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AKADÉMIAI KIADÓ

The impact of oil price shocks on inflation: Do asymmetries matter?

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ABSTRACT

Using cointegration approach and Augmented Phillips Curve framework, this study examines the effects of changes in the global oil prices on the inflation rate for five CEE countries between 1994 and 2018. Our research indicates the existence of cointegration for Czechia, Poland and Slovakia. We find a positive relationship between changes of oil prices and the inflation rate in Poland in the long run. Additionally, it seems that the changes in oil prices impact the inflation rate in the long run for Czechia, Hungary and Poland. In a non-linear model framework cointegration is found in Czechia, Hungary, Poland and Slovenia. Our findings suggest that changes in oil prices significantly affect the inflation rate in Czechia, Hungary and Poland in the long-run and in all countries in the short-run. More importantly, we demonstrate that the short- and long-run asymmetries play a significant role in explaining the dynamics of the inflation rate.

KEYWORDS

oil prices, inflation, asymmetric effects, CEE countries, augmented phillips curve, cointegration

JEL CLASSIFICATION INDICES

C22, E31, Q31

1. INTRODUCTION

Since the first oil crisis in 1973, the effects of oil price changes on macroeconomic variables have been drawing considerable academic attention (Hamilton 1983; Bruno – Sachs 1985;

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Hooker 1996; Barsky – Killian 2004; Killian 2008). In an influential study, Hamilton (1983) noted that every recession in the US since World War II was followed by an oil price surge and it had also inflationary effects on the domestic prices. More importantly, this crisis had wider ramifications in macroeconomic thinking. If nothing else, the oil crisis has proved the importance of aggregate supply shocks in the macroeconomic analysis and also caused a modification in the Phillips curve framework in understanding inflation dynamics. Supply shocks such as sharp increases in oil prices have become an indispensable part of economic analysis since then.

Uncovering the relationship between the global oil prices and inflation rate has some important implications. For example, having a good understanding of this relationship is necessary and crucial to determine and conduct monetary and even fiscal policy as a response to the changes in global oil prices. Therefore, an increasing number of studies investigate the pass-through effect of oil prices on the price level and inflation rate through different methodologies and datasets (among others, Barsky – Kilian 2001; Valcarcel – Wohar 2013; Ibrahim – Said 2012; Ibrahim – Chancharoenchai 2014; Sek 2017). There is no doubt that this growing literature has greatly contributed to our understanding of the subject. On the other hand, we should note that despite extensive research efforts and publications, the relationship between the oil prices and inflation rate is not completely resolved or settled from the theoretical or empirical perspectives. Since mere theoretical explanations or arguments are not sufficient to provide a clear-cut conclusion, more empirical studies are needed to reveal this somewhat complex and mysterious relationship.

Our empirical paper examines the effects of changes in the global oil price on the inflation rate in Czechia, Hungary, Poland, Slovenia and Slovakia between 1994 and 2018. Although, the inflation rate was low in these oil importing countries until very recently[1], 2–3 decades earlier it was even higher than nowadays. Unlike in many other countries, the possible relationship between oil prices and inflation was not investigated for these countries. In other words, to the best of our knowledge, this is the first study examining the effects of changes in the global oil prices on the inflation rate in Czechia, Hungary, Poland, Slovenia and Slovakia. To shed light on the issue, we used linear and non-linear ARDL (autoregressive distributed lag) approaches to the cointegration. These two methods have well-known advantages and enable us to answer some critical questions as follows. Does a change in the global oil price affect the inflation rate? Does this effect differ in the short- and long-terms? Is this effect linear? Is there an asymmetry or nonlinearity, as pointed out in Mork (1989), Hooker (2002), Balke et al. (2002), Hamilton (2011), Bala – Chin (2018) and Long – Lian (2018)? There is no compelling reason to theoretically accept that the effects of negative and positive changes in the global oil prices must be the same or symmetric on the domestic price level. For example, monetary policy can give a strong reaction to the positive changes in oil prices to keep the inflation rate stable. However, it is not realistic to claim that monetary policy will try to prevent a reduction in the inflation rate when there exists a negative shock in oil prices. Our empirical findings suggest that the changes in the global oil prices matter for the inflation rate. Moreover, we lend evidence for the asymmetric effects. Finally, it seems that inflation inertia was important in the sample countries in the examined time period.

[1]Meaning 2021–2022, during the time the present manuscript was finalized (Editor's note).

2. LITERATURE REVIEW

The relevant literature divides the possible effects of oil price changes into three effects: direct, indirect and second-round effects (Alvarez et al. 2011; Castro et al. 2017). Direct effects reflect the higher energy bills or prices for consumers, an increase in oil prices rapidly influences the prices of refined oil products. Indirect effects are mainly related to the production and distribution costs arising from a change in oil prices. Second-round effects refer to the reaction of price and wage setters to the direct and indirect effects of changing oil prices, including the changes in inflation expectations.

Using the aggregate supply and demand framework (AS-AD), we can investigate the effects of oil prices on inflation or price level in more detail for the oil-importing countries. In principle, a temporary change in oil prices is the classic textbook example of aggregate supply shocks (Mishkin 2014). It is clear that an increase in oil prices pushes production costs up. Consistent with this argument, a temporary increase in oil prices causes a leftward shift in the AS curve, indicating an increase in the price level. However, this rise in price level does not mean a sustained increase of the inflation rate, in the absence of some additional assumptions such as real wage rigidity (Bruno – Sachs 1985; Killian 2014).

The dynamic AD-AS model does not tell a completely different story, either. As a response to a temporary rise in oil prices, AS curve shifts to the left and upwards in the long run, indicating a higher inflation rate for a while. However, in the long run, the AS curve returns to the initial point, and hence, no increase in inflation if the economy is at its long-term equilibrium before the rise in oil prices. Additionally, if a change in oil prices influences the inflation expectations, as suggested by the second-round effects, then the shift of the AS curve would be greater, resulting in a higher and possibly longer-lasting effect on inflation. Finally, if there exists a permanent increase in oil prices, then the long-run AS curve shifts to the left and inflationary effects will be more persistent. This analysis assumes that policymakers do not react to a rise in oil prices. In reality, the response of policymakers is crucial in investigating the possible effects of oil price shocks, as demonstrated by Bernanke et al. (1997). For example, after a temporary shock to oil prices, the central banks accommodate and shifts the AD curve to keep inflation or output stable. If a central bank tries to stabilize output, then the inflationary impact of oil price changes will be more pronounced.

Textbook discussions on the inflationary effects of oil prices usually neglect or ignore the aggregate demand channel for simplicity. These discussions assume that the oil price changes do not cause a shift in the AD curve. However, some studies question this assumption and convincingly argue that changes in the (imported) oil prices would directly affect the aggregate demand through several channels such as income effect, uncertainty effect, precautionary savings, and operating cost effect (Kilian 2009, 2014). Moreover, this aggregate demand channel would be even more important than the aggregate supply channel (Hamilton 2009; Kilian – Park 2009; Castro et al. 2017). This implies that a rise in oil prices would lead to a deflationary rather than an inflationary effect.

Nevertheless, it seems difficult to confidently assert that a rise in oil prices has an unambiguously positive or negative effect on the inflation rate on mere theoretical grounds. There is a truly vast empirical literature trying to document the effects of oil prices on inflation or price level. We summarize the main findings of selected studies in Table 1.

Table 1. Brief summary of the oil price-inflation nexus

Study	Sample	Methodology	Main findings
Darby (1982)	US, UK, Canada, France, Germany, Italy, Japan and Netherlands. Quarterly data from 1957 to 1976.	Two-Stages Least Squares Principal Component Model	The magnitude of oil prices on inflation differs in most of the sample.
Hamilton (1983)	US monthly data from 1947M1–1980 M12	SVAR methodology	Unprecedented oil shocks are the main driver of inflation performance in the US.
Mork (1989)	US monthly data from 1949M1 to 1988M2	SVAR methodology	The transmission mechanism between the inflation and oil prices is asymmetric.
Berument – Tasci (2002)	Turkey, 1990	Input – Output Tables	The increasing oil prices have a minor effect on inflation.
Hooker (2002)	US quarterly data from 1960Q1 to 1990Q4.	Phillips curve with structural breaks.	The inflationary impact of oil prices is limited by means of core inflation in 1980.
Cunado – de Gracia (2003)	EU countries, quarterly data from 1960 to 1999	Cointegration with structural breaks	Oil prices have long-lasting effects on the inflation.
LeBlanc – Chinn (2004)	G5 countries, quarterly from 1980Q1 to 2001Q4	Augmented Phillips Curve with VAR	10 percentage points increase in oil prices would contribute to domestic prices of about 0.1–0.8 percentage points in the US and Europe, respectively.
Cunado – de Gracia (2005)	Japan, Singapore, South Korea, Malaysia, Thailand and Philippines, quarterly data from 1975Q1 to 2002Q2	Gregory – Hansen cointegration test	There is a significant pass-through effect of oil prices on CPI in the Asian countries but only long-run.
Blanchard – Gali (2007)	Six industrialized countries (France, US, UK, Germany, Japan and Italy)	VAR methodology	The pass-through effects of oil price shocks on inflation declined over time.

(continued)

Table 1. Continued

Study	Sample	Methodology	Main findings
de Gregorio et al. (2007)	34 developed countries	Generalized Phillips Curve with rolling VAR	There is a proof of considerable decreasing effect in oil price pass-through to inflation.
Herrera – Pesavento (2009)	US, quarterly data from 1959Q1 to 2006Q4	Modified VAR model	Higher crude oil prices occurred in 2006 contributed to the US inflation rate positively.
Chen (2009)	19 developed countries, quarterly data from 1970Q1 to 2006Q4	Error correction mechanism with endogenous structural breaks	There is an evidence for declining pass-through effect in most of the countries considered.
Wu – Ni (2011)	US, monthly data from 1995M1 to 2005M12	Granger causality, VAR model	Energy prices have a prominent role in determining inflation.
Mandal et al. (2012)	India, monthly data from 1994M4 to 2010M3	Generalized VAR with Phillips curve	There is a pass-through effect of oil prices on industrial output and inflation.
Valcarcel – Wohar (2013)	US, Quarterly data from 1948Q1 to 2011Q2	TVP-VAR with Phillips Curve	Oil price volatility is not the main factor in explaining inflation.
Chou – Lin (2013)	Thailand, monthly data from 1981M1 to 2011M12	Nonlinear VECM	The significant nonlinear error-correction mechanism between oil prices, output, wages and inflation.
Cavalcanti – Jalles (2013)	US and Brazil, quarterly data from 1975Q1 to 2008Q2	Structural VAR	Oil price shocks have a minor influence on inflation in Brazil.
Gao et al. (2014)	US, monthly data from 1971M1 to 2014M4	Bivariate VAR model	Energy driven price increases affect total consumer price index.
Yoshizaki – Haomori (2014)	US and Japan, monthly data from 1974M12 to 2010M12	Structural VAR model	The transmission mechanism between oil price and individual expenditure categories differs remarkably in Japan and the US.

(continued)

Table 1. Continued

Study	Sample	Methodology	Main findings
Dedeoglu – Kaya (2014)	Turkey, yearly data from 1990 to 2012	Recursive VAR model	The impact of oil prices is two times higher on producer prices than the consumer prices.
Yanikkaya et al. (2015)	Turkey, yearly data from 1990 to 2013	Augmented Phillips Curve with recursive OLS	Oil price contributions into inflation have prominently increased over time.
Katircioglu et al. (2015)	26 OECD countries, yearly data from 1980 to 2011	Durbin-H Panel cointegration test	Oil prices have negative effects on the consumer price index.
Basnet – Upadhyaya (2015)	ASEAN-5 countries, quarterly data from 1970Q1 to 2010Q2	Structural VAR model	There is no relationship between global oil prices and inflation except in Thailand.
Sek (2017)	Malaysia, yearly data from 1980 to 2015	ARDL and NARDL cointegration	Oil prices have indirect effects on inflation through import prices and production costs.
Albulescu et al. (2017)	Romania, monthly data from 2005M12 to 2013M6	Breitung – Candelon frequency domain causality test	The pass-through effect of oil prices is observed only in the medium-run.
Long – Liang (2018)	China, quarterly data from 1998Q1 to 2014Q1	NARDL approach	Global oil prices have long-term impacts on the producer price index.
Lacheheb – Sirag (2019)	Algeria, yearly data from 1970 to 2014	NARDL approach	There is a significant nonlinear effect of oil prices on inflation.

3. A BRIEF OVERVIEW OF OIL PRICE AND INFLATION IN SAMPLE COUNTRIES

Before explaining the methodology and executing the empirical analysis, we present a short evolution of global oil prices and inflation rates in Czechia, Hungary, Poland, Slovenia and Slovakia (Figure 1).

The oil prices stay at low levels in the 1990s before starting to rise in the early 2000s. This upward trend continues until the global financial crisis in 2008–2009. As expected, during the crisis a sharp decline is observed. In the aftermath of the financial crisis the oil prices first reach very high levels and then experience another remarkable decline. As for the inflation rate, we observe relatively high levels in the sample countries during the early years of the transformation in the 1990s. It seems that inflation rate gets lower in the 2000s. In general, we clearly detect an increase in the inflation rates during the financial crisis, even exceeding 6% in Czechia, Hungary and Slovakia. This increase is not permanent, though. Additionally, although the inflation rate has been low, under 4%, and more stable in recent years, we should note that there is a rise in the inflation rate in all countries after 2016. However, we need a robust econometric analysis before reaching a definite conclusion.

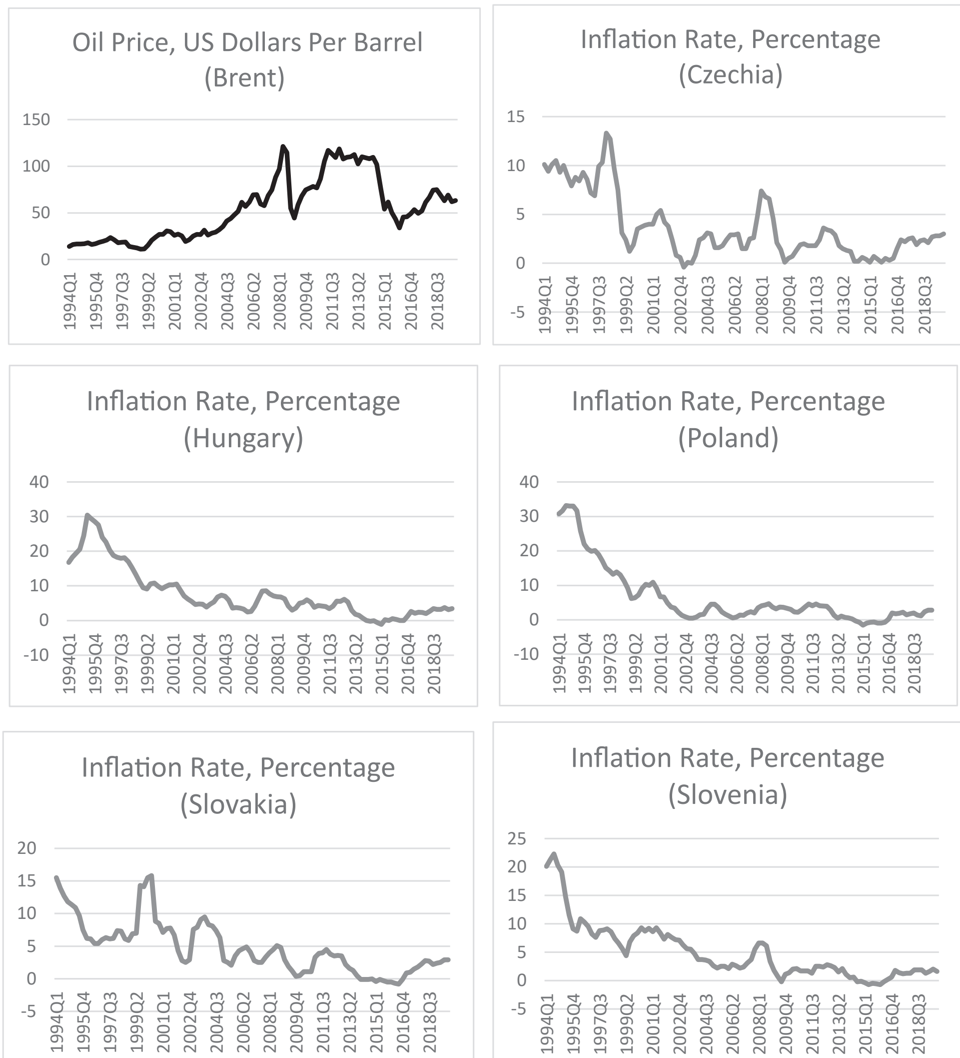

Fig. 1. The evolution of oil prices and inflation
Source: St. Louis FRED Economic Database and OECD.

4. THEORETICAL AND EMPIRICAL FRAMEWORK

To analyse the impact of oil price shocks on inflation, we consider the Augmented Phillips Curve as in many related studies. The Augmented Phillips Curve can be composed as:

$$\pi_t = \beta(L)\pi_{t-i} + \gamma UG_t + \vartheta(L)o_t + \varepsilon_t \tag{1}$$

where π_t postulates the inflation rate and $\pi_t = p_t - p_{t-1}$. p_t is the logarithm of the CPI; UG denotes the gap between natural employment rate and actual employment rate; o_t refers to the logarithm of the global oil prices, (L) is the polynomial in the lag operator and ε_t is the error term. To measure the extent of the pass-through to inflation rate, the coefficient of ϑ must range between zero and one (Çatık – Önder 2011; Salisu et al. 2017; Turan – Ozer 2018). The closer coefficient of ϑ to zero (one) means a low (high) degree of the pass-through effect. As in the original Okun's law, we can substitute the output gap for UG_t. Further, eq. (1) can be specified as:

$$\pi_t = \beta(L)\pi_{t-i} + \gamma(\frac{Y_t - Y_t^*}{Y_t})_t + \vartheta(L)o_t + \varepsilon_t \tag{2}$$

Y_t and Y_t^* refer to actual output and potential output, respectively. Further, we can define $(\frac{Y_t - Y_t^*}{Y_t})$ as the output gap and the oil price shocks stay the same at the right-hand side of the Augmented Phillips Curve.

In this study, we employ both linear and nonlinear autoregressive distributed lag (ARDL) models to uncover the long-run relationship between inflation and oil prices. These tests have some superior advantages over the residual-based co-integration tests such as Engle – Granger (1987) and Johansen (1991). First, these tests can be applied whether the time series have a different order of integration (Pesaran et al. 2001). Second, ARDL and NARDL techniques generate a single reduced equation, while other co-integration techniques produce the system of equations. Third, the ARDL models perform better in detecting co-integration for the finite samples.

To determine the linear co-integration using the ARDL methodology, Augmented Phillips Curve (eq. 2) can be specified as the conditional error correction model:

$$\begin{aligned}\Delta LOGCPI_t = {} & \beta_0 + \beta_1 LOGCPI_{t-1} + \beta_2 OUTPUTGAP_{t-1} + \beta_3 LOGOIL_{t-1} \\ & + \sum\nolimits_{i=1}^{I}\beta_i \Delta LOGCPI_{t-i} + \sum\nolimits_{i=0}^{I}\beta_i \Delta OUTPUTGAP_{t-i} + \sum\nolimits_{i=0}^{I}\beta_i \Delta LOGOIL_{t-i} \\ & + \varepsilon_t\end{aligned} \tag{3}$$

In the ARDL model, optimal lag determination is a vital subject to estimate the model with autocorrelation-free. To tackle this issue, we use Akaike Information Criteria with maximum of six lags. The existence of a co-integrating relationship can be tested by means of Fpss test with the null hypothesis, $H_0 : \beta_1 = \beta_2 = \beta_3 = 0$. Also, estimated F_{PSS} statistics must be compared to upper and lower bounds values produced by Pesaran et al. (2001). If F statistics are higher than the upper bound, we can conclude that a cointegrating relationship exists between the variables.

To employ the nonlinear ARDL model introduced by Shin et al. (2014), we decompose oil prices into negative and positive partial sums. The partial sums of oil prices can be calculated as:

$$LOGOIL\_POS_t = \sum\nolimits_{j=1}^{t} \Delta LOGOIL\_POS_t = \sum\nolimits_{j=1}^{t} \max(\Delta LOGOIL_t,\ 0) \quad (4)$$

$$LOGOIL\_NEG_t = \sum\nolimits_{j=1}^{t} \Delta LOGOIL\_NEG_t = \sum\nolimits_{j=1}^{t} \min(\Delta LOGOIL_t,\ 0) \quad (5)$$

Then, we impose partial sums into the conditional error correction equation (eq. 3) to allow nonlinearities in the ARDL model. The general form of NARDL model can be presented as:

$$\begin{aligned}\Delta LOGCPI_t = \beta_0 + \beta_1 LOGCPI_{t-1} + \beta_2 OUTPUTGAP_{t-1} + \beta_3^- LOGOIL\_NEG_{t-1} \\ + \beta_4^+ LOGOIL\_POS_{t-1} + \sum\nolimits_{i=1}^{I} \beta_i \Delta LOGCPI_{t-i} + \sum\nolimits_{i=0}^{I} \beta_i \Delta OUTPUTGAP_{t-i} \\ + \sum\nolimits_{i=0}^{I} \beta_i^- \Delta LOGOIL\_NEG_{t-i} + \sum\nolimits_{i=0}^{I} \beta_i^+ \Delta LOGOIL\_POS_{t-i} + \varepsilon_t \quad (6)\end{aligned}$$

Similar to the linear ARDL, after estimating eq. (6), we can test the validity of the long-run relationship by using null hypothesis $H_0 : \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$ against the alternative. If the long-run relationship is established, the long- and short-run asymmetric tests are carried out. Long-run asymmetric tests are estimated via positive and negative partial sums of the oil prices in eq. (6). First, we determine whether the negative and positive long-run effects are significant or not. To do so, we normalize ${\beta_3}^-$ and ${\beta_4}^+$ by means of β_1 and illustrate normalized coefficients as $\left(-\frac{{\beta_3}^-}{\beta_1}\right)$ and $\left(-\frac{{\beta_4}^+}{\beta_1}\right)$. Then, we use Wald tests to check the coefficient significance via testing $H_0 : \left(-\frac{{\beta_3}^-}{\beta_1}\right) = 0$ and $H_0 : \left(-\frac{{\beta_4}^+}{\beta_1}\right) = 0$ against alternatives. The estimated Wald test statistics are marked as L^- and L^+ for the negative and positive long-run effects, respectively. Lastly, the long-run asymmetry is examined by testing the equality of normalized long-run positive and negative coefficients. Specifically, long-run asymmetry is tested by $H_0 : \left(-\frac{{\beta_3}^-}{\beta_1}\right) = \left(-\frac{{\beta_4}^+}{\beta_1}\right)$ and that is denoted as W_{LR}.

The short-run asymmetric dynamics are displayed by the first differences of positive and negative partial sums in eq. (6). Firstly, we control whether positive and negative short-run effects are statistically significant. In this manner, we design the null hypothesis as $H_0 : \sum_{i=0}^{I} {\beta^-}_i = 0$ for the short-run cumulative negative effects. Alternatively, we propose the short-run cumulative positive effects as $H_0 : \sum_{i=0}^{I} {\beta^+}_i = 0$. These tests are denoted as S^- and S^+. Next, the existence of short-run asymmetry is tested by the equality of short-run positive and negative cumulative effects. So, we define $\sum_{i=0}^{I} {\beta^-}_i = \sum_{i=0}^{I} {\beta^+}_i$ as the null hypothesis, denoting the test statistics as W_{SR}.

5. DATA AND UNIT ROOT TESTS

Our main goal is to analyse the impact of oil price shocks on inflation for Czechia, Hungary, Poland, Slovakia and Slovenia. To do so, we utilize the quarterly data for each country and all variables are in the logarithmic form (except the output gap). Brent oil prices (in US dollars per barrel) and real GDP series are collected from St. Louis FRED database, inflation is proxied by the consumer price index and gathered from the OECD economic database. To purge the seasonal movements, the Census X-12 ARIMA approach is applied to all series, and the output gap is estimated by applying Hodrick – Prescott Filter on the de-seasonalised real GDP. Due to

Table 2. Kapetanios – Shin – Snell unit root tests

Variables in level	LOGCPI	OUTPUTGAP	LOGOIL
Countries	KSS Stat.		
Czechia	−0.981	−2.620	−2.327
Hungary	0.188	−2.625*	−2.203
Poland	−1.882	−3.676***	−2.341
Slovakia	0.098	−3.939***	−2.324
Slovenia	−1.982	−2.230	−2.203
Variables in First Differences	ΔLOGCPI	ΔOUTPUTGAP	ΔLOGOIL
Countries	KSS Stat.		
Czechia	−3.317***	−4.454***	−2.998**
Hungary	−2.867**	−3.414***	−4.027***
Poland	−3.956***	−3.111**	−4.035***
Slovakia	−2.572**	−3.000**	−4.024***
Slovenia	−5.976***	−2.566**	−4.528***

Note: ***, ** and * refer to 1%, 5% and 10% significance levels, respectively. Lag selections are based on Akaike Information Criteria.

the unavailability of some data, our sample size is constrained to 1996Q2 – 2017Q4 for Czechia, 1995Q4 – 2017Q4 for Hungary, 1995Q2 – 2017Q4 for Poland, 1996Q1 – 2018Q1 for Slovakia and 1995Q2 – 2017Q3 for Slovenia.

ARDL and NARDL co-integration tests strongly require that the regressors must be stationary in I(0) or I(1). Hence, we apply Kapetanios – Shin – Snell (KSS) (2003) test to determine the unit root properties of the series[2]. The unit root test results are presented in Table 2. The findings in Table 2 indicate that each series has a unit root in level except the output gap in Hungary, Poland and Slovakia. On the other hand, none of the series contain unit roots in the first differences. According to the KSS test results, we can move on to the cointegration tests, and hence, investigate a long-run relationships by employing ARDL and NARDL models.

6. EMPIRICAL RESULTS AND DISCUSSION

6.1. ARDL results

To select the optimal lag lengths, we utilize Akaike Information Criteria with maximum of six lags. Also, we check the parameter instability and structural breaks with CUSUM and

[2]We obtain similar results when we apply other unit root tests such as KPSS and ADF. These results are not reported for space considerations but available from authors.

CUSUMSQ tests. If we detect any parameter instability over time, dummy variables are employed to correct the structural breaks and trend misspecifications. Further, we report some diagnostics tests such as LM and ARCH for autocorrelation and heteroscedasticity, respectively. Panel C in Table 3 confirms that there are no autocorrelation and heteroscedasticity problems in all our estimations.

F_{pss} tests confirm the existence of a co-integration between CPI and independent variables for Czechia, Poland and Slovakia. For the Czechian case, there is no significant relationship between oil prices and inflation but the coefficient on lagged inflation implies inertia in the long-run. In the Polish case, there is a positive association between oil prices and inflation in the long-run. This result shows the importance of world energy price variations on the domestic prices. Since Poland imports its oil needs, this result is not surprising. Additionally, we should also note that the coefficient on the output gap has a positive effect on the inflation in the long-run in Poland. It seems that this result is in line with the theoretical explanations of Augmented Phillips Curve. In other words, when the output gap reveals an upward trend then there will be inflationary pressures on the domestic prices. This result is consistent with Cunado – Perez De Gracia (2003) and Long – Liang (2018). On the other hand, in the short-run, there is also a positive relationship between the output gap and inflation in Poland. Another important result in Table 3 is that the lagged inflation is significant in some cases (e.g. Czechia and Poland), implying an inertia in the inflation rate in the short-run. It seems that neither changes in oil prices nor the output gap exert a significant impact on the inflation rate in Slovakia in the long-term.

6.2. NARDL results

Table 4 presents the empirical results related to the NARDL equation. Panel C in Table 4 indicates a long-run relationship between inflation and regressors in Czechia, Hungary, Poland and Slovenia by means of F_{pss} test. However, we do not find any cointegrating relationship for Slovakia. Our findings suggest that positive changes in the oil prices have a positive effect on inflation in the long-run for Czechia, Hungary and Poland. Another important result is that both the long-run negative and positive changes in oil price significantly affect the inflation in Hungary. In this case, a negative (positive) oil price shock leads to a fall (rise) in inflation. Additionally, for the Polish and Slovakian cases, there is a positive relationship between the output gap and inflation in the long-run. Moreover, negative and positive changes in oil prices have significant effects on the inflation in the cases of Hungary, Poland and Slovenia in the short-run. We should also note that the coefficient of the output gap in Poland is significant. These results imply that in the short-run negative and positive shocks in oil prices play a significant role in explaining the inflation rate in the CEE countries.

The asymmetry tests W_{lr} are presented in Panel D. It appears that the long-run asymmetry is valid for the cases of Czechia, Hungary and Poland. We also control the short-run negative and positive cumulative effects via S– and $S+$, respectively. We conclude that in the short-run the negative changes in oil prices have significant effects on the inflation and also an asymmetry exists for Slovenia. Lastly, the diagnostics tests suggest that there are no autocorrelation, heteroscedasticity, and parameter instability problems in our estimations.

Table 3. ARDL results

	Czechia	Hungary	Poland	Slovakia	Slovenia
Variables	*Panel A: Short-run coefficients*				
ΔLOGCPI(-1)	−0.009	0.529***	0.189*		−0.059
ΔLOGCPI(-2)	0.223	−0.320***	−0.176**		0.026
ΔLOGCPI(-3)	−0.202***	0.097	−0.088		−0.169**
ΔLOGCPI(-4)		0.439***	0.582***		0.576***
ΔLOGCPI(-5)		−0.363***	−0.182**		
ΔOUTPUTGAP	−0.005	0.016	0.017*	−0.008	−0.005
ΔOUTPUTGAP(-1)		0.018		−0.012	0.006
ΔOUTPUTGAP(-2)		−0.051***		−0.017**	0.014*
ΔOUTPUTGAP(-3)				0.020**	−0.01
ΔLOGOIL	0.010	0.015***	−0.006*	0.01	0.021***
ΔLOGOIL(-1)	−0.011*	−0.017***		0.004	
ΔLOGOIL(-2)				0.026	
Variables	*Panel B: Long-run coefficients*				
C	0.164***	0.108***	0.139***	0.080***	0.089***
LOGCPI(-1)	−0.038***	−0.028	−0.033***	−0.014	−0.021***
OUTPUTGAP(-1)	0.016	0.008	0.029**	0.007	0.007*
LOGOIL(-1)	0.004	0.005**	0.003*	−0.003	0.002
	Panel C: Diagnostic tests				
Fpss	6.274***	4.064	4.444*	11.103***	3.321
R^2	0.371	0.878	0.837	0.552	0.782
Adjusted R^2	0.298	0.857	0.812	0.473	0.740
LM Prob.	[0.111]	[0.517]	[0.197]	[0.529]	[0.982]
ARCH Prob.	[0.210]	[0.393]	[0.118]	[0.407]	[0.719]
CUSUM	Stable	Stable	Stable	Stable	Stable
CUSUMSQ	Stable	Stable	Stable	Stable	Stable

Note: *, ** and*** indicate the significance at 10%, 5% and 1% levels, respectively. F_{pss} test represents *F* test statistics provided by Pesaran et al. (2001). LM and ARCH represent autocorrelation and heteroscedasticity tests, respectively. CUSUM and CUSUMSQ tests indicate parameter stability. Numbers that are in square brackets represent the probability values. Lag selections are based on Akaike Information Criteria with maximum of six lags.

Table 4. NARDL results

	Czechia	Hungary	Poland	Slovakia	Slovenia
Variables	*Panel A: Short-run coefficients*				
ΔLOGCPI(-1)	0.127	0.489***	0.111	−0.038	−0.023
ΔLOGCPI(-2)	0.170	−0.374***	−0.208**	−0.050	−0.167**
ΔLOGCPI(-3)	−0.173*	0.026	−0.157*	−0.057**	−0.337***
ΔLOGCPI(-4)	0.226**	0.372***	0.540***	0.381	0.447***
ΔLOGCPI(-5)	−0.271**	−0.374***	−0.146*		−0.237***
ΔOUTPUTGAP	−0.017	0.011	0.018*	−0.005	−0.009
ΔOUTPUTGAP(-1)		0.015		−0.015**	
ΔOUTPUTGAP(-2)		−0.049***		−0.026	
ΔOUTPUTGAP(-3)				0.012	
ΔLOGOIL_NEG	0.006	0.015**	0.006***	−0.002	0.031***
ΔLOGOIL_NEG(-1)		−0.011**		0.021*	
ΔLOGOIL_NEG(-2)				0.032**	
ΔLOGOIL_NEG(-3)				0.018	
ΔLOGOIL_POS	0.013	0.017*	0.028***	0.028	−0.003
ΔLOGOIL_POS(-1)	−0.015	−0.024**	−0.004		
ΔLOGOIL_POS(-2)	−0.017		0.001		
ΔLOGOIL_POS(-3)	0.018*		0.017**		
ΔLOGOIL_POS(-4)	−0.003		−0.012		
ΔLOGOIL_POS(-5)	−0.019*				
Variables	*Panel B: Long-run coefficients*				
C	0.324**	0.246***	0.276***	0.048	0.103***
LOGCPI(-1)	−0.075**	−0.060***	−0.065***	−0.009	−0.018*
OUTPUTGAP(-1)	0.011	0.008	0.031**	0.011*	0.012***
LOGOIL_NEG(-1)	0.002	0.005**	0.001	−0.005	0.001
LOGOIL_POS(-1)	0.006*	0.010***	0.005***	−0.004	−0.002
	Panel C: Diagnostic tests				
Fpss	4.717**	5.613***	7.659***	3.059	7.828***
R^2	0.560	0.892	0.871	0.664	0.741
Adjusted R^2	0.444	0.868	0.839	0.577	0.702
LM Prob.	[0.529]	[0.226]	[0.139]	[0.676]	[0.307]

(continued)

Table 4. Continued

	Czechia	Hungary	Poland	Slovakia	Slovenia
ARCH Prob.	[0.371]	[0.185]	[0.299]	[0.654]	[0.997]
CUSUM	Stable	Stable	Stable	Stable	Stable
CUSUMSQ	Stable	Stable	Stable	Stable	Stable
	Panel D: Asymmetry tests				
L–	0.021	0.094***	0.02	−0.525	0.037
L+	0.080***	0.175***	0.084***	−0.442	−0.102
S–	0.006	0.004	0.006	0.069***	0.031***
S+	−0.022	−0.006	0.031	0.028	−0.003
Wsr	0.029	−0.011	0.024	−0.041	0.035**
Wlr	−0.058***	−0.081***	−0.064***	−0.083	0.139

Note: *, ** and*** indicate the significance at 10%, 5% and 1% levels, respectively. F_{pss} test represents *F* test statistics provided by Pesaran et al. (2001). LM and ARCH represent autocorrelation and heteroscedasticity tests, respectively. CUSUM and CUSUMSQ tests indicate parameter stability. *L*– and *L*+ represent long-run negative and positive effects while *S*– and *S*+ denote the short-run cumulative negative and positive effects, respectively. Wsr and Wlr indicate short- and long-run asymmetry. Numbers that are in square brackets represent the probability values. NARDL lag selections are based on Akaike Information Criteria with maximum of six lags.

7. CONCLUSION

Our study examined the effects of changes in the global oil prices on the inflation rate in Czechia, Hungary, Poland, Slovenia and Slovakia in the Augmented Phillips Curve framework by the means of ARDL and NARDL approaches. Using the linear ARDL method we report a cointegrating relationship for Czechia, Poland and Slovakia. We find a positive (negative) relationship between the changes in oil prices and the inflation rate in Poland in the long- (short-) run. More specifically, for long- (short-) run case, a 10% increase in global oil prices will generate 0.03 (0.06)% increase (decrease) in inflation for the Polish case. Additionally, it seems that the changes in oil prices have significant effects on the inflation rate in the long-run for Czechia and Hungary. Moreover, it seems that the output gap has a significant impact on the inflation rate in Poland in the long-term. Finally, there exists a strong inflation inertia in Czechia and Poland.

As for NARDL results, a long-run relationship is found in Czechia, Hungary, Poland and Slovenia. Our findings suggest that a positive change in the oil prices positively affects the inflation rate while a negative change does not exert any significant effect in Czechia and Poland in the long-run. On the other hand, the long-run negative and positive changes in oil prices significantly impact the inflation rate in Hungary. More importantly, we find an asymmetric effect of changes in the oil prices on the inflation rate in Czechia, Poland and Hungary in the long-run. Although, changes in the oil prices affect the inflation rate in Czechia, Poland, Hungary and Slovenia, an asymmetric effect is detected only in Slovenia in the long-run.

Moreover, there is a positive relationship between the output gap and inflation in Poland and Slovenia in the long-run.

We think our empirical results indicate some important points. 1) It seems that changes in the global oil prices matter in explaining the inflation rate in the sample countries confirming the role of supply shocks. This also suggests that it is more reasonable to treat the changes in oil price as aggregate supply rather than demand shocks in this context. 2) Distinguishing between negative and positive shocks in the oil prices is crucial to capture the exact relationship. 3) We conclude that the augmented Phillips Curve is a useful framework to examine the inflation dynamics. Moreover, the significant coefficient on the output gap demonstrates the need to account for the demand side effects as well. 4) There is a strong inertia in the inflation rate, implying the importance of using a dynamic specification. 5) Interestingly, a positive change in oil prices has a significant impact on the inflation rate in Czechia, Poland and Hungary, all of them are not the part of Euro area, while in Slovenia and Slovakia, both Euro area countries, changes in oil prices don't have any significant impact on the inflation rate in the long-run. 6) Since there are considerable differences regarding the effects of oil prices on the inflation rate among our sample countries, we conclude that the country specific or time series studies would be more helpful.

As for policy implications, we should first point out that there are well-known difficulties in designing and implementing economic measures against shocks such as a sharp change in oil prices. For example, it is important to decide whether a shock in oil prices is temporary or permanent before formulating macroeconomic policies. Nonetheless, keeping the difficulties in mind, policy makers have some options available at their disposal. More specifically, to prevent the inflation rate from rising, policy makers could use the contractionary policies when a sharp increase occurs in the oil prices. It seems that Czechia, Hungary and Poland would use both monetary and fiscal policy options since they are not a part of the Euro area. On the other hand, note that this comes at the expense of destabilizing the output more. Another option is to manage the expectations of economic agents. In this way, the economy could rapidly return back to the long-run equilibrium without a long-lasting impact on the inflation rate and output. We are fully aware that this suggestion is easier said than done. However, a credible policy supported by a strong institutional structure and coherent policy framework would make it possible and less costly. Moreover, since the negative changes in oil prices do not impact the inflation rate in the long-run, except the case of Hungary, we conclude that there is no need for specific economic policy measures when oil prices decline in terms of the inflation objectives. Finally, our findings clearly imply that the fine-tuning is neither necessary nor advisable in this context.

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