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Price and output effects of long-term exchange rate changes: Central and Eastern European countries in 2002-2019

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ABSTRACT

Objective: The objective of the article is to measure the magnitude of the long-term exchange rate price and output effects in the Central and Eastern European countries (plus Turkey and Russia) which practice flexible exchange rate policies, while controlling for the institutional quality and policy stance as measured by the Index of Economic Freedom (IEF) from the Heritage Foundation database.

Research Design & Methods: To analyse long-term price and output effects, the anticipated value of a nominal effective exchange rate was used as obtained by the ARIMA (n,m) model. We analysed the relationships between selected macroeconomic variables with the panel DOLS model using quarterly data from 2002 to 2019. Individual country estimates were provided as well. The study considered alternative specifications for regression models, with control for the money supply and institutional developments.

Findings: Our study revealed that anticipated depreciation of the exchange rate was associated with the incomplete exchange rate pass-through (ERPT) into consumer prices and a decrease in output, with the former becoming stronger over the low-inflationary 2010-2019 period. Among other results, there was a trade-off between price and output effects of the money supply. As expected, investments in physical capital were the factor behind higher output. Finally, liberalisation efforts as proxied with the IEF were inflationary and contractionary.

Implications & Recommendations: It was demonstrated that policies aimed at gradual strengthening of local currencies could be helpful for both acceleration of output growth and containment of inflation in the long run. At the same time, it is not recommended to proceed with further liberalisation of regulatory environment, as it seems not to bring about any favourable output effects while contributing to higher consumer prices.

Contribution & Value Added: The novelty of this study is the estimation of the long-term price and output effects of the anticipated exchange rate while controlling for institutional quality and the progress of market reforms as measured by the IEF. The findings may serve as suggestions for reliable exchange rate policy, with a focus on predictability and the long-term macroeconomic effects.

Article type: research article

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INTRODUCTION

Exchange rate macroeconomic effects are important for the assessment of monetary regime effectiveness in the Central and Eastern European (CEE) countries with a floating of domestic currency. If the exchange rate depreciation is associated with a high extent of the exchange rate pass-through (ERPT) into consumer prices combined with output contraction in the long run, it cannot but weaken a rationale for exchange rate flexibility as a shock-absorbing tool in the short run either.

Similar to other developing and emerging economies, see survey by Aron, Macdonald, and Muellbauer (2014), the recent empirical studies for the CEE countries are in favour of the incomplete ERPT

(Beckmann & Fidrmuc, 2013; Jimborean, 2013; Hájek & Horváth, 2015). However, there is evidence that the EPRT can be complete in the long run, while being incomplete in the short run (Kurtović *et al.*, 2018). Exchange rate output effects are less clear. Earlier studies for the CEE countries are mostly in favour of contractionary exchange rate depreciations (Bahmani-Oskooee & Miteza, 2006; Bahmani-Oskooee & Kutan, 2008; Miteza, 2006), but recent studies incline towards a more favourable treatment of a weaker currency (Cuestas, Monfort, & Ordóñez, 2019; Cizmović, Shachmurove, & Vulanovic, 2021). In turn, it strengthens an argument in favour of a floating exchange rate regime (Dabrowski & Wroblewska, 2020; Ihnatov & Capraru, 2012). However, a stronger exchange rate anchor is suggested for inflation-targeting emerging economies as a better resistance tool for the inflationary shocks like in the 2007-2008 pre-crisis period (Pourroy, 2012).

While linking of the ERPT to institutional features such as openness or monetary regime is present in many studies – for example Frankel, Parsley, and Wei (2005) or Ghosh (2013) – much less attention is given to similar effects of institutional environment on the relationship between exchange rate and output. For the CEE countries, it is plausible to assume that a decrease in the ERPT may be due to improvements in the institutional quality following the EU accession, with a shift towards a conventional positive relationship between exchange rate depreciation and output as well.

This article aims to study the long run ERPT and output effects of anticipated changes in the nominal exchange rate for a panel of four CEE countries (plus Turkey and Russia) which follow free or managed floating exchange rate policies in the inflation targeting framework. As in the post-crisis environment of 2010-2019 expansionary monetary policy and currency depreciations were widely used for stabilization purposes without any immediate inflationary repercussions, it might be considered as a sign of new realm in the monetary sphere. However, such policies could have unpleasant price and output effects in the long run, with the danger of stagflation to be materialized. The main motivation behind this research was to check whether abovementioned concerns were justified to any extent.

Several research questions were expected to be answered:

RQ1: What is the long-term ERPT in the case of anticipated currency depreciation?

RQ2: What are the output effects of the anticipated currency depreciation?

RQ3: Are there any changes to the impact of the anticipated currency depreciation on consumer prices and output when controlled for institutional quality?

RQ4: Are there any changes to the anticipated exchange rate effects in the post-crisis environment of 2010-2019?

Our main contribution to the literature is empirical verification of the fact that the anticipated exchange rate depreciation is both inflationary and contractionary in the long run for the CEE countries (plus Turkey and Russia), with the ERPT becoming stronger in the 2010-2019 period. Such results are of interest especially in the context of recent surge in inflation. In contrast to other studies, anticipated changes in the nominal exchange rate are considered, with a control for institutional quality. In our view, it is highly relevant for the inflation targeting framework practiced by all countries in the study. Also, a higher level of economic freedom is likely to be inflationary, while contributing to a decrease in output. Results of panel regressions were supported by the country-by-country estimates.

The rest of the article is organized as follows. A brief literature review will be presented in the next section. It will be followed by the description of research methodology, including analytical issues, data analysis, and statistical model. Then, we will move to a discussion of empirical results. The article will end with concluding remarks.

LITERATURE REVIEW

Exchange Rate pass-through to Domestic Prices

Most studies show the decline of ERPT over the last decades across both developed and emerging economies (Lopez-Villavicencio & Mignon, 2016; Aguirre & Conzales Padilla, 2019; Ortega & Osbat, 2020). Standard explanations of a lower ERPT include nominal rigidities, price discrimination (Corsetti, Dedola & Leduc, 2008), incomplete information (Garetto, 2016), trade liberalisation, lower transportation costs,

and less labour-intense services in wholesale and retail trade (Frankel, Parsley & Wei, 2005), pricing-to-market behaviour (Betts & Devereux, 2000), or improved monetary policy performance (Carriere-Swallow *et al.*, 2016; García-Schmidt & Garcia-Cicco, 2020). As surveyed by Aron, Macdonald and Muellbauer (2014), explanations of delayed and incomplete ERPT in developing and emerging markets is determined by many additional factors, such as quality adjustments, structural changes in trading basket and geographical composition of trading partners, trade integration, as well as shifts in the weights of CPI components. Ha, Stocker and Yilmazkuday (2020) argue that the ERPT used to be lower in countries that practice flexible exchange rate policies in the presence of credible inflation targets that helps to neutralize external shocks. Empirical studies for emerging and middle-income economies lay stress on more stable and anti-inflationary environment (Lopez-Villavicencio & Mignon, 2016), or money growth and terms-of-trade (Aguirre & Conzales Padilla, 2019) than factors behind the lower ERPT.

Many recent empirical studies for the CEE countries, including Beckmann and Fidrmuc (2013), Jimborean (2013), Hájek and Horváth (2015), Hajnal, Molnár, and Várhegyi (2015), Baxa and Šestořád (2019) are in favour of the incomplete ERPT, though in the past high ERPT had been found for Hungary and Poland (Ca′Zorzi, Hahn, & Sánchez, 2007). For 9 CEE countries, Beirne and Bijsterbosch (2011) obtained the ERPT to consumer prices at 0.5 or 0.6 on average using impulse responses or the cointegrated VAR, respectively. It should be noted that earlier studies produced very different ERPT estimates for a single transition economy (Coricelli, Égert, & MacDonald, 2006). The ERPT tends to be high for the CIS countries (Comunale & Simola, 2016).

Empirical studies of the ERPT incorporate both single equation models and systems methods, as vector autoregression (VAR) or dynamic stochastic general equilibrium (DSGE) models (Aron, Macdonald, & Muellbauer, 2014). Although most of recent studies use VAR models, for example, Beirne and Bijsterbosch (2009), Baxa and Šestořád (2019), which are advantageous from the point of feedback effects from endogenous exchange rates, single equation models nevertheless remain popular as being more suited to the cases of co-integration and structural changes (Aguirre & Padilla, 2019). As exchange rate changes may reflect not only stochastic shocks, important variables reflecting systemic changes in policy are usually omitted in the typical VAR (Aron, Macdonald, & Muellbauer, 2014). Studies for the CEE countries that use single equation models include Jimborean (2013) or Comunale and Simola (2016). Similar to other EU countries, nonlinearities in the ERPT may require the use of a multivariate smooth transition approach (Cheikh, Ben Zayed, & Nguen, 2018).

Exchange Rate and Output

The traditional view of a currency depreciation as an expansionary policy tool is based mainly upon a stimulating effect on the net exports. However, demand impulse may be weakened by low price elasticities of exports and imports, decrease in real wages, capital outflows (Lizondo & Montiel, 1988), the redistribution of income in favour of capital owners (Krugman & Taylor, 1978), or the balance sheet effect (Blanchard, Faruqee, & Das, 2010). The contractionary effect is more likely if the supply-side effects are taken into account, in the case of anticipated depreciations (Agenor, 1991). While the expansionary effect of depreciation on output is supported for industrial countries, for example Hutchison and Noy (2002), empirical results are not so uniform for developing countries and former transition economies (Bahmani-Oskooee & Miteza, 2006; Bahmani-Oskooee & Kutan, 2008). Contractionary effects of nominal (real) depreciation are found for Bulgaria (Miteza, 2006), the Czech Republic (Hsing, 2016a), Slovakia (Hsing, 2016b), and Turkey (Karahan, 2020). However, the expansionary effect of depreciation on output is observed for Poland (Bahmani-Oskooee & Kutan, 2008; Haug, Jędrzejowicz, & Sznajderska, 2013). Recently, an expansionary effects of currency depreciation on industrial production has been obtained for 25 Eastern European countries (Cizmović, Shachmurove, & Vulanovic, 2021). As control variables, the trade openness and several indexes of institutional quality had been used. The importance of links between trade openness and exchange rate regime has been stressed recently by Stoykova (2021). Regarding the exchange rate effects on output, the control for institutional variables is provided by Chavez (2020). Similar to the discussion on the ERPT, it is natural to assume that institutional quality and related policies also play a role in the exchange rate effects on output, especially in the long run.

Similar to the ERPT empirical studies, most recent studies on the exchange rate effects on output make use of the VAR models. However, there are examples of the use of single equation models as well (Bahmani-Oskooee & Kutan, 2008; Ihnatov & Capraru, 2012; Hsing, 2016a; Hsing, 2016b). Recently, directional asymmetries have attracted attention. For example, it has been obtained for Australia with the nonlinear ARDL approach that only currency appreciation has the long-term output effects (Bahmani-Oskooee & Mohammadian, 2016). However, the output effects of depreciation and appreciation are quite heterogeneous for emerging economies (Bahmani-Oskooee & Mohammadian, 2017), including the CEE countries (Bahmani-Oskooee & Mohammadian, 2018).

While the recent empirical findings are in favour of incomplete and declining ERPT, the estimates of exchange rate effects on output lack such uniformity suggesting potential problems in the use of exchange rate as a policy tool. As the policy regime of inflation targeting suggests a stronger role for the exchange rate (Comunale & Simola, 2016), it is of interest to study both price and output effects of anticipated exchange rate developments within the theoretical framework that allows for a combination of positive ERPT with the possibility of both expansionary and contractionary output effects dependent on structural features of the economy. The level of economic freedom deserves attention as closely related to the monetary regime in general and exchange rate policy in particular.

These prior empirical results allowed to assume the following research hypotheses:

H1: There is a positive relation between anticipated exchange rate depreciation and consumer prices, although it is not complete and declining over time.

H2: There is a possibility of the inverse relation between currency depreciation and output that reflects import-dependent and/or financially-constrained pattern of the real sector.

RESEARCH METHODOLOGY

Analytical Framework

Besides more comprehensive macroeconomic models, for example García-Schmidt and García-Cicco (2020), the analysis of the ERPT often applies rather simple models based on aggregate demand and money demand equations, interest parity equation, import price setting process etc. On the other hand, the exchange rate effects on output are important as there can be a trade-off between the correction of external balances in the case of incomplete ERPT and contractionary output developments. For this purpose, a rather simple AD-AS model with rational expectations seems to be a proper analytical framework, sufficient to outline the basic relationships for the economies with undeveloped financial markets. Obviously, the economies of the well-developed financial markets require more sophisticated modelling approaches for the exchange rate analysis.

For economies with the financial constraint in the real sector and the wealth effect in the aggregate demand, a simple AS-AD model is presented below:

$$y_t = s_1(m_t - E_{t-1}p_t) - s_2E_{t-1}(e_t + p_t^* - p_t) + u_t, \quad (1)$$

$$y_t = a_1(m_t - E_t\pi_{t+1}) + a_2E_t(e_{t+1} + p_{t+1}^* - p_{t+1}) + a_3(E_t\pi_{t+1} - \pi_t) - a_4r_t + a_5y_t^* + v_t, \quad (2)$$

$$\pi_t = \gamma p_t + (1-\gamma)(e_t + p_t^*), \quad (3)$$

$$r_t = r_t^* + E_te_{t+1} - e_t - (E_t\pi_{t+1} - \pi_t) + (E_tp_t^* - p_t^*) + \varphi_t, \quad (4)$$

$$e_t = \rho e_{t-1} + \varepsilon_t, \quad (5)$$

in which:

y_t - real output;
m_t - money supply;
p_t and p_t^* - domestic and foreign prices, respectively;
r_t and r_t^* - domestic and foreign real interest rates, respectively;
e_t - nominal exchange rate (the domestic currency price of foreign currency);
ε_t - stochastic shock to the exchange rate that is independent and identically distributed with mean zero and constant variance;
π_t - consumer price index (CPI);

φ_t - measure of risk premium;
u_t and v_t - stochastic supply and demand shocks, respectively.

All variables, except for r_t and r_t^*, are expressed in logarithms. Operators E_t and E_{t-1} denote expectations made in the periods t and t–1, respectively.

Model (1)-(5) was standard in all respects. Equation (1) described the aggregate supply function based on a composition of tradable and non-tradable goods, with micro-foundations provided by Rojas-Suarez (1992). Output was stimulated by the amount of the real credit (*the financial effect*), and it was depressed by the relative price (*the price effect*). The decisions made by producers were based on the last period's expectations of relative prices. The positive financial effect (s_1) reflected the financial constraint in production, while the price effect (s_2) measured the strength of dependence on the import of capital goods and intermediates. Equation (2) related aggregate demand for the domestic good to the real money supply (*the wealth effect*), expectations of the relative price (*the price effect*), expectations of inflation and the real interest rate. Higher foreign prices contribute to aggregate demand due to the price effect (a_2), as do the real value of money supply due to the wealth effect (a_1), expectations of higher inflation (a_3) and a decline in the real interest rate (a_4). In the familiar structuralist tradition, an adverse effect of currency depreciation on producers or consumers may be compensated by an increase in the money supply. The productivity and demand shocks, u_t and v_t, respectively, are assumed to be expansionary.

Equation (3) defined the CPI as a weighted average of the prices of domestic and foreign goods (in domestic prices). In the equation (4), the interest rate was specified in real terms as the foreign interest rate plus the expected depreciation of the domestic currency, subtracting the expected rate of domestic inflation. It was assumed that domestic prices do not affect foreign prices. In the presence of risk premium, a positive relationship between ex-post exchange rate change and the interest rate differential as it was predicted by the UIP used to be restored (Kumar, 2019). Finally, in the equation (5) the exchange rate was subject to either permanent or transitory shocks (for the former, ρ=1).

After necessary substitutions for i_t and r_t, the model (1)-(5) was solved for the equilibrium values of y_t and p_t by the undetermined coefficients technique. It was assumed that the exchange rate was exogenous in respect to both output and prices, along with foreign output and foreign prices, and the world interest rate. As our focus was on the price and output responses to changes in the exchange rate while controlling for the money supply, the reduced-form solutions to the system (1)–(5) for the values of output and domestic price contain only monetary variables and stochastic shocks as follows:

$$\begin{aligned} y_t = \bar{y} + \left(\frac{1}{\Delta_0}\right)[(a_2 - (1-\gamma)a_1)s_1 + a_1 s_2]m_t - \\ - \left(\tfrac{1}{\Delta_1}\right)[\rho a_2 s_1 + \rho a_1 s_2 + (1-\rho)(\gamma a_3 + \gamma a_4)s_2 - (1-\gamma)\rho a_1 s_1]e_{t-1} + u_t, \end{aligned} \tag{6}$$

$$\begin{aligned} p_t = \bar{p} + \left(\frac{1}{\Delta_1}\right)(a_1 - s_1)m_t + \left(\frac{1}{\Delta_1}\right)[s_2 + \rho a_2 - (1-\gamma)\rho a_1]e_{t-1} + \left(\frac{1}{\gamma a_3 + \gamma a_4}\right)(v_t - u_t) + \\ + \left(\frac{1}{\gamma a_3 + \gamma a_4}\right)\left[\rho a_2 + (1-\rho)(\gamma a_4 - (1-\gamma)a_3) - (1-\gamma)\rho a_1 - (a_2 + \gamma(a_1 \right. \\ \left. - a_3))\frac{s_2 + \rho a_2 - (1-\gamma)\rho a_1}{\Delta_1}\right]\varepsilon_t, \end{aligned} \tag{7}$$

in which:

$\Delta_0 = \gamma a_1 + a_2 + s_2 - s_1$;
$\Delta_1 = \gamma a_1 + \rho a_2 + (1-\rho)(\gamma a_3 + \gamma a_4) + s_2 - s_1$;
$\bar{y}$ and $\bar{p}$ - the equilibrium values of output and domestic price level, respectively.

A temporary depreciation of the exchange rate, ε_t, was neutral in respect to output, but had a price effect. Assuming a permanent depreciation of the exchange rate ($\rho = 1$), the magnitude of domestic price effects of e_{t-1} was affected by the relative strength of both price effects (a_2 and s_2) and the wealth effect (a_1) in comparison to the financial effect (s_1), as well as on the composition of CPI (for higher values of γ, the reaction of prices became stronger). A permanent depreciation of the

exchange rate was likely to bring about a decline in output if the price effect in the aggregate demand was not sufficient to offset contractionary supply effects. If $a_1 < s_1$, a stronger ERPT is associated with a more pronounced contractionary effect on output. If strong enough in comparison to the wealth effect (a_1), the financial effect (s_1) may bring about a decline in domestic prices combined with an expansionary output effect.

Stochastic demand shocks are neutral in respect to output while contributing to higher prices. As expected, the supply shock was pro-growth and anti-inflationary. That kind of asymmetry is kept if the supply shock is modelled as the autoregressive process, *i.e.* $u_t = \theta u_{t-1} + \omega_t$, where ω_t is the stochastic component. Such an assumption is more realistic if associate supply shocks with investments.

Data

Quarterly time series from 2002:Q1 to 2019:Q4 for the Czech Republic, Hungary, Poland, and Romania were used, with relevant data for Turkey and Russia for comparison, as countries which follow the same floating exchange rate policies but significantly differ in respect to the institutional quality. Quarterly series of the CPI (index, 2010 = 100), cpi_t, the real GDP (index, 2010 = 100), y_t, the nominal effective exchange rate (index, 2010 = 100), e_t, as well as the money aggregate M3 (in local currency), m_t, openness for trade in goods and services (% of GDP), $open_t$, and the investments (% of GDP), inv_t, were retrieved from the IMF's *International Financial Statistics* database (www.imf.org). As mentioned above, institutional quality was measured by the IEF, $herit_t$, from the Heritage Foundation (www.heritage.org). The IEF suited well the purpose of our study, as it comprises most important components that used to be discussed in relation to the exchange rate effects, *i.e.* monetary freedom, which measures the stability of prices, business freedom, which signals the scope of administrative regulations, trade freedom, investment freedom and financial freedom, which characterise the openness of the economy to trade and capital flows, as well as independence of financial institutions.

Applying the ARIMA(1,1) structure for Romania and ARIMA(1,2) for other countries, the anticipated component of the exchange rate, ea_t, was derived on the basis of in-sample one period ahead forecast as obtained with the ARIMA(n,m) model.

Table 1. Descriptive statistics

Statistics	cpi_{it}	y_{it}	ea_{it}	m_{it}	inv_{it}	$open_{it}$	$herit_{it}$
Mean	4.585	4.627	4.688	4.630	3.147	4.400	4.132
Std. Dev.	0.296	0.184	0.240	0.693	0.177	0.407	0.103
Max	5.503	5.114	5.984	5.984	3.669	5.164	4.327
Min	3.724	4.177	4.239	2.537	2.787	3.771	3.877

Source: own elaboration in EViews.

Results of tests for the presence of cross-dependency in the panel set are presented in Table 2. All four tests indicated the strong presence of cross-sectional dependency. Only in the case of investments, the Pesaran CD test suggested cross sectional independence.

The results of the panel unit root tests are presented in Table 3. Both unit root tests, Cross-sectional Augmented Dickey-Fuller (CADF), and the Cross-sectional Im-Pesaran-Shin (CIPS), clearly indicated that all panels except $open_{it}$ were non-stationary in levels and stationary in first differences. Each of the tests was carried out to include an intercept (ea_{it}, $open_{it}$, $herit_{it}$) or intercept and trend (cpi_{it}, y_{it}, m_{it}, inv_{it}).

For the test of cointegration, seven Pedroni's tests were applied for several sets of variables which were hypothesised as potential determinants of the consumer prices and output (Table 4). For the former, a data set that consisted of cpi_{it}, ea_{it}, m_{it}, and $open_{it}$ revealed a weak evidence of cointegration. However, all tests suggested the presence of cointegration if $open_{it}$ is substituted for inv_{it} and $herit_{it}$. Somewhat different pattern of cointegration was found for output, with evidence of cointegration being stronger in the absence of $herit_{it}$. On the other hand, cointegration test results became much weaker if trade openness was accounted for. As the group rho-test and panel v-test may have a very low power in the case of small samples, it was possible to conclude that our models were in fact panel cointegrated. Noteworthy, no cointegration between output and price levels was detected.

Table 2. Pesaran's cross sectional independence test results

Tests	cpi_{it}	y_{it}	ea_{it}	m_{it}	inv_{it}	$open_{it}$	$herit_{it}$
Breusch-Pagan LM	1026.2***	929.36***	366.0***	1023.9***	179.89***	831.70***	841.99***
Pesaran scaled LM	184.62***	166.94***	64.08***	184.2***	30.11***	107.40***	108.77***
Bias-corrected scaled LM	184.58***	166.90***	64.04***	184.16***	30.06***	107.34***	108.71***
Pesaran CD	32.03***	30.44***	8.88***	31.99***	0.20	15.43***	25.77***

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

Table 3. Panel unit roots test results

Variables	CADF		CIPS	
	Level	Δ	Level	Δ
cpi_{it}	0.97	-3.94***	0.69	-4.20***
y_{it}	0.84	-10.84***	0.77	-14.86***
ea_{it}	-0.67	-12.14***	-0.61	-18.51****
m_{it}	-0.04	-10.61***	-0.09	-16.00***
inv_{it}	0.09	-11.18***	0.08	-17.94***
$open_{it}$	-1.96**	-13.62***	-2.08**	-24.01***
$herit_{it}$	-0.12	-11.62***	-0.18	-12.90***

Note: ***, ** and * mean rejection of null hypotheses at 1%, 5% and 10% level, is the operator of first differences.
Source: own elaboration in EViews.

Table 4. Pedroni panel cointegration test results

Statistics	Consumer Price Index		Output	
	cpi_{it}, ea_{it}, m_{it}, $open_{it}$	cpi_{it}, ea_{it}, m_{it}, inv_{it}, $herit_{it}$	y_{it}, ea_{it}, m_{it}, inv_{it}	y_{it}, ea_{it}, m_{it}, inv_{it}, $herit_{it}$
Panel v-Statistic	1.20	2.06**	-0.96	-0.35
Panel rho-Statistic	-1.59*	-1.68**	-2.78***	-0.99
Panel PP-Statistic	-2.11**	-2.54***	-3.24***	-1.60*
Panel ADF-Statistic	-1.86*	-2.42***	-2.01**	-1.09
Group rho-Statistic	-0.91	-0.72	-2.86***	-0.88
Group PP-Statistic	-1.78**	-1.92**	-3.90***	-2.01**
Group ADF-Statistic	-1.40*	-1.56*	-2.55***	-1.38*

Note: ***, ** and * mean rejection of null hypotheses of no cointegration at 1%, 5%, and 10% level.
Source: own elaboration in EViews.

As variables were integrated, the Dynamic Ordinary Least Squares (DOLS) estimator was applied. Its main advantage was that the use of lead and lagged differences of the regressor allowed for a robust correction of endogeneity in the exogenous variables (Afonso & Jalles, 2012). It was important for our study as the exchange rate may be influenced to some extent by both price and output, along the lines of the monetary model of exchange rate. Besides correcting for the small sample bias caused by an endogeneity problem, in the context of rational expectations and anticipated changes in the exchange rate, it was an important advantage of the DOLS estimator that lead differences of the regressor were taken into account. However, it should be admitted that our empirical approach did not allow for a comprehensive specification of the shocks in the financial sector nor for asymmetries in output effects that can be related to the strength of ERPT. For a differentiated data, it was easier to study price and output effects of the exchange rate with interaction effects for institutional variables.

Statistical Model

A general representation for the consumer prices and real output baseline models is provided below:

$$cpi_{it} = a_0 + a_1 ea_{it} + a_2 time10_t + a_3 ea_{it} \cdot time10_t + a_4 m_{it} + a_5 inv_{it} + a_6 open_{it} + \zeta_{it}, \quad (8)$$

$$y_{it} = b_0 + b_1 ea_{it} + b_2 time10_t + b_3 ea_{it} \cdot time10_t + b_4 m_{it} + b_5 inv_{it} + \xi_{it}, \quad (9)$$

in which:

$time10_t$ - the time dummy (0 for the 2002-2009 period, and 1 otherwise);

ζ_{it} and ξ_{it} - stochastic shocks to inflation and output, respectively.

Our regression model incorporated monetary and structural variables in levels and a slope dummy variable $ea_{it} \cdot time10_t$. Such a choice of an interaction term aimed at assessment of the exchange rate effects in the period after the world 2008-2009 financial crisis. A time dummy $time10_t$ controled for specific features of the 2010-2019 period.

A decision to use variables in levels was reinforced by the fact that the anticipated component of the exchange rate was supposed to be relatively stable over time. Alternative approaches with time series in a differentiated form that prevail in empirical studies with the VAR models may have led to a loss of information contained in levels of dependent and independent variables.

Based on the solutions in equations (6) and (7), it was expected that the anticipated exchange rate depreciation contributed to consumer prices ($a_1 > 0$), while its impact on output was rather ambiguous ($b_1 \neq 0$). In the estimates of exchange rate effects, it was important to control for the monetary policy which itself affects prices and output, at least in the short run (Ortega & Osbat, 2020). The money supply was likely to be inflationary ($a_2 > 0$) and expansionary ($b_2 > 0$). For example, a positive effect of money supply on output was found for the Czech Republic, Romania (Simionescu *et al.*, 2018), and Russia (Ono, 2013). In line with the predictions of AD-AS model, it was likely that the exchange rate depreciation and money supply were both inflationary but with uncertain effect on the output.

Investments were chosen as a straightforward proxy for the supply shock. It was supposed to stimulate output ($a_3 > 0$) and exert the downward pressure on prices ($b_3 < 0$), with the latter effect being dependent on the aggregate demand sensitivity to the interest rate. Openness could have served as another proxy for the expansionary supply shock, but it was decided to exclude this variable from the output regression as suggested by the cointegration test results. However, external conditions were controlled by using world oil prices as a deterministic regressor. The impact of trade openness on consumer prices seemed to be ambiguous ($a_4 \neq 0$). While trade liberalisation and relevant benefits of higher openness were considered as one of standard explanations for a decline of the ERPT in the developed countries (Frankel, Parsley & Wei, 2005), just the opposite outcome was found for the developing countries (Ghosh, 2013).

In the extended model, the IEF was included into both regressions. As suggested by the literature (Corsetti, Dedola, & Leduc, 2008; Carriere-Swallow *et al.*, 2016; García-Schmidt & Garcia-Cicco, 2020), proper account for institutional quality was highly important for the estimations of ERPT. To the same extent, it is possible to argue that accounting for economic freedom as an integral indicator of institutional quality may modify the exchange rate effects on output. For the CEE countries, a favourable relationship between economic freedom and economic growth is found by Uzelac, Davidovic, and Dukić Mijatović (2020). As established by Khalilov and Yi (2021) for the OECD countries, it is necessary to create a friendly regulation for entrepreneurs in order to accelerate economic growth. In addition, there was a control for investments in the regression for consumer prices that include $herit_{it}$. It was motivated mainly by the results of cointegration analysis.

Control for the IEF provided a robustness check for the exchange rate effects in the presence of institutional features of the economy. Comparisons between the estimates for the 2002-2019 sample and sub-samples provided information on the stability of coefficients over the time frame. In addition, country-by-country estimates allowed for assessment of the credibility of panel DOLS estimates. As argued by Bahmani-Oskooee & Mohammadian (2018), heterogeneous country-specific results may reduce the importance of estimates by panel models. Also, it is worth noting that our study was focused

on the exchange rate long-term effects solely. In order to assess the short-term effects of exchange rate changes, estimation of the error-correction models (ECMs) is required.

RESULTS AND DISCUSSION

Panel Data Analysis

The estimates of the cointegrating relationship for CPI and GDP for two regression models are presented in Tables 5 and 6, respectively. A grouped version of the DOLS was used, with the trend suppressed in the estimates for CPI. The use of a slope dummy variable provided an opportunity to conclude whether the exchange rate price and output effects changed over time.

Our results were in favour of the incomplete ERPT, which was consistent with other studies. Both the baseline model and the extended model brought about the value of the parameter on ea_{it} at 0.272 and 0.191, respectively. However, there was no evidence of the decline of the ERPT in the post-crisis period of 2010-2019. As suggested by the slope dummy variable, there was statistically significant strengthening of the anticipated exchange rate effect on consumer prices over the 2010-2019 period. Thus, the hypothesis H1 was confirmed only partially, with no support for a declining ERPT in the post-crisis environment. A stronger ERPT was observed against a decline in consumer prices in the 2010-2019 period, as the value of the parameter on $time10_t$ was negative both in the baseline model (-0.998) and in the extended model (-0.697).

Table 5. Long-term estimates of the CPI determinants, 2002-2019

Explanatory variables	Dependent variable cpi_{it}	
	Baseline model	Extended model
ea_{it}	0.272***	0.191***
$time10_t$	-0.998***	-0.697***
$ea_{it} \cdot time10_t$	0.259***	0.163***
m_{it}	0.274***	0.228***
$open_{it}$	0.009	–
inv_{it}	0.003	-0.038**
$herit_{it}$	–	0.522***

Note: ***, ** and * mean statistical significance at 1%, 5%, and 10% level
Source: own elaboration in EViews.

Table 6. Long-term estimates of the GDP determinants, 2002-2019

Explanatory variables	Dependent variable y_{it}	
	Baseline model	Extended model
ea_{it}	-0.171***	-0.184***
$time10_t$	0.128	-0.038
$ea_{it} \cdot time10_t$	-0.029	0.005
m_{it}	0.230***	0.225***
inv_{it}	0.194***	0.183***
$herit_{it}$	–	-0.223***

Note: ***, ** and * mean statistical significance at 1%, 5%, and 10% level
Source: own elaboration in EViews.

A stronger link between the exchange rate and consumer prices can be attributed to the strength of both price effects (s_2 and a_2) combined with a weaker wealth effect (a_1). Among other explanations, a lower exchange rate volatility was found to be the most likely factor behind the higher ERPT (Jimborean, 2013). Also, a more competitive domestic distribution sector may have an impact of its own, as it was found for the EU countries (Ortega & Osbat, 2020), or monetary policy stability, as it is the case for the developing countries (Ghosh, 2013).

As for the hypothesis H2, it was confirmed in an unambiguous way. Anticipated depreciation of the exchange rate was contractionary, with no signs of any changes to the inverse relation to output in the post-crisis period of 2010-2019. It is worth noting that the abovementioned combination of strong price effects with a weak wealth effect bought about an inverse relationship between the anticipated exchange rate depreciation and output. In the presence of a stronger price effect by the anticipated exchange rate, somewhat weakening of its asymmetric impact on output was expected in the case of smaller financial effect (s_1).

Regardless of the specification, it was found that the money supply brings about an increase in both consumer prices and output. Among other results, investments contributed to output, while becoming anti-inflationary if there is control for the economic freedom. The post-crisis period of 2010-2019 seems not to be different in respect to output. Contrary to the studies for the developing countries (Ghosh, 2013), the higher openness was not inflationary.

In the extended model, control for the economic freedom curbs the ERPT from 0.272 to 0.191, while the exchange rate effect on output did not change significantly. A higher level of economic freedom, as measured by the IEF, brought about an increase in consumer prices combined with a decrease in output. Our results imply that the adoption of liberal policies in the 2000s might have been excessive. While being motivated by the requirements of the EU accession, all kinds of liberal policies associated with economic freedom did not contribute, at least in a direct way, to deceleration of inflation and acceleration of economic growth.

Country-by-country Analysis

In order to detect potential differences in the estimates, the exchange rate effects on consumer prices and output were estimated for each country by using the same specification as in the panel data estimates. For all countries, the anticipated exchange rate, money supply, CPI and output were non-stationary in levels and stationary in first differences. Also, the Johansen test indicated cointegration of the variables along the lines of two models used in the panel data analysis of the exchange rate effects on the CPI and output.

Estimates of the ERPT for individual countries (Table 7) show that majority of coefficients were statistically significant and had the positive sign. The mean group estimator, computed as the average of the individual coefficients estimated for each country, was very close to the long-term ERPT estimated in Table 5, especially for the baseline model, *i.e.* 0.285 vs. 0.272. When compared to the study by Jimborean (2013), there was not much heterogeneity of the ERPT estimates at the individual country level. Similar to Hajnal, Molnár, and Várhegyi (2015), there was an increase of the ERPT for Hungary in the post-crisis period, but the coefficient on ea_{it} became insignificant in the extended model. Regardless of the regression model, individual country estimates were not different from the panel estimates in that the ERPT became stronger over the 2010-2019 period, which in turn was characterized by a downward pressure on consumer prices.

Table 7. Individual country estimates of the ERPT, 2002-2019

Countries	Dependent variables					
	Baseline model			Extended model		
	ea_{it}	$time10_t$	$ea_{it} \cdot time10_t$	ea_{it}	$time10_t$	$ea_{it} \cdot time10_t$
Czech Republic	0.345***	-0.797***	0.188***	0.195***	-0.655***	0.148***
Hungary	0.385***	-0.925**	0.203**	0.080	-1.677***	0.388***
Poland	0.095**	-0.759*	0.189**	0.480***	-1.280*	0.284*
Romania	0.539***	-1.145*	0.285*	0.585***	-1.449**	0.352**
Turkey	0.137**	-0.892***	0.173***	0.297***	-1.024***	0.203**
Russia	0.206***	-0.896***	0.205***	0.296***	-1.266***	0.306***
Mean group	0.285	-0.903	0.207	0.309	-1.161	0.267

Note: ***, ** and * mean statistical significance at 1%, 5%, and 10% level.
Source: own elaboration in EViews.

When comparing the mean group estimates of the exchange rate effects on GDP in Table 8 with the panel estimates in Table 6, it is clear that these ones were very close, *i.e.* -0.203 versus -0.171 (the baseline model) and -0.207 versus -0.184 (the extended model). The close values of long-run coefficients for the panel regression and the average of coefficients obtained in individual country regressions confirmed robustness of the estimated results. Except Russia, both a slope dummy variable and a time dummy variable were insignificant, which was consistent with the panel estimates. Control for the level of economic freedom, the inverse relationship between the anticipated exchange rate, and output seemed to become stronger only in Poland, with the opposite outcome in Hungary.

Table 8. Individual country estimates of the exchange rate effects on GDP, 2002-2019

Countries	Dependent variables					
	Baseline model			Extended model		
	ea_{it}	$time10_t$	$ea_{it} \cdot time10_t$	ea_{it}	$time10_t$	$ea_{it} \cdot time10_t$
Czech Republic	-0.136**	-0.131	0.031	-0.130***	-0.021	0.008
Hungary	-0.262***	0.705	-0.155	-0.147*	0.639	-0.135
Poland	-0.125***	-0.156	0.041	-0.195**	0.158	-0.001
Romania	-0.160***	1.330	-0.316	-0.213***	1.282	-0.303
Turkey	-0.383**	-0.862	0.175	-0.403*	-1.406	0.289
Russia	-0.154***	-1.259***	0.263***	-0.153***	-1.265***	0.265***
Mean group	-0.203	-0.062	0.007	-0.207	-0.102	0.020

Note: ***, ** and * mean statistical significance at 1%, 5% and 10% level.
Source: own elaboration in EViews.

The estimates of the negative exchange rate effects on output for Turkey were much stronger when compared with the CEE countries, albeit at a lower level of statistical significance. As for Russia, results were somewhat below the mean of the group. At the same time, the ERPT for both countries was lower in comparison with the estimates of such countries as Romania (both models), the Czech Republic, and Hungary (the baseline model), or Poland (the extended model). Both time and interaction terms were not much different from the mean of the group. On the whole, differences between the CEE countries and their two low-income neighbours with regard to the ERPT were not strong enough.

CONCLUSIONS

In the article, the DOLS estimates of anticipated exchange rate effects on the consumer prices and output in the CEE countries (plus Turkey and Russia) are provided. The main result was that the anticipated exchange rate depreciation was associated with the incomplete ERPT and a decrease in output, with the former effect apparently becoming stronger over the 2010-2019 period. Thus, our research hypothesis that the positive relation between exchange rate depreciation and domestic consumer prices that is not complete and declining over time was confirmed only partially. On the other hand, the second hypothesis of the contractionary effect of currency depreciation on output was confirmed. Control for the level of economic freedom and the output effects of the exchange rate remained much the same while the ERPT seems to become smaller. Higher level of economic freedom was a factor behind higher prices and lower output. Among other results, the money supply was expansionary but at the cost of higher prices. As expected, the investments in physical capital was the factor behind output growth, with an anti-inflationary effect of control for the economic freedom.

Our study implies that there is not much room for relative price incentives for the long-term economic growth as currency depreciation is inflationary and contractionary. Consequently, the exchange rate appreciation may be considered for stabilisation purposes. Also, further liberalisation of the CEE economies seems to be counter-productive. Although our results seem to be quite robust, it is necessary to admit serious limitations of the study to be addressed in future research. Firstly, causal links between exchange rate, consumer prices, and output both in the short- and long run within the VAR/VEC framework require additional research, with an account for the structural break in 2008-2009

and more precise specification of the shocks in the financial sector. Secondly, interaction effects for institutional variables are worth attention for better understanding of the exchange rate impact on prices and output. Third, a time-varying nature of the exchange rate price and output effects is of interest for future studies. On the theoretical side, impact of nominal rigidities and interest rate links with the world financial markets deserve research efforts.

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