (2022). Exchange rate parities and Taylor rule deviations. *Empirical Economics*, 63(4), 1809-1835. https://doi.org/10.1007/s00181-021-02192-3

Angeletos, G.-M., & Lion, C. (2021). Determinacy without the Taylor principle. *NBER Working Paper*, 28881. Cambridge, MA: National Bureau of Economic Research.

Ayres, K., Belasen, A., & Kutan, A. M. (2014). Does inflation targeting lower inflation and spur growth*? Journal of Policy Modelling*, 36(2), 373-378. https://doi.org/10.1016/j.jpolmod.2012.12.008

Barguellil, A., Ben Salha, O., & Zmami, M. (2018). Exchange rate volatility and economic growth. *Journal of Economic Integration*, 33(2), 1302-1336. http://dx.doi.org/10.11130/jei.2018.33.2.1302

Bartóková, L., & Ďurčová, J. (2015). Effectiveness of the monetary policy implementation in the context of crisis: Use of short-term interest rates in the Czech Republic and the EMU. *Ekonomie a Management*, XVIII, 1, 14-17. http://dx.doi.org/10.15240/tul/001/2015-1-001

Borys, M. M., & Horváth, R. (2008). The effects of monetary policy in the Czech Republic: An empirical study*. William Davidson Institute Working Paper*, 922. Ann Arbor: University of Michigan.

Canova, F., & Ciccarelli, M. (2013). Panel vector autoregressive models. A survey. *ECB Working Paper Series*, 1507, Frankfurt: European Central Bank.

Ciżkowicz-Pękała, M., Grostal, W., Niedźwiedzińska, J., Skrzeszewska-Paczek, E., Stawasz-Grabowska, E., Wesołowski, G., & Żuk, P. (2019). Three decades of inflation targeting. *NBP Working Paper*, 314. Warsaw: National Bank of Poland.

Clinton, K., Hlédik, T., Holub, T., Laxton, D., & Wang, H. (2017). Czech magic: Implementing inflation-forecast targeting at the CNB. *IMF Working Paper*, WP/17/21. International Monetary Fund.

Coricelli, F., Égert, B., & MacDonald, R. (2006). Monetary transmission in Central and Eastern Europe: Gliding on a wind of change. *Focus on European Economic Integration*, 1, 44-87.

Dobešová, A., & Hampel, D. (2014). Inflation targeting during financial crisis in Visegrád Group countries. *Economics and Management*, 2, 12-19.

Drygalla, A. (2015). Switching to exchange rate flexibility? The case of Central and Eastern European inflation targeters. *FIW Working Paper*, 139. Halle Institute for Economic Research.

Égert, B., & MacDonald, R. (2009). Monetary transmission mechanism in Central and Eastern Europe: Surveying the surveyable. *Journal of Economic Surveys*, 23(2), 277-327. http://dx.doi.org/10.1111/j.1467-6419.2008.00563.x

Engel, C. (2019). Real exchange rate convergence: the roles of price stickiness and monetary policy. *Journal of Monetary Economics*, 103(1), 21-32. https://doi.org/10.1016/j.jmoneco.2018.08.007

Fabris, N., & Lazić, M. (2022). Evaluating the role of the exchange rate in monetary policy reaction function of advanced and emerging market economies. *Journal of Central Banking Theory and Practice*, 11(2), 77-96. https://doi.org/10.2478/jcbtp-2022-0014

Fazio, D. M., Silva, T. C., Tabak, M., & Cajueiro, D. (2018). Inflation targeting and financial stability: Does the quality of institutions matter? *Economic Modelling*, 71(C), 1-15. https://doi.org/10.1016/j.econmod.2017.09.011

Feldkircher, M., Huber, F., & Moder, I. (2016). Modeling the evolution of monetary policy rules in CESEE. *Focus on European Economic Integration*, Q1, 8-27.

Franta, M., Horváth, R., & Rusnák, M. (2012). Evaluating changes in the monetary transmission mechanism in the Czech Republic. *IES Working Paper*, 11/2012, Prague: Charles University in Prague.

Fratscher, M., Grosse-Steffen, C., & Rieth, M. (2020). Inflation targeting as a shock absorber. *Journal of International Economics*, 123(C), 103038. https://doi.org/10.1016/j.jinteco.2020.103308

Frömmel, M., & Schobert, F. (2006). Monetary policy rules in Central and Eastern Europe. *Hannover Economic Papers*, 341. Hannover: Leibniz Universität Hannover.

Frömmel, M., Garabedian, G., & Schobert, F. (2011). Monetary policy rules in Central and Eastern Europe: Does the exchange rate matter? *Journal of Macroeconomics*, 33(4), 807-818. https://doi.org/10.1016/j.jmacro.2011.05.003

Ha, J., Stocker, M., & Yilmazkuday, H. (2019). Inflation and exchange rate pass-through, Policy Research Working Paper No. 8780. World Bank.

Haug, A., Jedrzejowicz, T., & Sznajderska, A. (2019). Monetary and fiscal policy transmission in Poland. *Economic Modelling*, 79(C), 15-27. https://doi.org/10.1016/j.econmod.2018.09.031

Horká, E. (2015). The monetary transmission in the selected CEE countries. *"Ovidius" University Annals*, XV(2), 449-452.

Ireland, P. N. (2006). The monetary transmission mechanism. *FRB of Boston Working Papers*, 06-1. Federal Reserve Bank of Boston.

Kapuściński, M., Łyziak, T., Przystupa, J., Stanisławska, E., Sznajderska, A., & Wróbel, E. (2014). Monetary policy transmission mechanism in Poland. What do we know in 2013? *NBP Working Paper*, 180. Warsaw: National Bank of Poland.

Klose, J. (2019). Are Eastern European Taylor reaction functions asymmetric in inflation or output: empirical evidence for four countries. *Eastern European Economics*, 57(1), 31-49. https://doi.org/10.1080/ 00128775.2018.1517600

Lesuisse, P. (2017). External monetary shocks to Central and Eastern European countries. *Études et Documents*, 5. Clermont: Centre d'Etudes et de Recherches sur le Developpement International (CERDI).

López-Villavicencio, A., & Pourroy, M. (2019). Does inflation targeting always matter for the ERPT? A robust approach. *Journal of Macroeconomics*, 60(C), 360-377. https://doi.org/10.1016/j.jmacro.2019.04.004

Lukmanova, E., & Rabitsch, K. (2022). New evidence on monetary transmission: interest rate versus inflation target shocks. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3437907

Mollick, A. V., Torres, R. C., & Carneiro, F. G. (2011). Does inflation targeting matter for output growth? *Journal of Policy Modelling*, 33(4), 537-551. https://doi.org/10.1016/j.jpolmod.2011.03.010

Myšková, K., Hampel, D., & Dobešová, A. (2013). Impulse-response analysis of monetary policy – Visegrad Group countries case. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, LXI(295), 2561-2567. http://dx.doi.org/10.11118/actaun201361072561

Nene, S. T., Damilola Ilesanmi, K. D., & Sekome, M. (2022). The effect of inflation targeting (IT) policy on the inflation uncertainty and economic growth in selected African and European countries. *Economies*, 10(37). https://doi.org/10.3390/economies10020037

Nikolsko-Rzhevskyy, A., Papell, D. H., & Prodan, R. (2019). The Taylor principles. *Journal of Macroeconomics*, 62(C), 103159. https://doi.org/10.1016/j.jmacro.2019.103159

Petreski, M. (2014). Inflation targeting at the crossroads: evidence from post-communist economies during the crisis. *Communist and Post-Communist Studies*, 47(2), 247-269. https://doi.org/10.1016/ j.postcomstud.2014.04.010

Rupert, P., & Šustek, R. (2019). On the mechanics of New-Keynesian models. *Journal of Monetary Economics*, 102(1), 53-69. https://doi.org/10.1016/j.jmoneco.2019.01.024

Ryczkowski, M. (2016). Poland as an inflation nutter: the story of successful output stabilization. *Zbornik radova Ekonomskog fakulteta Rijeka*, 34(2), 363-392. http://dx.doi.org/10.18045/zbefri.2016.2.363

Ryczkowski, M., & Ręklewski, M. (2021). Macroeconomic performance of countries across monetary policy regimes from 2000 to 2017. *Economic Research-Ekonomska Istraživanja*, 34(1), 1224-1243. https://doi.org/ 10.1080/1331677X.2020.1820360

Shevchuk, V. (2020). Monetary policy transmission mechanisms in the Central and Eastern European countries. *Argumenta Oeconomica Cracoviensia*, 2(23), 51-68. https://doi.org/10.15678/AOC.2020.2303

Stakėnas, J., & Stasiukynaitė, R. (2017). Monetary policy transmission: the case of Lithuania. *Baltic Journal of Economics*, 17(1), 1-24. http://dx.doi.org/10.1080/1406099X.2016.1242330

Su, C-W., Si, D-K., Chang, H-L., & Li, X-L. (2018). Can the Taylor rules explain exchange rate movements? Evidence from Central and Eastern European countries. *Argumenta Oeconomica*, 2(41), 35-60. http://dx.doi.org/10.15611/aoe.2018.2.02

Svensson, L. E. (2009). Flexible inflation targeting: lessons from the financial crisis. Speech on September 21, 2009. http://archive.riksbank.se/en/Web-archive/Published/Speeches/2009/Svensson-Flexible-Inflation-Targeting-Lessons-from-the-Financial-Crisis/index.html

Szafranek, K. (2017). Flattening of the New Keynesian Phillips curve: evidence for an emerging, small open economy. *Economic Modelling*, 63, 334-348. https://doi.org/10.1016/j.econmod.2017.01.009

Ulrichs, M. (2018). Identification of financial and macroeconomic shocks in a VAR model of the Polish economy. A stability analysis. *Economics and Business Review*, 4(18), 29-43. https://doi.org/10.18559/ ebr.2018.1.3

Vašiček, B. (2014). Monetary policy rules and inflation process in open emerging economies: evidence for 12 new EU members. *Working Paper*, 09.03. Bellaterra: Universitat Autònoma de Barcelona, 36-58.

Vradin, A. (2015). Inflation targeting and financial stability: Providing policymakers with relevant information. *BIS Working Papers*, 503. Basle: Bank of International Settlements.

Wang, Y., Jiang, C., Chang, H-L., & Su, C-W. (2015). Are Taylor rules valid in Central Eastern European countries? *Ekonomický časopis*, 63(7), 665-685.

Wlodarczyk, P. (2017). Monetary policy transmission and the labour market in the non-eurozone Visegrad Group countries in 2000-2014: Evidence from a SVAR analysis. *Comparative Economic Research. Central and Eastern Europe*, 20(4), 23-43. https://doi.org/10.1515/cer-2017-0026

Woodford, M. (2001). The Taylor rule and optimal monetary policy. *American Economic Review*, 91(2), 232-237. https://doi.org/10.1257/aer.91.2.232

Woodford, M. (2003). Optimal interest-rate smoothing. *The Review of Economic Studies*, 70(4), 861-886. https://doi.org/10.1111/1467-937X.00270

Zobl, F. X., & Ertl, M. (2021). The condemned live longer – new evidence of the New Keynesian Phillips curve in Central and Eastern Europe. *Open Economies Review*, 32(4), 671-699. https://link.springer.com/ article/10.1007/s11079-020-09604-4

Received: June 2022, revised: July 2023