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Asymmetry in the exchange rate pass-through to consumer prices in Eastern European countries[1]

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Abstract. Using quarterly data from Q1 2002 to Q4 2021, a Nonlinear Autoregressive Distributed Lag (NARDL) model is utilised to investigate the potential asymmetry in the exchange rate pass-through (ERPT) to consumer prices in 11 Eastern European countries. The findings show that both the appreciations and depreciations of the nominal effective exchange rate (NEER) have significant long-term effects on consumer prices, with the appreciations being stronger in countries with a fixed exchange rate regime, especially the Baltic States. Incomplete long-term ERPT is observed in the majority of countries, except Estonia. Short-term ERPT is much weaker and often of an opposite direction for appreciations and depreciations. Additionally, a strong uniform long-term effect of both the money supply and crude oil prices was observed, while the short-term effects are mixed. As regards economic liberalisation, both long- and short-term effects are country-specific and of a different direction.

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1. Introduction

Asymmetry of the exchange rate pass-through (ERPT) means that consumer (or import) prices react differently to the exchange rate appreciations and depreciations, regardless of whether it involves a long-term relationship, short-term dynamics or both (Colavecchio & Rubene, 2020). Recent studies often indicate asymmetry in the ERPT for both industrial (Anderl & Caporale, 2023; Delatte & López-Villavicencio, 2012) and developing countries (Caselli & Roitman, 2016), including Eastern European states (Nasir et al., 2020; Przystupa & Wróbel, 2011; Stoian & Murarașu, 2015). It is also the case for many Euro area countries, although a symmetric ERPT is observed for the whole Euro area (Colavecchio & Rubene, 2020).

The aim of this paper is to investigate the ERPT to consumer prices in the short and long run in 11 Eastern European countries, focusing on any potential asymmetry occurring during periods of appreciation and depreciation. The estimates of the Nonlinear Autoregressive Distributed Lag (NARDL) model, which allows for exchange rate asymmetry, are assessed against a benchmark ARDL linear (symmetric) model. More specifically, the research presented in the paper seeks to answer the following questions: is the ERPT symmetric during periods of appreciation and depreciation? Is the ERPT stronger in the long run? What is the effect of the exchange rate regime on the magnitude of ERPT? The estimates of the ERPT pattern appear to be crucial for an effective disinflationary monetary policy primarily in countries with flexible exchange

rates. Nevertheless, it is also important to estimate the strength of inflationary pass-through regardless of the exchange rate regime.

The remaining part of the paper is organised as follows: Section 2 outlines the theoretical issues regarding asymmetry in the ERPT. Section 3 provides a brief account of selected empirical studies, Section 4 presents the data and the statistical model, while Section 5 discusses the empirical results and summarises the key findings. Finally, Section 6 presents the conclusions of the research.

2. Theoretical framework

As the relevant literature suggests, there are three main groups of explanations for asymmetry in the ERPT (Aron et al., 2014; de Melo Modenesi et al., 2017):

- Capacity constraints. When the currency of the exporter country depreciates, it creates incentives for exports due to a higher demand for imports abroad. In the presence of quantity constraints, exporters are not able to raise their sales in response to favourable relative prices. Consequently, exporters increase their mark-up instead of lowering prices in the importer's currency, while in the case of an appreciation, exporters can keep their price level stable as their profits expressed in foreign currencies increase (such a situation results in the fact that the ERPT after depreciations is greater than after appreciations);
- Production technology switching. If the producing firm exports the final product but, at the same time, has the possibility to buy its inputs abroad, appreciations may result in a higher ERPT than depreciations;
- Pricing to market behaviour. It occurs when exporting firms seek to maintain market share by setting the lowest possible price in the importer's currency. If the importing country's currency appreciates, exporters are likely to allow

the prices to fall; if the importer's currency depreciates, the mark-ups are adjusted to maintain prices in the local currency. In this case, the ERPT is higher after the appreciation of the domestic currency than after its depreciation.

Thus, two of the three above-mentioned theoretical reasons for asymmetry in the ERPT lead to a higher pass-through after a currency appreciation rather than depreciation. Assuming that prices are rigid downward due to firms being more likely to increase their mark-up than to reduce it, the ERPT should be greater after a depreciation of the currency rather than after an appreciation. Downward rigidity in Eastern European countries is likely to result from the insufficient competitiveness of the domestic market and excessive labour regulations.[2] In the case of depreciation in a competitive environment, foreign firms may not raise prices in the importing country's market in order to retain market share; the response of domestic prices to appreciation becomes then stronger (Pollard & Coughlin, 2004).

As argued by Bussière (2013), depreciations have a larger effect on import prices than appreciations, as exporters are able to absorb only a part of the currency movements into their mark-up. Asymmetry in the ERPT is even higher in the case of a large appreciation, as it is more difficult for exporters to adjust their mark-up, thus leading to a higher pass-through on the importers' part. On the other hand, it is likely that exporting firms may find it difficult to increase their production capacities and raise their mark-up instead of setting up a new plant, with a lower ERPT on the importer's side (Aron et al., 2014).

[2] If the level of competitiveness is compared with the persistence of profits, Germany, Portugal, Sweden and the United Kingdom emerge as the most competitive economies in the short term among a sample of European economies (Eklund & Lappi, 2019). On the other hand, Czechia and Hungary have the highest short-run profit persistence, along with Greece and Spain.

Capacity constraints which constitute a factor behind a greater ERPT after depreciations are less likely to appear in Eastern European countries.

From a macroeconomic perspective, the ERPT may be asymmetric if the monetary authority is concerned with inflationary pressures arising from exchange rate movements and the central bank reacts more strongly after a currency devaluation than after an appreciation (Delatte & López-Villavicencio, 2012). Furthermore, the ERPT may depend on the level of economic activity. In periods of economic recession, for example, the effects of depreciations in the form of rising prices may be smaller than the effects of appreciations, i.e. the reduction of domestic prices (Goldfajn & Werlang, 2000).

In a wider analytical context, the magnitude of asymmetric ERPT is explained by other institutional factors, such as imperfect competition (Delatte & López-Villavicencio, 2012), the presence of menu costs (Ben Cheikh, 2012), downward rigidity in prices combined with upward rigidity in the supply of goods (Stoian & Marurasu, 2015), or the pricing to market phenomenon (Przystupa & Wróbel, 2011). Institutional environment, measured by the concept of economic freedom comprising monetary, administrative, trade, investment and financial components, could be a factor behind the ERPT. For Eastern European countries, the control of economic freedom curbs the ERPT from 0.272 to 0.191, while the exchange rate effect on output does not change significantly (Shevchuk, 2022). As outlined below, such an outcome is in line with several theoretical concepts.

As demonstrated by a two-country model with imperfect competition and price inertia, the magnitude of ERPT decreases in a low inflation regime due to the weakening of the expected future effect of monetary shocks (Choudhri & Hakura, 2001). Lower variability of monetary shocks also plays a role. Although a change in the exchange rate has a direct impact on the costs, the

prices for only a fraction of goods are reset as a result of the staggered price adjustment process, which, in turn, depends on the expected values of future costs. A stronger monetary policy response to the deviations from the regime targets reduces the destabilising effects on the future costs and thus lowers the ERPT. A similar conclusion of a lower ERPT attributed to a low-inflation environment is obtained by the open economy model with the Phillips curve (Takhtamanova, 2008). The argument asserting that ERPT decreases in an environment characterised by lower and rather stable inflation has been empirically supported in relation to the Euro area countries (Ben Cheikh, 2012).

Trade openness, which is another component of economic freedom, implies that foreign exporters become more responsive to the prices of their competitors and find it optimal to increase their prices to a lesser degree when an exchange rate movement occurs, with a lower ERPT to follow (Gust et al., 2010). A two-country model consists of households which consume both domestically-produced goods and imported goods, and of firms which are monopolistically competitive. Among other theoretical aspects, a lower ERPT should be expected in cases of nominal rigidities, price discrimination (Corsetti et al., 2008), lower transportation costs and less labour-intensive services in wholesale and retail trade (Frankel et al., 2012).

Based on the favourable price effects of the monetary and trade freedom, it is likely that the aggregated Index of Economic Freedom (IEF) will have the same impact, assuming that it is also of a disinflationary character. However, price stability in a low inflation regime could have an opposite effect if it is associated with exchange rate stability and expectations of the exchange rate dynamics. If the exchange rate changes are considered permanent, then selling prices are adjusted rapidly, whereas if exchange rate changes are considered as temporary, the price adjustment is delayed (Beirne & Bijsterbosch, 2009).

In general, the literature on the subject suggests that price adjustments to exchange rate fluctuations depend on the monetary regime and other institutional features of the economy, on market structures and firm pricing strategies, which all differ across industries and countries. Although the control of economic freedom is likely to weaken the ERPT for both appreciations and depreciations, especially if the changes in exchange rates are considered to be permanent, the above-mentioned arguments for capacity constraints, production technology switching and pricing to market remain a source of uncertainty in the study of exchange rate effects on inflation. Considering what was stated above, the existence and direction of asymmetric ERPT to consumer prices may not be asserted *a priori*.

3. A brief account of selected empirical studies

Depreciations are passed through prices more than appreciations over the long run in the study of Germany, Japan, the United Kingdom and the United States (Delatte & López-Villavicencio, 2012). Asymmetry is found in five out of 12 Euro area countries, with no clear evidence about the direction of the asymmetry (Ben Cheikh, 2012). Additionally, it has been confirmed that pass-through decreases in a lower and more stable inflation environment.

As regards Eastern European countries, asymmetry in the ERPT to consumer prices has been found for Czechia (Nasir et al., 2020), Poland (Przystupa & Wróbel, 2011) and Romania (Stoian & Marurasu, 2015). However, it has been empirically established that euro appreciations and depreciations affect the level of the Euro-area ERPT symmetrically; however, the results differ across countries and the impact on headline inflation is limited (Colavecchio & Rubene, 2020). For Germany, Portugal and Spain, the ERPT is stronger for appreciations, while the opposite is true for Belgium and Luxembourg.

The ERPT is higher in the long run for Romania (Stoian & Murarașu, 2015), although the evidence in favour of the complete ERPT is rather scarce. The incomplete ERPT is found for Czechia, Hungary, Poland and Romania (Przystupa & Wróbel, 2011; Shevchuk, 2022; Stoian & Murarașu, 2015), which is in line with the earlier studies on Eastern European countries. For example, no evidence in favour of the extreme hypotheses of Local Currency Pricing (zero pass-through) and of Producer Currency Pricing (complete pass-through) is found by María-Dolores (2010). In this context, it is worth noting that in such developed countries as Australia or Sweden the ERPT is close to being complete (Anderl & Caporale, 2023).

For Eastern European countries, there is evidence that the ERPT is higher for countries that have adopted some form of a fixed exchange rate regime, with reduced exchange rate responsiveness to external price shocks (Beirne & Bijsterbosch, 2009; Mirdala, 2014). However, earlier estimates demonstrate that a less volatile exchange rate implies a lower degree of ERPT (María-Dolores, 2010). Pass-through is likely to be stronger in countries targeting inflation with exchange rate flexibility (Anderl & Caporale, 2023). Among the states practising such a monetary regime are Czechia, Hungary, Poland and Romania, where a higher degree of ERPT tends to occur. Under inflation-targeting policies, domestic inflation is expected to be sensitive to oil prices as well (Baharumshah et al., 2017).

Several studies indicate that the magnitude of ERPT in the aftermath of the global financial crisis of 2008–2009 declined due to a relatively low inflation environment (Poghosyan, 2020). However, it was found that in relation to Czechia, Hungary, Poland and Romania the long-term ERPT became higher over the low-inflationary 2010–2019 period, with inflationary effects of the money supply and economic freedom, as well as an opposite impact of investments (Shevchuk, 2022). Earlier studies on Poland did not find any

relationship between the ERPT and inflation (Przystupa & Wróbel, 2011). As in the case of energy-importing countries of Caucasus and Central Asia (Poghosyan, 2020), the same direct relationship between consumer prices and crude oil prices is likely to occur in Eastern European countries. However, the inflationary influence of an increase in oil prices can be significant on impact, but have no effect in the long run (Choi et al., 2018). In general, emerging markets differ from advanced economies in terms of their exposure and sometimes vulnerability to the terms of trade shocks (Caselli & Roitman, 2016).

There are various approaches to studying ERPT asymmetries, including the local projections method (Caselli & Roitman, 2016; Colavecchio & Rubene, 2020; Poghosyan, 2020), vector autoregression models (de Melo Modenesi et al., 2017; Przystupa & Wróbel, 2011), OLS error-correction models (María-Dolores, 2010), smooth transition regression models (Anderl & Caporale, 2023; Ben Cheikh, 2012), or Markov switching models (Baharumshah et al., 2017). Several studies utilise a nonlinear cointegrating ARDL (NARDL) model (Delatte & López-Villavicencio, 2012; Nasir et al., 2020), which provides a framework for the analysis of both long- and short-term relationships by allowing for asymmetries in a nonlinear error correction model while showing weak requirements for data of a functional type.

To sum up, our account of the theoretical and empirical issues leads to three main conclusions. Firstly, the existence and direction of asymmetric ERPT to consumer prices is a country-specific phenomenon, entailing significant monetary policy implications. Secondly, the ERPT is expected to be stronger in the long run. Thirdly, it is important to control any domestic and external conditions as the ERPT can be dependent on the inflation environment, monetary regime, openness of the economy to foreign trade and capital flows, the business cycle, institutional features, commodity prices, etc.

4. Data and statistical model

All time series for the Q1 2002–Q4 2021 sample have been extracted from the IMF International Financial Statistics and FRED databases.[3] The IEF has been obtained from the Heritage Foundation. The following variables were used: the consumer price index (2016=100), p_t, the nominal effective exchange rate (NEER) (2010=100), e_t, the money supply (index, 2010=100), m_t, the level of economic freedom, $herit_t$, the crude oil price (index, 2016=100), $brent_t$. The NEER is defined as domestic currency units per unit of foreign currency, so that an increase in the value of e_t represents a depreciation for the home country.

Among country-specific controls, several extra variables were used: the consumer price index in Germany (2016=100), investments (% of GDP), openness to foreign trade (% of GDP), the U.S. lending rate (%), obtained from the IMF International Financial Statistics, and FRED databases. The liberalisation of trade and higher-level openness are common reasons for a decline in the ERPT in developed countries (Frankel et al., 2012), while the opposite is true for developing countries (Ghosh, 2013). A slightly positive relationship for Eastern European countries between ERPT and openness to foreign trade was reported by María-Dolores (2010), but no impact of trade openness was found by Shevchuk (2022).

Since none of the variables is I(2), it is justifiable to use the ARDL framework to investigate the asymmetric ERPT into consumer prices.[4] The choice of the

[3] For Estonia, Romania and Slovenia, a shorter sample of Q1 2002 – Q1 2020 is used due to the limited availability of data for the money aggregates.

[4] As indicated by the Phillips-Perron (PP) test, variables of CPI, NEER, IEF and money supply are non-stationary in levels and stationary in first differences for all countries (the results of the calculations are available upon request). It means that the variables are integrated of order one or I(1). The Augmented Dickey-Fuller (ADF) test results are very similar, but somewhat weaker in the case of CPI for Hungary, Lithuania, Poland

ARDL model is advantageous for our study, as it is applicable in a situation where the variables are I(0), I(1) or a mixture of I(1) and I(0), and it is possible to estimate both the short-term and the long-term effects simultaneously (Pesaran et al., 1999). Following Kripfganz and Schneider (2022), the statistical model for the CPI is as follows:

$$p_t = \mathrm{c}_0 + \mathrm{c}_1 t + \sum_{i=1}^{l} \emptyset_i p_{t-i} + \sum_{i=1}^{q} \eta_i e_{t-i} + \sum_{i=0}^{q} \beta_i' \boldsymbol{x}_{t-i} + \varepsilon_t, \quad t = 1 + q^*, \dots, T, \tag{1}$$

where c_0 is the intercept, $\mathrm{c}_1 t$ is the linear trend, e_t is the NEER, $\boldsymbol{x}_t$ is the vector of other exogenous variables (money supply, crude oil prices, output gap), $l \in [1, q^*]$ and $q \in [0, q^*]$ are lag orders, q^* is the maximum admissible lag order, T is the number of observations in the dataset, ε_t is a vector of normally distributed, serially uncorrelated and mutually orthogonal white noise disturbances, and t is the time dimension.

The ARDL model can be reformulated into the error-correction representation:

$$\Delta p_t = \mathrm{c}_0 + \mathrm{c}_1 t - \alpha(p_{t-1} - \gamma e_{t-1} - \theta \boldsymbol{x}_{t-1}) + \sum_{i=1}^{l} \psi_{pi} \Delta p_{t-i} + \sum_{i=1}^{q} \psi_{ei} \Delta e_{t-i} + \sum_{i=0}^{q} \psi_{xi}' \Delta \boldsymbol{x}_{t-i} + \varepsilon_t, \tag{2}$$

where α is what is called a speed-of-adjustment coefficient, while $\gamma\alpha$ and $\theta\alpha$ stand for the long-term coefficients. The speed-of-adjustment coefficient demonstrates how fast the output reverts back to its long-run equilibrium, with $0 < \alpha < 1$ reflecting a partial-adjustment process, where the gap to the

and Slovenia. The output gap measured as a percentage difference between the actual and the Hodrick-Prescott filtered real gross domestic product is stationary at levels across all countries, regardless of the stationarity test used.

equilibrium is gradually closed over time. The coefficient on the exchange rate, $\gamma\alpha$ measures the ERPT as the direct effect of the exchange rate on the CPI level. In order to analyse asymmetries in the ERPT, the NEER is decomposed into its positive (e_t^+) and negative (e_t^-) partial sums: $e_t^+ = \sum_{t=1}^{k} \Delta e_t^+ = \sum_{t=1}^{k} \max(\Delta e_t, 0)$, $e_t^- = \sum_{t=1}^{k} \Delta e_t^- = \sum_{t=1}^{k} \min(\Delta e_t, 0)$.

For computational purposes, the following NARDL model was estimated:

$$\Delta p_t = \mathrm{c}_0 + \mathrm{c}_1 t + \pi_p p_{t-1} + \pi_e^+ e_{t-1}^+ + \pi_e^- e_{t-1}^- + \pi_x \boldsymbol{x}_{t-1} + \sum_{i=1}^{p-1} \psi_{pi} \Delta p_{t-i} + \sum_{i=1}^{q} \psi_{ei}^+ e_{t-1}^+ + \sum_{i=1}^{q} \psi_{ei}^- e_{t-1}^- + \sum_{i=0}^{q} \psi_{xi}' \Delta \boldsymbol{x}_{t-i} + \varepsilon_t, \quad (3)$$

from which the speed-of-adjustment coefficient is $\alpha = -\pi_p$, and the long-term ERPT coefficients are π_e^+/α and π_e^-/α, respectively. Among the components of vector $\boldsymbol{x}_t$, our ARDL and NARDL models included the money supply and the crude oil prices.

It is customary for the ARDL/NARDL models to allow for up to four or eight lags with quarterly data. For the NARDL models, the long-run symmetry used to be tested by a Wald test of joint null hypothesis $\pi_e^+/\alpha = \pi_e^-/\alpha$. The short-run symmetry can be tested by a standard Wald test of joint null hypothesis $\sum_{i=1}^{q-1} \psi_{ei}^+ = \sum_{i=1}^{q-1} \psi_{ei}^-$.

The presence of co-integration is confirmed by the Wald F-Bounds and *t*-Bounds tests, which suggest the rejection of the null hypothesis of no co-integration for the ARDL and NARDL models in the first place (the results of the calculations are available upon request). If the output gap is included into the NARDL model, the *t*-Bounds test does not indicate co-integration for Czechia, Estonia, Latvia and Slovakia, and shows rather weak evidence for co-integration in the case of Hungary and Poland. As there is rather weak evidence of co-integration for the NARDL with an output gap model, it is eliminated from

further discussion. In order to preserve the comparability of the results across countries, the next section presents the estimates from the ARDL and NARDL models only.

5. Empirical results

As presented in Table 1, estimates of the linear ARDL model are uniform in the sense that there is a significant incomplete long-term ERPT across all Eastern European countries, with the estimates ranging from 0.153 for Slovakia to 0.672 for Latvia. On the other hand, estimates of the short-term ERPT are quite heterogeneous. A relatively high value of the short-term ERPT relates to Estonia and Slovenia, followed by Croatia, Lithuania and Poland. A counter-intuitive negative value of the short-term ERPT is obtained for Czechia and Slovakia. No relationship between the exchange rate and inflation is observed in Bulgaria, Hungary, Latvia and Romania. Ultimately, our results are in line with the international evidence that the ERPT is higher in the long run.

Table 1. Estimates of the ERPT (ARDL)

Country	β	Long-term	Short-term	R^2
Czechia	–0.309***	0.398***	–0.141*	0.52
Hungary	–0.205***	0.423***	–0.001	0.69
Poland	–0.415***	0.481***	0.023**	0.42
Romania	–0.251***	0.209***	—	0.71
Bulgaria	–0.326***	0.424***	—	0.75
Croatia	–0.349***	0.554***	0.189***	0.68
Slovakia	–0.397***	0.153***	–0.261**	0.69
Slovenia	–0.367***	0.218***	0.476***	0.85
Estonia	–0,078***	0.376**	0.367**	0.67
Latvia	–0.104***	0.672***	–0.028	0.71
Lithuania	–0.199***	0.560***	0.116*	0.49

Note. Czechia, Hungary, Poland and Romania practice a monetary regime of inflation targeting, while Bulgaria, Croatia, Slovakia, Slovenia, as well as the Baltic States are countries with a fixed exchange rate regime.

Source: authors' calculations.

The NARDL model, as defined in (3) is estimated for each country with a maximum lag length of four for both dependent and independent variables, with all insignificant control variables removed from the model.[5] Table 2 presents the results of the Wald symmetry tests for exchange rate effects in both the long and short term. The null hypothesis of a long-term symmetric ERPT is rejected at a 5% level of statistical significance in eight out of 11 countries. Therefore, a long-term asymmetry is confirmed in most of the Eastern European countries, except Poland and Slovenia. No evidence of a short-term asymmetry is found only in Lithuania, but there are no results for symmetry tests for Bulgaria, Latvia, Romania and Slovenia.

Table 2. Results of symmetry tests (NARDL)

Country	Short-Term Tests (WST)	Long-Term Tests (WLT)	Country	Short-Term Tests (WST)	Long-Term Tests (WLT)
Czechia	3.17***	11.93***	Estonia	9.82***	16.23***
Hungary	14.29***	4.16**	Latvia	—	4.20**
Poland	9.10***	1.12	Lithuania	0.17	2.70*
Romania	—	2.51**			
Bulgaria	—	19.19***			
Croatia	4.92**	11.69***			
Slovakia	4.36**	6.39**			
Slovenia	—	0.62			

Note. ***, ** and * mean that the null hypothesis of symmetry is rejected at 1%, 5% and 10% statistical significance levels, respectively.
Source: authors' calculations.

[5] For all country-specific NARDL models, the Breusch–Godfrey LM and Breusch-Pagan-Godfrey tests report no residual serial correlation and no functional misspecification, respectively (the results of the tests are available upon request). The stability of the NARDL model estimates is verified with the Ramsey RESET test, as well as the CUSUM and CUSUM Square tests. The Ramsey RESET test shows the presence of homoscedasticity in all countries, except for Slovenia, for which the results show a somewhat lower than 10% statistical significance. Despite the slightly weaker results of one of the recursive tests in the case of Czechia and Poland, both CUSUM and CUSUM Square tests are also in favour of homoscedasticity; thus, heteroscedasticity is not a concern. Additionally, the model's residuals are normally distributed according to the Jarque–Bera test.

The long-term ERPT is significantly greater following appreciations in Bulgaria, Croatia, Latvia, Lithuania and Slovenia i.e. all countries with a fixed exchange rate regime, as well as in Poland, which practices a floating exchange rate of its currency (Table 3). According to the theoretical arguments, it means that product technology switching and pricing to market effects prevail over capacity constraints. The appreciation of the NEER is neutral in respect to CPI in Romania, while a counterintuitive inflationary effect of appreciation is observed in Slovakia.

Table 3. Estimates of the ERPT (NARDL)

Country	β	Long-term		Short-term		R^2
		Appr (–)	Depr (+)	Appr (–)	Depr (+)	
Czechia	–0.252***	0.203***	0.291***	0.380**	–0.357**	0.64
Hungary	–0.275***	0.412***	0.448***	–0.409**	0.375***	0.77
Poland	–0.337***	0.711***	0.544***	–0.037**	0.016***	0.47
Romania	–0.701***	–0.036	0.329***	—	–0.392**	0.76
Bulgaria	–0.348***	0.871***	0.337***	—	–0.381**	0.77
Croatia	–0.358***	0.846***	0.340**	0.121	0.336**	0.68
Slovakia	–0.288***	–0.314***	0.479***	0.273***	–0.356**	0.66
Slovenia	–0.387***	0.887***	0.519***	0.566**	—	0.88
Estonia	–0.149***	0.513**	1.017***	0.549**	0.227**	0.73
Latvia	–0.169***	0.879***	0.648***	–0.165*	—	0.72
Lithuania	–0.179***	0.739***	0.150	0.217**	0.334**	0.55

Note. ***, ** and * mean statistical significance at a level of 1%, 5% and 10%, respectively.
Source: authors' calculations.

Depreciations are inflationary in the long run for all countries except Lithuania. A positive association between depreciations and consumer prices, with an opposite price effect for appreciations is likely to reflect a dependency on imports in Eastern European countries. In addition to the above-mentioned theoretical argument on capacity constraints, a much stronger long-term ERPT for Estonia and Romania for depreciations can result from the fact that their monetary policy is focused much more on the reaction to a currency

appreciation than to a depreciation. Among other countries with a monetary regime based on inflation targeting, a similar assumption can be relevant to Czechia and Hungary (to a lesser extent), but not for Poland, where the ERPT for appreciation is higher than the pass-through for a depreciation.

The pattern of short-term ERPT asymmetry varies across countries. First of all, inflationary pass-through is much weaker for appreciations in Croatia, Lithuania and Slovenia, and depreciations in Hungary and Poland. No effect of the former is observed in Bulgaria and Romania and of the latter in Latvia and Slovenia. Moreover, depreciations bring about a counterintuitive decrease in the CPI dynamics in Bulgaria, Czechia, Romania and Slovakia, while appreciations are associated with a short-term acceleration in the inflation rate in Hungary, Latvia and Poland (to a lesser extent). It is not possible to find any significant differences in both the magnitude and direction of the asymmetric ERPT between countries with floating and fixed exchange rate regimes.

Except for Czechia and Hungary, estimates of the long-term asymmetric ERPT (Table 3) are higher in comparison to the symmetric ERPT (Table 1). It means that the linear ARDL model underestimates the magnitude of the pass-through from NEER to consumer prices.

The estimates of the short-term asymmetric ERPT are consistent with those of the symmetric ERPT for Croatia, Estonia, Lithuania and Slovenia. For Bulgaria, Latvia and Slovakia, as well as for all countries with a floating exchange rate, comparisons are mixed. However, it is worth noting that the lack of any short-term relationship between the exchange rate and inflation in Bulgaria, Hungary, Latvia and Romania, as obtained in the linear specification disappears if the nonlinearity in the exchange rate effects on inflation is allowed. For Czechia and Hungary, estimates of the short-term asymmetric ERPT are much stronger when compared to the magnitude of a symmetric ERPT.

As revealed by coefficient of determination R^2, the explanatory power is higher in the estimates of the NARDL model compared to the ARDL model for nine out of 11 countries, except for Croatia and Slovakia. On average, the long-term pass-through coefficients are larger in the asymmetric (nonlinear) model presented in (3) than in the symmetric (linear) model shown in (2) for countries with a fixed exchange rate, especially in the Baltic States, whereas differences are much smaller (if any) for countries with a floating exchange rate. Causality running from the exchange rate to inflation over the short term seems to be country-specific and dependent on the choice of the specification of the model: linear or nonlinear.

Our results are in line with other studies that report asymmetries in the pass-through to consume prices for the Eastern European countries (Nasir et al., 2020; Przystupa & Wróbel, 2011; Stoian & Murarașu, 2015). Similarly to such Euro area members as Germany, Portugal and Spain (Colavecchio & Rubene, 2020), the ERPT is stronger for appreciations for most of the Eastern European countries with a fixed exchange rate regime, except for Estonia and Slovakia.

Evidence of a complete ERPT is found only for the long-term effect of depreciation in Estonia (Table 3). The long-term effects of appreciation are close to the complete ERPT in Bulgaria, Croatia, Latvia and Slovenia, as the value of the coefficient on e_t^- exceeds 0.8. Similarly to the results presented by Anderl and Caporale (2023), the long-term ERPTs for the inflation-targeting countries with exchange rate flexibility are far from zero pass-through.

On average, the long-term estimates of ERPT are higher for countries with a fixed exchange rate regime. The ERPT for appreciations is as high as 0.573 for fixers (it increases to 0.868 if Slovakia is not included) and 0.323 for floaters (it increases to 0.442 if Romania is not accounted for), with the corresponding values for depreciations standing at 0.419 and 0.403, respectively. As far as the Baltic States are concerned, the long-term ERPT for

appreciations and depreciations are the highest and reach 0.710 and 0.605, respectively. If asymmetry is not accounted for, the Baltic States still have the highest ERPT (0.536), although the differences between countries with floating and fixed exchange rate regimes disappear, standing at 0.378 and 0.337, respectively. Our results are in accordance with other studies asserting that the ERPT seems to be higher for countries that have adopted some form of a fixed exchange rate regime (Beirne & Bijsterbosch, 2009; Mirdala, 2014).

As regards the adjustment speed of consumer prices toward long-term equilibrium prices, it is slightly higher in the asymmetric specification of the NARDL as compared to the linear specification of the ARDL, where the asymmetries are neglected. If ERPT asymmetries are taken into account, the highest level of the coefficient of adjustment speed of –0.701 is found in Romania. On the other hand, a relatively slow speed of adjustment is obtained for the Baltic States, with coefficient β reaching the value between –0.149 and –0.179.

Estimates of other determinants of consumer prices are presented in Table 4. As expected, there is a strong long-term relationship between the money supply and CPI for all countries except for Slovakia, where the coefficient on m_t is smaller and statistically significant at a 1% level. Concerning the short-term impact, our findings reveal that the money supply changes lack any inflationary effects (only in Bulgaria and Croatia positive coefficients on m_t are statistically significant at a 10% and 5% level, respectively).

Similarly to the money supply effects, the long-term reaction of consumer prices to the world crude oil prices is quite uniform, which implies an increase in the level of prices in response to oil price hikes, but the short-term effects are quite heterogeneous. In the case of higher oil prices, an acceleration in inflation is observed in five countries, with the opposite outcome in Romania and neutrality in five other countries.

Table 4. Other consumer price determinants (NARDL)

Country	Money supply		Crude oil price		Index of economic freedom	
	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term
Czechia	0.336***	–0.085**	0.067***	0.010**	0.001	—
Hungary	0.190***	–0.429**	0.034***	0.038**	–0.271*	–0.141**
Poland	0.326***	—	0.093***	0.010**	–0.302**	0.103*
Romania	0.160***	–0.139**	0.084***	–0.112**	–0.032	–0.290**
Bulgaria	0.368***	0.063*	0.045***	0.001**	–0.192**	–0.690***
Croatia	0.201***	–0.148**	0.040***	—	–0.300***	–0.007
Slovakia	0.034*	0.010	0.055***	0.005	–0.240**	–0.022**
Slovenia	0.153***	–0.023**	0.035***	—	–0.029	–0.178**
Estonia	0.170***	–0.011**	0.169***	0.031**	0.678***	—
Latvia	0.169***	–0.048**	0.059***	—	–0.093	—
Lithuania	0.439***	–0.087***	0.097***	—	–1.210***	0.013

Source: authors' calculations.

The liberalisation of the economy, as characterised by the IEF from the Heritage Foundation, has a predominantly anti-inflationary impact both in the long and short run. In a more liberal environment, a long-term decrease in the consumer price level is observed at a statistically significant level in six countries, while the short-term inverse relationship between the IEF and inflation is statistically significant in five countries. Evidence of an increase in the price level is found only for Estonia over the long run and for Poland in the short run. No price effects of economic freedom are found for Czechia and Latvia.

It is worth noting that in the absence of IEF control the estimates of the ERPT for appreciations and depreciations become very similar for Czechia, Latvia, Poland, Romania, Slovakia and Slovenia, while for Hungary they are lower (the results of the calculations are available upon request). Among other findings, a counterintuitive inverse relationship between depreciation and the consumer price level emerges for Bulgaria. The ERPT is lost for appreciation in Estonia and depreciation in Croatia. On the other hand, the ERPT becomes

exaggerated for appreciation in Lithuania. Estimates of the short-term asymmetric ERPT are similar with and without the IEF control only for Croatia, Czechia and Hungary. Empirical estimates become less similar if there is no control from the IEF and crude oil prices. However, in this case the cointegration between exchange rates and consumer prices is not observed for Czechia, Estonia, Hungary, Poland and Romania. In conclusion, the control of economic freedom and crude oil prices appear to be justified due to better cointegration properties and the consistency with the theoretical arguments.

6. Conclusions

It has been found that both appreciations and depreciations of the NEER have significant long-term effects on consumer prices. Appreciations are stronger in countries with a fixed exchange rate regime, especially in Bulgaria, Croatia, Lithuania and Poland. Regarding the estimates of short-term ERPT, comparisons are mixed between linear and nonlinear specifications for countries with both fixed and floating exchange rate regimes. The ERPT is stronger in the long run, but it is incomplete in most of the countries, except for depreciation in Estonia. However, the long-term effects of appreciation are close to the complete ERPT in Bulgaria, Croatia, Latvia and Slovenia. On average, the long-term estimates of ERPT are higher for countries with a fixed exchange rate regime. For short-term estimates of ERPT, it is not possible to find any significant differences in both the magnitude and direction of the asymmetric ERPT between countries with floating and fixed exchange rate regimes.

The observed statistically significant asymmetric effects of exchange rates on consumer prices, both in the long and short run suggest that underestimating the impact of exchange rate appreciations could result in a biased conclusion

with regard to the appropriate disinflationary policy to be implemented. The question whether prices respond differently depending on the magnitude of the exchange rate variation remains yet to be answered. In terms of the modelling strategy, this might be examined by allowing the threshold to be different from zero. This is a topic for future studies, along with the estimation of the pass-through asymmetries to import prices. The aim of future research could be to explain the significant differences in the results relating to the direction and magnitude of the ERPT across countries, providing a list of the likely explanations (structural changes, capital flows, forward or retrospective expectations, policy interventions, household preferences, etc.). For this purpose, the estimation of the ERPT for disaggregated consumer prices time series could be informative. Moreover, our findings must be interpreted with caution due to a relatively short sample covering the 2002–2021 period. As longer time series become available in the future, it should enhance the quality of the analysis as well, lowering the risk of small sample biases in the estimates.

Furthermore, our findings show a strong long-term correlation between consumer prices and both the money supply and crude oil prices in all Eastern European countries. However, a counterintuitive inverse relationship between changes in the money supply and inflation prevails in the short run, while higher crude oil prices are inflationary in half of the studied countries. More economic freedom is predominantly associated with a long-term decline in the consumer prices and a short-term disinflation.

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