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The Macroeconomic Effects of the Taylor Rule Deviations in Central and Eastern European Countries

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Abstract: A standard Taylor rule was estimated for several Central and Eastern European (CEE) countries (Czechia, Hungary, Poland, Romania) based on quarterly data over the 2002-2021 period. The SVAR model indicates, for all CEE countries, that the level of central bank policy rate below the Taylor rule implied rate is caused by both output gap and inflation, with the Taylor rule deviations having heterogeneous effects on other endogenous variables. Among other results, the depreciation of the exchange rate is contractionary and inflationary, the output gap is inflationary (except for Romania), while inflationary effects on output are different across the CEE countries.

Keywords: Taylor rule, output, inflation, exchange rate, SVAR.

1. Introduction

It is popular to argue that since the beginning of the 1980s, less discretionary and more price-stability focused (rule-like) monetary policy contributed to a simultaneous decrease in inflation and better real sector performance (Taylor, 2017). However, the loosening of monetary policy in the mid-2000s reversed the outcomes, with the world financial crisis of 2008-2009 to follow. In the post-crisis environment, an expansionary monetary policy stance continued to prevail, though not without shifts in favour of inflation control around 2015 (Nikolsko-Rzhevskyy et al., 2017). The monetary policy developments of 2020-2023 demonstrate a shift from expansionary to tight monetary stance that resembles the reaction of the monetary authorities in the middle of the last decade. Nevertheless, it is argued that major central banks have been slow in their reaction to the surge in inflation following the COVID-19 pandemic and the war in Ukraine, with a very likely repeat of the mistakes from the 1960s and 1970s (Walsh, 2022).

Regardless of nuances in the assessment of monetary policy stance, the interest rate rules, as proposed by Taylor (1993), are considered as good representations of how the central bank reacts by changes in

its short-term policy rate to deviations of inflation and output from their equilibrium levels (Carvalho et al., 2021). On the other hand, the consequences of deviations of the central bank policy rate from a rule-based level of this monetary policy instrument are of interest. As found for the USA, the endogeneity of output and inflation improves correlation of the values of the Taylor rule with the actual values for the federal funds rate (Madeira and Palma, 2018).

The aim of this study was an empirical estimation of the relation between the monetary policy stance, as measured by deviations of the central bank policy rate from the Taylor rule implied rate, and several macroeconomic indicators (output, inflation, exchange rate) for the Central and Eastern European (CEE) countries (Czechia, Hungary, Poland, Romania) which practise the monetary policy of inflation targeting. For empirical estimates, the author applied the Structural Vector Autoregression (SVAR) modelling framework that is well suited to tackle the problem of endogeneity, as central banks react to nominal and real variables that are endogenous to monetary policy shocks (Carvalho et al., 2021). This study's contribution is twofold. First, for all the CEE countries studied, the level of central bank policy rate below the Taylor rule implied rate was caused by both output and inflation gaps. Second, such Taylor rule deviations have heterogeneous effects on other endogenous variables across countries.

The rest of this paper is structured as follows. A brief outline of the analytical issues is presented in the next section, followed by data, statistical model and a discussion of the results obtained. The closing section concludes.

2. Analytical Framework

As proposed by Taylor (1993), the monetary policy rule is as follows:

$$i_t = r_t^* + \overline{\pi}_t + \alpha\left(\overline{\pi}_t - \pi^*\right) + \gamma\left(y_t - \overline{y}\right), \tag{1}$$

where i_t is the central bank policy rate, r^*_t is the equilibrium (or natural) real interest rate, $\overline{\pi}_t$ is the rate of inflation rate over the previous four quarters, π^* is the target inflation rate, y_t is the actual level of output and $\overline{y}$ is the natural level of output. The Taylor rule implies that the central bank sets its policy rate in response to the inflation gap $\left(\overline{\pi}_t - \pi^*\right)$ and the output gap $\left(y_t - \overline{y}\right)$.

The original proposal by Taylor regarded setting $\alpha = 0.5$ and $\gamma = 0.5$, with the level of r^*_t and π^* at 2%. In practice, up to 12 variants of Taylor rules can be analysed, with different coefficients on the inflation and output gaps as well as alternative definitions of the equilibrium real interest rate (Nikolsko-Rzhevskyy et al., 2017). Output tilting rules imply that $\alpha < \gamma$, while it is the opposite for inflation tilting rules, $\alpha > \gamma$. It was found that the variations of the Taylor rule-based monetary policy improve inflation stability in several industrial countries (Teryoshin, 2023), as well as in such middle-income countries as Brazil (De-Losso, 2012), Mexico and India (Taylor, 2017). Earlier empirical studies indicate that a Taylor rule also explains the monetary policy for the CEE countries (Frömmel et al., 2011).

Despite the several merits of the rule-based monetary policy, such as the anchoring of price expectations, inflation stability and welfare gains (Taylor, 2017), some criticism was raised as early as in the 1990s, especially in the context of the zero bound on nominal interest rates. For example, Benhabib et al. (2001) argued that following the Taylor rule can be destabilising under conditions of sticky prices. More recently, Khan et al. (2020) indicated that at low trend inflation of 2-3%, a strong monetary response to inflation may not be significant enough to ensure macroeconomic stability. It was also suggested that central bank should react to output growth, not to output gap.

Although there are numerous informal arguments about the role of Taylor rule deviations in the US real estate bubble and the financial imbalances which led to the world fiscal crisis of 2008-2009, for example Kahn (2010), empirical studies are limited. The same holds for explanations of the Taylor rule

deviations, in contrast to numerous studies concerning calculations of the Taylor rule itself. It was not ruled out that deviations from the Taylor rule are mainly of an external origin, with not too much scope for the central bank activities. For instance, in Australia domestic factors account for just 22.5% of the total variation in deviation from the Taylor rule, suggesting a stronger role for an international monetary policy trend (Hudson and Vespignani, 2015). Besides traditional discussion on the relation to inflation, financial markets or output, at least in the short run, the example of the Deutschmark--Dollar and Yen-Dollar real exchange rate indicates that the Taylor rule deviations could be important determinants of the exchange rate, too (Wilde, 2012). As it is likely that there are both nominal and real effects of the nominal exchange rate changes in the CEE countries (Shevchuk, 2022), such a feature cannot but expand the analysis of the Taylor rule implementation.

It is frequent in the literature to distinguish several econometric problems in estimating Taylor rules, such as endogeneity, high serial correlation of the variables, lack of robustness with respect to assumptions of estimation techniques and presence of monetary policy inertia (Carare and Tchaidze, 2008; Carvalho et al., 2021). Other econometric considerations refer to the interest rate smoothing behaviour of central banks, stability of the equilibrium real interest rate, structural shifts in the weight coefficients for the inflation and output gap, measures of the inflation rate and potential output, or the use of backward or forward-looking expectations (Siklos and Wohar, 2006).

3. Data and Statistical Model

This study used quarterly data for the 2002-2021 period for Czechia, Hungary, Poland, and Romania. All these countries implement monetary policy of inflation targeting under a floating exchange rate regime. The central bank policy rates, i_t, were obtained from the Bank of International Settlements database (https://www.bis.org/statistics/), with quarterly series calculated as the average of monthly time series. Among other variables, quarterly time series on the gross domestic product (GDP), y_t, consumer price inflation (CPI), π_t, and the nominal effective exchange rate (NEER), e_t, were obtained from the International Monetary Fund International Financial Statistics database (https://data.imf.org/). All data were seasonally adjusted using the Census X12 procedure, except for CPI and NEER.

Although there are arguments in favour of larger preferences for the output gap in the monetary response function (Grui et al., 2022), the original version of the Taylor rule with $\alpha = \gamma = 0.5$ still dominates in the design of monetary policy. Moreover, there is evidence that preferences shifted in favour of 'inflation gap tilting' since the middle of the last decade, as was found for the Federal Reserve monetary policy (Nikolsko-Rzhevskyy et al., 2017). For the purpose of this study, a standard Taylor rule was calculated with equal weights for inflation and output gaps at 0.5; the value of equilibrium real interest rate was set at 1%.

As shown in Figure 1, the central bank rate in Czechia remained below the Taylor rule implied level for most of the 2002-2022 period, except for 2003-2004. For other CEE countries, the monetary policy stance had been in line with the Taylor rule until 2013, when the central bank rates were above the Taylor rule for the 2014-2017 period, but the situation has since reversed. In other studies, for example, Nikolsko-Rzhevskyy et al. (2019), the Taylor rule deviations are defined as the difference between the actual central bank policy rate and the interest rate target implied by Eq. (1). It is easy to observe that deviations from the Taylor rule seem to be synchronised, with a clear expansionary monetary policy stance since 2014. As of the end of 2022, only Hungary has tightened its monetary policy, whilst it has been just the opposite for Czechia, Poland, and Romania.

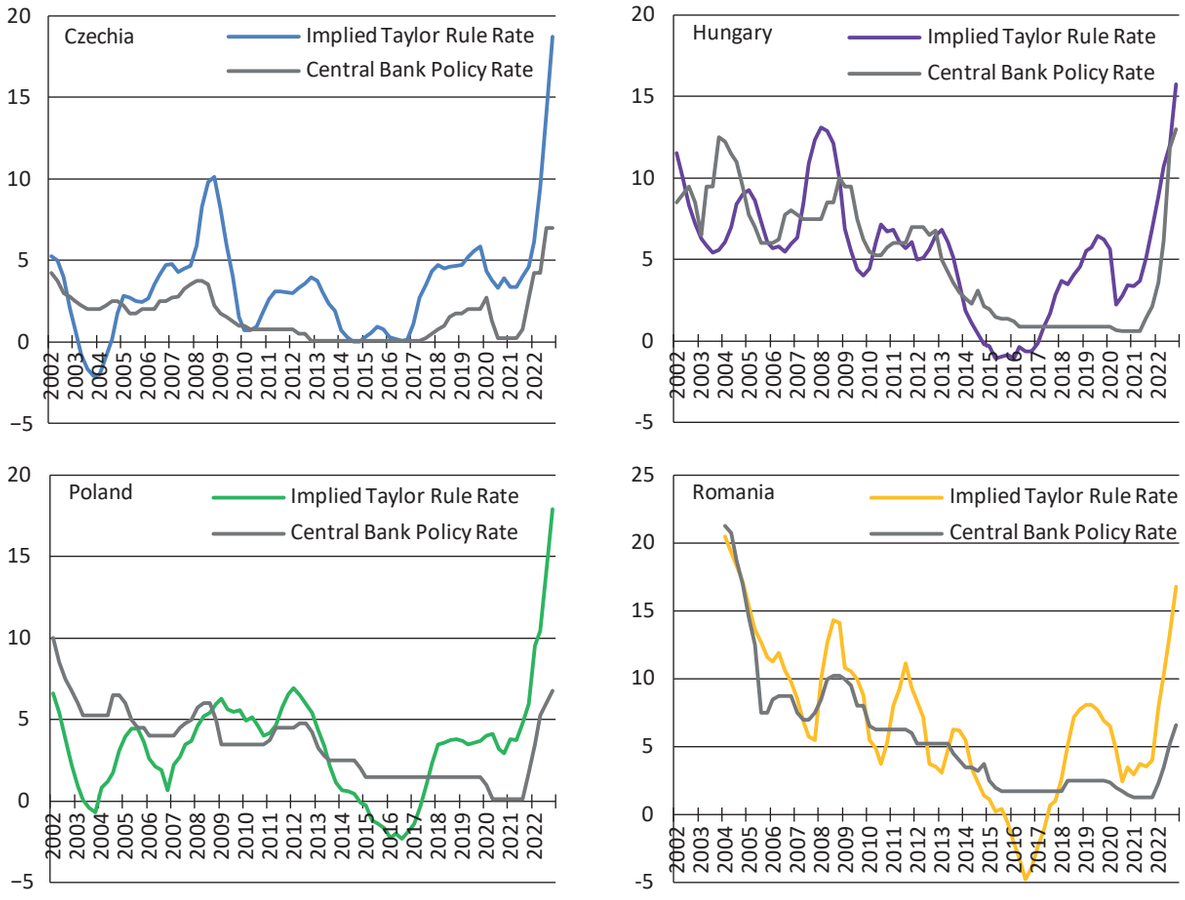


Fig. 1. The actual and the Taylor rule implied central bank rates

Source: author's calculations.

All the macroeconomic variables are stationary at the 5% significance level according to at least two of three tests, namely the Augmented Dickey-Fuller (ADF), the Phillips-Perron (PP) and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) (not reported due to space restrictions). The CPI series for Hungary is the only one with stationarity in levels supported by the KPSS test only. As deviations of the central bank policy rate from its Taylor rule implied level are stationary, it helps to avoid the problem with the economic interpretation of a unit root in interest rates (Siklos and Wohar, 2006). Considering the stationarity of all endogenous variables, the relations between them can be estimated in levels. Although the use of autoregressive distributed lag (ARDL) methods is recommended to overcome the problems of lagged dependent variables and serially correlated residuals (Sam et al., 2023), it does not deal with the issue of endogeneity. From this vantage point, the use of a SVAR model appears to be a better option.

Assuming a SVAR model of $A_0 X_t = A(L)X_{t-1} + B\varepsilon_t$, the reduced form is as follows:

$$X_t = A_0^{-1}A(L)X_{t-i} + A_0^{-1}B\varepsilon_t = C(L)X_{t-i} + u \ , \tag{2}$$

where X_t is the n × 1 vector of the endogenous variables, $A(L)$ is a polynomial variance-covariance matrix, A_0 is a non-singular matrix normalised to have ones on the diagonal, and summarizes the contemporaneous relations between the variables in the model contained in vector X_t, $C(L)$ is a matrix

representing the relation between lagged endogenous variables, L is the lag operator, ε_t is a n × 1 vector of structural shocks, u_t is a n × 1 vector of the reduced-form innovations.

As the reduced-form VAR disturbances are related to the structural disturbances as $A_0 u_t = B\varepsilon_t$, this SVAR presents them in the following way (in terms of the contemporaneous innovations):

$$ygap = a_1 e + u_1, \tag{3}$$

$$e = b_1 idev + u_2, \tag{4}$$

$$\pi = c_1 ygap + c_2 e + u_3, \tag{5}$$

$$idev = d_1 ygap + d_2 \pi + u_4, \tag{6}$$

where *ygap* is the output gap (%), *e* is the de-trended NEER (%), π is the inflation rate (%), *idev* is the deviation of actual central bank policy rate from the Taylor rule implied rate (%). The output gap is obtained as the percentage difference between the actual and trend values of GDP. Both the GDP and NEER trends are obtained with the Hodrick-Prescott filter.

All the variables in Eq. (3)–(6) represent the first stage SVAR residuals. It is assumed that the output gap depends in the current period on the exchange rate only (Eq. (3)). De-trended NEER is influenced by the deviation of the central bank policy rate from its Taylor rule implied level (Eq. (4)). Consumer price dynamics is affected by the output gap and NEER (Eq. (5)). Finally, the Taylor rule deviations are influenced by the output gap and inflation in the current period (Eq. (6)). Although there are proposals to include the exchange rate into the monetary policy rule (Kurihara, 2017), the author assumed that it is not the case in the current period.

Among the exogenous variables, the country-specific SVARs include the world crude oil prices (index, 2010 = 100), the US long-term interest rate (%), while the Index of Economic Freedom from the Washington-based Heritage Foundation (www.heritage.org) was used to control for institutional features of the CEE countries.

The statistical properties of the country-specific SVAR models are presented in Table 1. The author used in his estimation two (Hungary, Poland, Romania) to four (Czechia) lags of each endogenous variables, as implied by most of the lag length criteria. As indicated by the coefficient of determination R^2, the explanatory power of the estimated SVARs was above 80% across all countries in the equations for the Taylor rule deviations and inflation. The value of R^2 was as high as 93% for Czechia and 80 % for Poland in the equation for output gap, with a somewhat lower value of R^2 for Hungary and Romania. The explanatory power of the equation for NEER ranged between 51% (Hungary) and 67% to 69% (Czechia, Poland, Romania).

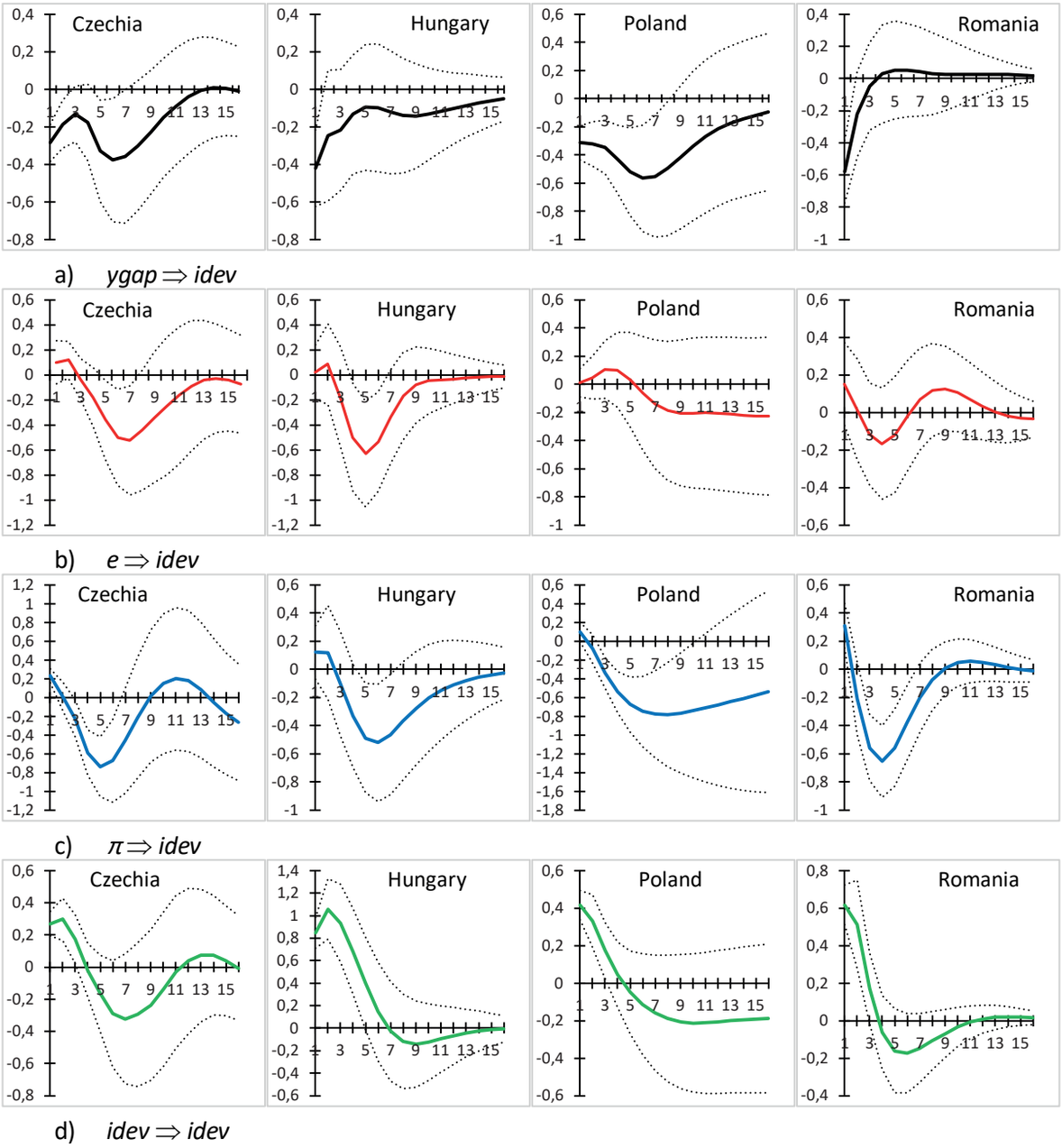
Table 1. Statistical properties of the country-specific SVAR models

Countries	Lags	Log Likelihood	Akaike's Information Criterium (AIC)	Adj. R^2			
				ygap	*e*	π	*idev*
Czechia	4	−252.50	8.86	0.93	0.67	0.81	0.95
Hungary	2	−445.36	12.65	0.72	0.51	0.87	0.88
Poland	2	−336.67	10.12	0.80	0.68	0.86	0.96
Romania	2	−387.64	12.93	0.73	0.69	0.90	0.89

Source: author's calculations.

4. Empirical results

The impulse response functions for determinants of the Taylor rule deviations and their macroeconomic effects are presented in Figures 2 and 3, respectively. The forecast error variance decomposition (FEVD) is shown in Table 2.



* Impulse response functions are shown within the band of ±2 standard deviations.

Fig. 2. Determinants of the Taylor rule deviations (*idev*)

Source: author's calculations.

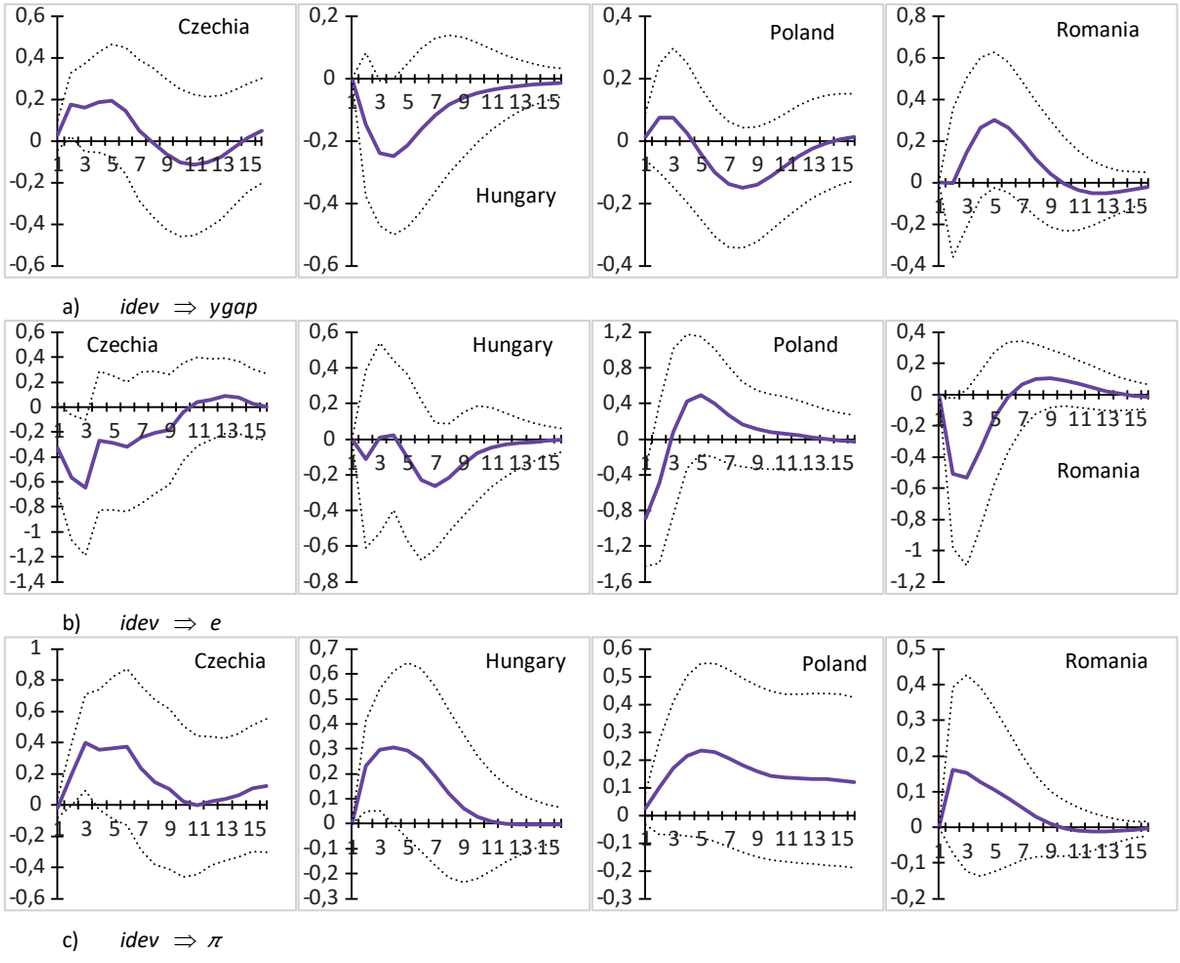


Fig. 3. Macroeconomic effects of deviations from the Taylor rule

Source: author's calculations.

In Hungary and Romania, the increase in the output gap is associated with a short-lived (over a quarter) decrease in the deviation of the central bank policy rate from its Taylor rule implied level. The same downward effect on the Taylor rule deviation is more prolonged in Czechia and Poland. The reaction to the inflation rate is similar for both countries, except for the effect on impact (however, it is rather weak). As for Hungary, there is a decrease in the Taylor deviation with 4 to 7 lags. The same pattern of monetary response is observed in Romania, with a somewhat stronger positive effect on impact. In general, the results are in accordance with the earlier study by Frömmel et al. (2011), namely that monetary policy for the CEE countries can be explained by a Taylor rule. As the monetary reaction to output gap is quite significant, especially in Czechia and Poland, there are no grounds for suggestions, for example by Khan, Phaneuf and Victor (2020), that the central bank should react to output growth, not to output gap.

Changes in the Taylor rule deviation were not so uniform across countries in response to the exchange rate shock – there was no response in Poland and Romania. The two other CEE countries are similar in that exchange rate depreciation was followed by a decrease in the Taylor rule deviation with 3 to 7 lags. It is also worth noting that the positive effect on impact is close to statistical significance in Czechia.

Deviations from the Taylor rule are not without endogenous changes in the output gap which are quite heterogeneous (Figure 3a). Expansionary effects were observed in Czechia and Romania, while in Hungary this was just the opposite. For Poland, there is a weak evidence of the same negative effect

with 7 to 9 lags. Inflationary spillovers of the Taylor rule deviations were observed in Czechia and Hungary (Figure 3c). For Poland and Romania, impulse responses also indicate an inflationary effect, but at a lower level of statistical significance. Overall, the author's estimates support the price puzzle when an increase in the central bank rate leads to an acceleration of inflation (Eichenbaum, 1992). It was not ruled out that deviations from the Taylor rule can be destabilising. In the presence of the price puzzle and contractionary output effects, the central bank policy rate above its Taylor rule implied level seems to be counterproductive in Hungary and Poland (to a lesser extent), with Romania being the opposite example. In Czechia, deviations from the Taylor rule were expansionary and inflationary.

As expected, an increase in the central bank interest rate above its Taylor rule implied level leads to an exchange rate appreciation in Czechia, Poland, and Romania, with neutrality in Hungary (Figure 3c). Thus the results provide support for international evidence that the Taylor rule deviations could be responsible for the exchange rate changes (Wilde, 2012). It is quite natural to assume that the exchange rate channel constitutes an additional mechanism of the monetary policy transmission.

Considering the proposals of including the exchange rate into the monetary response function, it is of interest that there is a significant contractionary effect of exchange rate depreciation on the output gap in Romania (Figure 4a), and a similar (albeit weaker) effect was observed in Poland. As for Hungary, there is evidence of the same contractionary effect on impact. As a result of the central bank rate above its Taylor rule implied level, a stronger currency was helpful for disinflation (Figure 4b). Czechia was the only country with a statistically significant expansionary effect of exchange rate depreciation, with 4 to 6 lags. It is interesting that Czechia showed the strongest exchange rate pass-through to consumer inflation; in Hungary and Romania, such an effect was short-lived. These results are in line with the study by Shevchuk (2022), providing further evidence that the exchange rate depreciation is both contractionary and inflationary.

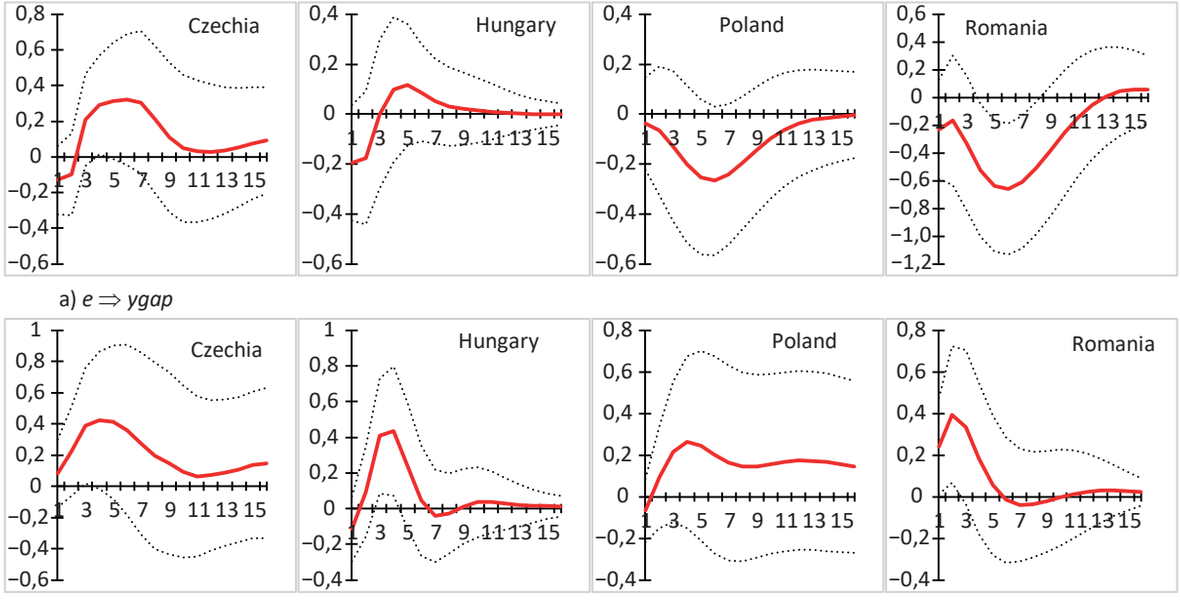


Fig. 4. Macroeconomic effects of the exchange rate shocks

Source: author's calculations.

Among other results, the output gap was inflationary (except Romania), while the reverse causality was different across the CEE countries (the findings are available on request); inflationary shock had a contractionary impact in Hungary. In Romania, a short-term expansionary effect on output was

followed by the opposite contractionary effect. No effect of inflation on the output gap was found in Czechia and Poland. There is no evidence of the exchange rate being affected by output shocks in all countries, while inflation shock was associated with appreciation in Czechia and Hungary.

The forecast error variance decomposition (FEVD) demonstrates that the contribution of inflation shocks to the Taylor rule deviations was very strong in Czechia, Poland, and Romania, with the fraction of *idev* explained by changes in π at above 50% (Table 2). For Hungary, inflation determined up to 21% of the changes in the Taylor rule deviations. The importance of the output gap was much weaker, especially in Hungary, with a different pattern over time (the shock is more influential at lower horizons). Causality $e \Rightarrow idev$ was rather strong in Czechia and Hungary (up to 26-29% of variance decomposition), with marginal importance in Poland and Romania. As output gap and inflation taken together were responsible for above 60% of the FEVD for the Taylor rule deviations in Czechia and Romania and almost 90% in Poland, it suggests that deviations from the Taylor rule were mainly of a domestic origin, in contrast to such countries as Australia where international factors prevail (Hudson and Vespignani, 2015). Obviously, Hungary fits the Australian pattern.

Table 2. Forecast error variance decomposition of selected endogenous variables

Countries	$idev \Rightarrow ygap$					$idev \Rightarrow e$				
	Forecast horizons					Forecast horizons				
	2	4	8	12	16	2	4	8	12	16
Czechia	5	8	7	8	8	9	15	18	18	18
Hungary	0	8	13	12	12	0	0	3	3	3
Poland	1	1	3	5	5	7	6	8	8	8
Romania	0	2	4	4	4	3	6	6	6	6
	$idev \Rightarrow \pi$					$ygap \Rightarrow idev$				
Czechia	3	10	16	16	15	33	19	17	17	17
Hungary	5	8	11	10	10	10	5	3	4	4
Poland	1	3	5	6	6	40	40	35	27	23
Romania	1	2	3	3	3	33	19	15	15	15
	$e \Rightarrow idev$					$\pi \Rightarrow idev$				
Czechia	7	7	24	26	26	15	52	46	43	44
Hungary	1	9	29	29	29	2	7	21	21	21
Poland	0	2	2	3	5	3	33	56	62	65
Romania	2	3	4	5	5	12	44	52	52	52

Source: author's calculations.

Except for Hungary, the Taylor rule deviations explain no more than 10% of variance decomposition in the output gap. With respect to other endogenous variables, Czechia had the highest fraction of exchange rate and inflation shocks explained by the Taylor rule deviations (shocks to *idev* account for 15-18% of fluctuations in the former and 10-16% of fluctuations in the latter). Poland and Romania are countries demonstrated the marginal importance of the Taylor rule deviations in changes not only in the output gap, but also in the exchange rate and inflation.

5. Conclusion

Empirical estimates for several CEE countries provide evidence that deviations of the actual central bank rate from its Taylor rule implied level are caused by both output gap and inflation across all countries, with the exchange rate playing a role in Czechia and Hungary. In the presence of the price puzzle and contractionary output effects, the central bank policy rate above its Taylor rule implied level seems to be not productive in Hungary and Poland (to a lesser extent), with Romania being the opposite example. In Czechia, deviations from the Taylor rule are expansionary and inflationary. According to

the variance decomposition, the contribution of output gap and inflation shocks to the Taylor rule deviations was strong in all CEE countries with the exception of Hungary. As the central bank policy rate below its Taylor rule level did not bring about any inflationary effects and seems to be expansionary in some countries (Hungary, Poland), this explains the lack of caution in the assessment of macroeconomic effects of a loose monetary policy. Among other results, the depreciation of the exchange rate was contractionary and inflationary, whereas the output gap was inflationary (except for Romania), while inflationary shock was contractionary in Hungary and Romania at different horizons (no effect was found for Czechia and Poland). For all CEE countries, the exchange rate was not affected by output shocks, while inflation shocks were not neutral in Czechia and Hungary.

For future research, it is of particular interest to extend the empirical analysis to the long-term effects of monetary policy, as suggested by Sam et al. (2023). Additionally, several alternative versions of the Taylor rule are worth more attention, along the lines of recent studies by Grui et al. (2022), Nikolsko-Rzhevskyy et al. (2017) and Teryoshin (2023). Finally, incorporating a time-varying equilibrium real interest rate would be worth of interest, especially in the context of academic discussion regarding the issue of secular stagnation.

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Efekty makroekonomiczne odchyleń od reguły Taylora w gospodarkach Europy Środkowej i Wschodniej

Streszczenie: Wykorzystując dane kwartalne z lat 2002-2021, standardową regułę Taylora oszacowano dla czterech krajów Europy Środkowej i Wschodniej (Czech, Węgier, Polski i Rumunii). Posługując się modelem SVAR, otrzymano, że we wszystkich krajach EŚW zaniżony poziom stopy procentowej banku centralnego względem stopy na podstawie reguły Taylora jest spowodowany przez lukę dochodu oraz inflację. Jednocześnie odchylenia od reguły Taylora mają zróżnicowany wpływ na inne zmienne endogeniczne. Ponadto stwierdzono, że deprecjacja kursu walutowego przeważnie powoduje cykliczny spadek dochodu oraz przyspieszenie inflacji, cykliczny boom jest inflacyjny (z wyjątkiem Rumunii), a także wskazano, jak efekty inflacyjne względem dochodu różnią się w przekroju poszczególnych krajów EŚW.

Słowa kluczowe: reguła Taylora, dochód, inflacja, kurs walutowy, SVAR.