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Aggregated Inflation in Poland: Examining Impact of the Energy Commodity Global Prices

Abstract: The relationship between energy commodity prices and inflation has important implications for fiscal policy and economic stability. The nature of energy commodities is multi-dimensional, serving both as basic raw materials in production processes and as critical consumer goods. This study focuses on estimating the impact of oil, natural gas and coal prices on inflation in Poland. Through the adoption of multiple regression models using quarterly data from Q2 2000 to Q3 2023, the study aims to estimate the impact of energy commodity prices, particularly oil, coal, and natural gas, on inflation in Poland and to answer the research question: What role do energy commodity prices play in shaping inflation in Poland? The empirical analysis revealed that oil and coal prices significantly influence inflation, reflecting Poland's energy dependency. Natural gas prices showed a limited impact due to lower consumption and mitigation policy measures. The significant impact of energy prices suggests that energy market developments should be closely monitored for their inflationary potential. The study offers valuable insights for policymakers in their efforts to effectively manage inflationary pressure. The article contributes to the literature by presenting the short-run relationship between inflation and energy commodity prices, covering long period of time with both financial, COVID-19 crisis and the Russian aggression in Ukraine.

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Introduction

The interplay between energy commodity prices and inflation is important for its profound implications for fiscal policy and economic stability (Abdallah, Kpodar, 2023; Bednář et al., 2022; Ibrahim Anyars, Adabor, 2023; Mirza et al., 2023). The complexity of this relationship stems from the multifaceted nature of energy commodities, which serve as both basic raw materials in production processes and critical consumer goods. Their prices are characterised by high volatility, influenced by a myriad of factors such as geopolitical events, natural disasters, market speculation and technological advances (Garratt, Petrella, 2022; Huawei, 2022; Min, 2022; Sharif et al., 2020). These price fluctuations have far-reaching consequences, permeating different sectors of the economy and affecting both production costs and consumer spending (Fasanya, Awodimila, 2020; Kilian, 2008; Thalassinos et al., 2012).

Understanding the impact of energy prices on inflation is crucial for policy makers, businesses and households (Chiang, Chen, 2023; Garratt, Petrella, 2022; Kilian, Zhou, 2023; Zheng et al., 2023). To policymakers, anticipating and managing inflationary pressures is essential to maintain economic stability. Inflation erodes purchasing power, distorts spending and saving decisions and, if not controlled, can lead to significant economic disruption (Abdallah, Kpodar, 2023; Bednář et al., 2022; Rubbo, 2024). Businesses need to manage their cost structures and pricing strategies in response to changes in energy prices, while households face direct impacts on the cost of living, especially in terms of expenditure on transport, heating and electricity. Households, particularly those with lower incomes, tend to experience a heightened financial burden during periods of increasing energy prices, as energy expenditures constitute a substantial portion of their budgets. Consequently, these changes often impact their consumption patterns and savings behaviour (Abdallah, Kpodar, 2023; Bednář et al., 2022; Bettarelli et al., 2023; Coletti et al., 2021; Kilian, Vigfusson, 2011; Kilian, Zhou, 2023; Rubbo, 2024; Śmiech et al., 2021).

The aim of the study is to estimate the impact of energy commodity prices, particularly oil, coal, and natural gas, on inflation in Poland and to answer the following research question: What role do energy commodity prices have in shaping inflation in Poland? The empirical analysis was based on multiple regression models built using simple OLS.

The article was organised as follows: the next section presents the impact of energy and energy commodity prices on inflation. The third section focuses on the research methodology, including data collection and analysis methods. Subsequently, an empirical analysis is presented that estimates energy commodity prices on inflation in Poland. The final section summarises the main results of the analysis and provides directions for further research.

Literature Review

The energy sector is one of the key drivers of the economy, as highlighted by numerous studies (Bórawski et al., 2019; Chiou-Wei et al., 2008; Karasek et al., 2023; Mirza et al., 2023; Ozcan, Ozturk, 2019). Energy is a fundamental ingredient for both industrial production and consumers. Thus, the stability and development of the energy sector has a direct impact on economic growth, business competitiveness and job creation (Dergiades et al., 2013; Gozgor et al., 2018; Narayan, Smyth, 2005). Energy is also seen as a strategic asset, which requires the involvement of decision-makers at the economic and geopolitical level (Kivimaa et al., 2022).

Energy prices have a key impact on inflation, both globally and domestically. Increases in oil, gas or coal prices affect production costs in almost all sectors of the economy, leading to higher consumer prices (Hamilton, 2011; Peersman, Van Robays, 2009). Supply and demand shocks in the energy sector have complex effects on the macroeconomy, affecting inflation and economic activity (Mirza et al., 2023; Van De Ven, Fouquet, 2017). When analysing the impact of energy prices on inflation, it is worth noting historical events that have significantly shaped global inflation trends. The oil shocks of the 1970s are one of the most prominent examples of how sudden changes in energy prices can affect inflation and the global economy. As a result of the oil embargo imposed by OPEC countries in 1973, oil prices skyrocketed, leading to stagflation (Hamilton, 1983; Ibrahim Anyars, Adabor, 2023; Kilian, 2008; Van De Ven, Fouquet, 2017). The rise in oil prices in the 1970s had a dramatic impact on the economies of developed countries. Production costs in various sectors rose significantly, which translated into higher consumer prices. Central banks were forced to tighten monetary policy, which in turn led to a slowdown in economic growth. This historical period is a key example of how price shocks in the energy sector can destabilise entire economies (Kilian, 2009; Van De Ven, Fouquet, 2017).

Another significant event that affected energy prices and inflation was the global financial crisis of 2008–09. In the run-up to the crisis, oil prices reached record levels, approaching USD 150 per barrel in mid-2008 (Hamilton, 2011). The financial crisis caused a sharp decline in demand for energy, which in turn led to oil prices falling to around USD 40 per barrel in early 2009. Although the fall in energy prices may have seemed like a positive development, the financial crisis had long-lasting effects on the global economy. Rising unemployment and falling consumption reduced inflation, but the recovery has been slow and uneven. Monetary policy in many countries focused on stimulating the economy through low interest rates and quantitative easing programmes, which had repercussions on subsequent increases in inflation (Álvarez et al., 2011; Bednář et al., 2022; Hamilton, 2011; Van De Ven, Fouquet, 2017).

Fluctuations in energy prices, triggered by the COVID-19 pandemic and the war in Ukraine, have had a direct impact on global inflation in previous years (Qiao et al., 2023). The COVID-19 pandemic caused significant disruptions in global supply chains, leading to an imbalance between energy supply and demand, resulting in higher oil prices (Siksnelyte-Butkiene, 2021). In turn, the war in Ukraine has exacerbated these problems, causing additional shocks to energy markets (Bettarelli et al., 2023). The increase in energy prices has been felt to varying degrees depending on the region. Countries heavily reliant on energy imports, such as many european countries, have felt the impact of rising energy prices particularly strongly, which has translated into higher inflation rates (Grodzicki et al., 2023).

The asymmetric impact of energy commodity prices on economic activity constitutes another significant area of research. The degree of asymmetry can have varied implications for individual economies (Agboola et al., 2024). Crude oil remains a primary energy source, playing a pivotal role in the economy (Śmiech et al., 2021). The literature widely recognizes the existence of an asymmetric relationship between oil prices and economic activity (Herrera et al., 2015). The asymmetry pertains to the effects of increases and decreases in oil prices (Brown, Yücel, 2002; Leszkiewicz-Kędzior, Welfe, 2014). As noted by Dąbrowski et al. (2022), responses to oil market shocks are characterized by heterogeneity and vary depending on the country and its level of economic development. Furthermore, unexpected changes in oil prices contribute to uncertainty, leading to reduced corporate spending and constrained household consumption (Brown, Yücel, 2002; Dąbrowski et al., 2022; Herrera et al., 2015). Additionally, Agboola et al. (2024) demonstrated that fluctuations in oil prices are associated with the cyclicality of government expenditures, which can influence production variability.

As a country heavily dependent on fossil fuels for the production of electricity and heat, Poland is vulnerable to changes in energy prices on global markets (Bórawski et al., 2023). In recent years, inflation in Poland has been largely driven by increases in energy prices, which is given particular prominence in the context of the war in Ukraine and related economic sanctions (Grodzicki et al., 2023; Prokopowicz, 2023). This has had a direct impact on production costs and consumer prices. In 2021, energy accounted for almost 13% of the Polish HICP consumption basket, making inflation in Poland one of the highest in the EU (Grodzicki et al., 2023). Government interventions, such as coal subsidies, aimed to mitigate the impact of rising energy prices on consumers, but at the same time contributed to increased demand and further price increases (Prokopowicz, 2023).

The energy sector plays a key role in shaping economic growth and macroeconomic stability. The impact of energy prices on inflation is significant, and events such as the COVID-19 pandemic and the war in Ukraine have highlighted the global vulnerability to energy shocks and political uncertainty (Agboola et al., 2024). Poland, as a country dependent on fossil fuels, is particularly exposed to these developments, highlighting the need for strategic interventions and energy policies to minimise negative economic impacts and ensure long-term inflationary stability. The next chapter describes in sufficient detail, the material and methods, which should enable others to replicate and use the published results.

Empirical setting and data

The aim of the study is to estimate the impact of energy commodity prices, particularly oil, coal, and natural gas, on inflation in Poland. Data used for the analysis of this study is quarterly time series data ranging from Q2 2000 to Q3 2023 obtained from several sources (Table 1. briefly describes all the variables and sources used for the analysis). Data of the inflation, oil, gas and coal prices are also presented on the Figure 1. To get a deeper insight into the association between energy commodity prices and inflation, we use the econometric model to study the impact of energy commodities price changes on headline CPI while controlling for other variables that influences inflation. Although there are potentially numerous factors that affect inflation, we use the output gap, exchange rate, and interest rate as our control variables that are mostly used in economic literature to control for inflation (Anwar et al., 2017; Bass, 2019; Ibrahim Anyars, Adabor, 2023; Ibrahim, Said, 2012). It is good to mention that there is ongoing debate about relationship between oil, gas and coal prices among themselves. Many studies have indicated that oil prices are leading the energy market, while coal and gas prices follow changes in oil prices (Brown, Yücel, 2008; Oberndorfer, 2009; Mohammadi, 2011). However, in this study we also want to investigate, if data of each prices carry the same information and thus the entire effect is reflected in oil prices. Therefore we investigate the relationship between inflation and energy commodity prices, both separately and together.

Table 1. Variable description

Variable	Description	Source
Consumer Price Index (CPI)	CPI represents the overall average prices of goods and services including food and energy (year-over-year quarterly inflation).	Statistics Poland
Output Gap (OG)	Output gap is computed by finding the difference between the actual GDP and projected GDP adjusted for inflation (US dollars, quarterly). A positive output gap is where the actual GDP is greater than the projected or potential GDP. Similarly, a negative gap is where the projected or potential GDP is greater than the actual GDP. The positive output gap creates an inflationary shock and the negative creates a recessionary gap.	OECD
Real Effective Exchange Rate (REER)	Exchange rate is the rate at which a domestic currency is traded against a particular foreign currency. The inclusion of the exchange rate as an independent variable is due to the openness of Poland to the international market.	OECD
Interest Rate (IR)	Interest rate is the monetary policy rate set by National Bank of Poland with the main aim of stabilizing inflation, and, hence, a very essential tool in the money, capital, and goods market. In this study we use the reference rate – yield on money bills issued by the National Bank of Poland during main open market operations.	Statistics Poland
Oil Price (OP)	As a proxy for the oil price in this study, we chose the Brent oil price. Brent Crude is well known as a benchmark for the oil market around the world (US dollars *per* Barrel, quarterly, not seasonally adjusted).	FRED
Coal Price (CP)	As a proxy for the coal price in this study, we chose the Australian Newcastle coal price (US dollars *per* Metric Ton, quarterly, not seasonally adjusted). Australia is one of the biggest exporters of coal in the world and the coal mined there is well known as a benchmark for the global coal market.	FRED
Natural Gas Price (GP)	As a proxy, we chose the global price of the natural gas, as provided by FRED (US dollars *per* Million Metric British Thermal Unit, quarterly, not seasonally adjusted).	FRED

Source: Own elaboration; access to data 19 June 2024

To examine the impact of energy commodity prices on inflation we follow previous studies Ibrahim Anyars, Adabor, 2023; Ibrahim, Said, 2012) and specify a general model as:

$$\Delta CPI_t = f(\Delta OG, REER, IR, ECP) \quad (1)$$

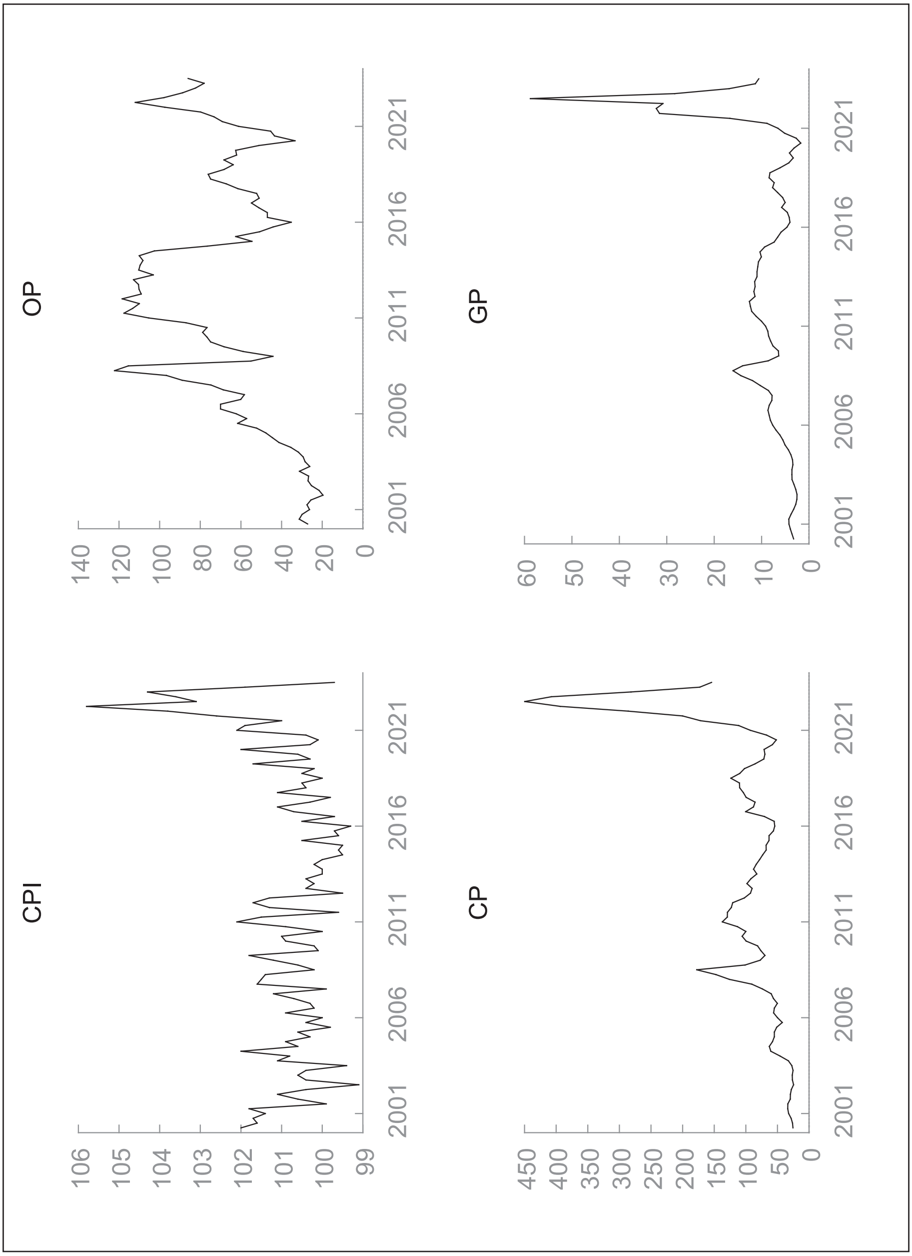
where ΔCPI_t represents inflation, ΔOG, REER, IR represents output gap, exchange rate and interest rate, ECP represents energy commodity prices, which will be added to the model both separately (coal, gas, oil) and together.

Equation (1) is specified bellow in an estimable form:

$$\Delta lnCPI_t = \beta_0 + \beta_1\, \Delta lnOG_t + \beta_2\, lnREER_t + \beta_3\, lnIR_t + \beta_4\, lnECP_t + \varepsilon_t \quad (2)$$

where all the variables are explained earlier in equation (1). β_0 is intercept and is the error term. The parameters β_i (i = 1, 2…, 4) are the coefficient of the respective variables represent the natural log.

Figure 1. Headline CPI and energy commodity prices (USD)



Source: Own elaboration; access to data 19 June 2024

To estimate the parameters, it was necessary to test the stationarity properties of the variables used in equation (2). This is so because using non-stationarity time series data could generate biases in our estimates which is associated with drawing an invalid conclusion. Each variable was examined using the Augmented Dickey-Fuller and KPSS tests (Fuller, 1976; Kwiatkowski et al., 1992) for the presence of a unit root. The results are presented in Table 2.

We also investigated for a potential long-run relationship, using Engle-Granger (1987) cointegration test. However, we find no stationarity of residuals in conducted model, thus there is no point in further long-run analysis. Although it is good to mention, there could be a presence of long-run relationship using ARDL bound testing method (Pesaran, Shin, 1999; Pesaran et al., 2001), which is more reliable for low amount of observations. If there is a cointegration among variables, we could perform a threshold cointegration approach (Enders, Granger, 1998; Enders, Siklos, 2001) to catch asymmetric relationship between energy commodity prices and inflation. The asymmetric relationship between economic activity and energy commodity price shocks is investigated in many studies (Geise, Piłatowska, 2015; Herrera et al., 2015; Leszkiewicz-Kędzior, 2014; Leszkiewicz-Kędzior, Welfe, 2014; Mork, 1989; Mork et al., 1994). However, as we find no long-run relationship using Engle-Granger cointegration test, we assumed more simplified linear relationship between variables.

Table 2. ADF and KPSS unit root tests

Variable	Augmented Dickey-Fuller		Kwiatkowski–Phillips–Schmidt–Shin	
	Levels	1st Diff.	Levels	1st Diff.
lnCPI	–3.64***	–4.81***	0.43	0.24
lnOG	–5.67***	–8.49***	0.08	0.03
lnREER	–4.02***	–6.90***	0.16	0.04
lnIR	–2.62*	–7.39***	1.60	0.11
lnOP	–2.12	–7.84***	1.13	0.08
lnCP	–2.60*	–5.48***	1.71	0.05
lnGP	–2.77*	–3.82***	0.73	0.05

Source: Own elaboration; ***, ** and * denote significance at 1%, 5% and 10% respectively. Critical values for KPSS test are 0.734, 0.462 and 0.349 for significance at 1%, 5% and 10% respectively

Despite the fact that the model described by equation (2) includes most variables in their levels, the results of the ADF and KPSS tests indicate that using such variables could lead to spurious regression. However, all variables are stationary after being transformed into first differences – the logarithmic rates of growth. We also added the lagged value of the inflation growth rate, after we ran several of first models and investigated a problems with residual component. Thus we also added several dummy variables to ensure the residuals follow a normal distribution. Therefore, the final core model used in the study is described as follows:

$$\Delta \ln CPI_t = \beta_0 + \beta_1 \Delta \ln CPI_{(t-1)} + \beta_2 \Delta \ln OG_t + \beta_3 \ln REER_t + \beta_4 \Delta \ln IR_t + \\ + \beta_5 \Delta \ln ECP_t + \beta_6 dummy_{(1,t)} + \cdots + \beta_9 dummy_{(4,t)} + \varepsilon_t \quad (3)$$

where most of the variables and parameters are similar to those used in equation (2); $dummy_1$ represents the Q3 2023, during which Poland experienced a strong disinflationary process associated with a significant drop in global grain prices; $dummy_2$ represents the period Q4 2000-Q1 2001, during which we find inflation changes were associated to internal processes related to the country's structural reforms; $dummy_4$ represents Q1 2020, which is the first quarter of the presence of COVID-19 in Europe, particularly in Poland; represents Q2 2022, during which Poland $dummy_4$ experienced a significant increase in inflation due to Russia's aggression against Ukraine and the resulting trade restrictions, including agricultural products.

Additionally we decided to build models of delayed changes in energy commodity growth rate of prices (models (2), (4) and (6)). To do this, we simply introduced a lagged forms of each energy commodity prices used in the analysis. We only use the first lag of the variables, as we investigate the structure of them using PACF function and find significant autocorrelation of first lags. Therefore for models (2), (4), (6) and we specify equation as follows:

$$\Delta lnCPI_t = \beta_0 + \beta_1 \Delta lnCPI_{(t-1)} + \beta_2 \Delta lnOG_t + \beta_3 lnREER_t + \beta_4 \Delta lnIRt + \\ + \beta_5 \Delta lnECP_{(t-1)} + \beta_6 dummy_{(1,t)} + \cdots + \beta_9 dummy_{(4,t)} + \varepsilon_t \quad (4)$$

Models (7) and (8) are built using together every of energy commodity price growth rates variable. Model (7) is built using energy commodity price growth rates in time *t*, while model (8) use their lagged values. Model (9) is compilation of previous models, which takes into account all ECP growth rate variables, both in time *t* and lagged. However, this model has 15 parameters and we use data set of 92 observations. Therefore, we need to take into account the presence of overfitting problem. The equations are resemble as used previously.

In order to conduct the analysis, multiple regression models were built using simple OLS. The significance of individual parameters was verified using the Student's *t*-test. The R^2 coefficient was used to assess the goodness of fit of the model to the data. The properties of the residuals were verified using several statistical tests. For checking the compliance of the residuals with the normal distribution we used Doornik Hansen, Shapiro-Wilk and Jarque-Bera tests. White test was used to check homogeneity of the variance. Durbin-Watson test and Ljung-Box were used to check for the autocorrelation between the residuals. Additionally, we investigated for any ARCH effect in the residuals.

The choice of research methods and the verified data sources used to conduct the analysis allowed the validity and reliability criteria to be met. Thus, the research carried out can be replicated.

Results and discussion

This section presents results from the study, and they are presented in the following chronological order. First, we present the results of the models we ran and the results of the tests performed. Secondly, we discuss the consistency of our model results with other studies on the inflation, especially from the CEE region.

Table 3. contains results of diagnostics tests of the residuals, specifically the *p*-values for tests performed. The residual component of all models is characterized by homogeneity of variance at each of the conventional levels of significance, as indicated by the White test results. Variance of the residuals also is not corelated with lagged values of the residual component, as indicated by ARCH-LM test results. Doornik-Hansen,

Shapiro-Wilk and Jarque-Bera indicates compliance of the residual component with the normal distribution – mostly – at all conventional levels of significance. Results for Ljung-Box autocorrelation test suggests, that there are symptoms of autocorrelation of residual component. However, assuming level of significance at 1%, we cannot reject the null hypothesis, which states that the residual component does not have an autocorrelation of order 5.

Table 3. Diagnostic tests results

Diagnostic tests estimates (p-value)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
White	0.13	0.27	0.44	0.61	0.26	0.34	0.34	0.48	0.80
ARCH-LM	0.45	0.51	0.44	0.70	0.32	0.44	0.50	0.34	0.14
Ljung-Box	0.07	0.05	0.03	0.03	0.04	0.04	0.07	0.03	0.10
Doornik-Hansen	0.45	0.16	0.23	0.64	0.24	0.20	0.50	0.62	0.81
Shapiro-Wilk	0.19	0.10	0.06	0.40	0.10	0.11	0.24	0.89	0.86
Jarque-Bera	0.58	0.13	0.24	0.81	0.23	0.18	0.65	0.91	0.94

Source: Own elaboration

Based on the above-described results of the model analysis, it should be concluded that at the significance level of 1%, the residual components meet most of the desired statistical properties, which proves the good specification of the model and its high power explaining the dynamics of Poland's inflation in the adopted time period. This should allow for a correct inference regarding the results of the estimation of structural parameters for individual variables and their interpretation.

Table 4. reports results obtained from the models for all energy commodity change of prices, both current and lagged by one period. The results of the estimated models indicate that it was possible to explain a high degree of variance in the observed phenomenon, which is confirmed by the high values of the $R2$ coefficient for each model. The Durbin-Watson statistics indicate there is no statistically significant autocorrelation of the residual term.

In every model, lagged change in CPI can be related positively with current change of CPI. Specifically, a 1% increase in lagged growth rate of CPI is associated with 0.269–0.402% (depending on which model) increase in growth rate of CPI variable in current period.

$\Delta lnOG$ turned out to be statistically insignificant in most of models we have built, although the relationship is positive. Results for model (9) is significant and indicates, that a 1% increase in growth rate of output gap can be related with 0.015% increase in growth rate of CPI variable. The positive relationship between the output gap and inflation could be attributed to the fact that increase in the output gap reflects an increase in economic activities. This could lead to a significant increase the demand for goods and services that may outweigh the supply on the market. A higher output gap could lead to demand-pull inflation (Machlup, 1960).

Real effective exchange rate ($lnREER$) exerts a significant and negative impact on inflation. Increase by 1% in real effective exchange rates can be related to decrease in growth rate of CPI by 0.021–0.028%. The real effective exchange rate is a stimulus responsible for inflation, especially among countries that are heavily dependent on oil imports (Sek et al., 2015). Additionally, real effective exchange rate is not only a measure of marginal costs, but is closely related to the internal demand pressure: when the real effective exchange rate is above the trend, the domestic price level is below the price level of trading partners which will cause demand pressure, which should bring the domestic price level in line with foreign prices (Celasun et al., 2004).

The interest rate has a significant positive impact on inflation. 1% increase in interest rate growth is associated with 0.007–0.009% increase in inflation growth rate. The significant positive linkage between the interest rate and CPI shows the importance of the interest rate as a monetary policy instrument for controlling inflation. These findings are consistent with other studies about the linkage between interest rates and inflation (Kollmann, 2021).

1% increase of the current oil price growth rate lead to 0.010–0.013% increase in polish inflation growth rate. The relationship is statistically significant. However, lagged change of oil prices lead to decrease in current inflation in models (8) and (9). We suppose, that this relationship is a spurious linkage. There is no reason why Poland, as a so-called small open economy, would have an opposite relationship between global oil prices and inflation. These outcomes are consistent with other studies, where oil prices significant affects inflation (Álvarez et al., 2011; Ibrahim Anyars, Adabor, 2023; Misztal, 2011) Oil should be seen as one of the important factors contributing to the spread of inflation in the short term of the business cycle. In addition, most of the volatility in oil prices is passed on to the consumer side, as reflected in higher prices for goods and services (Elsayed et al., 2021). In the long term, oil prices may not have an impact on inflation due to the persistence of inflation (Elsayed et al., 2021; Salisu et al., 2017).

Growth rate of coal global prices turned out to be positive and statistically significant, both lagged and current values. 1% increase in current growth rate of global coal prices can be related to 0.004–0.010% increase in inflation growth rate. Additionally, the same level of increase in lagged growth rate of coal prices can be related to 0.018–0.023% increase in polish inflation growth rate. We suppose, that both, lagged and current, relationship can be relevant. Coal is an important factor for domestic inflation in Poland due to (1) the structure of the energy supply system and (2) its importance for household heating. In previous years, coal accounted for more than 45% of electricity generation and more than 67% of heat generation in Poland, respectively (Bijańska, Wodarski, 2024; Katarzyński, Przekota, 2024). A notable amount of this raw material is imported in advance due to e.g. the heating season. Global coal prices may therefore influence partly immediately, but also with some delay.

In case of global prices of natural gas and its linkage to inflation in Poland, there is an insignificant relationsip, between both current or lagged change of prices and inflation growth rate. We suppose, the reason why this relationship is insignificant, is due to a relative low (compares to oil and coal) usage of natural gas in production and household heating. In fact, when the global price of natural gas increased, Polish government temporarily cut the taxes to lower inflation pressure (Grodzicki et al., 2023). Another explanation could be the consistent demand for natural gas compared to oil. It is also pointed out that natural gas prices are stable and relatively low compared to other energy sources (Sharma, Escobari, 2018). There is also third

Table 4. Models estimation results

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
const.	0.103* (0.054)	0.098* (0.058)	0.105* (0.055)	0.131** (0.052)	0.109* (0.056)	0.104* (0.056)	0.105* (0.054)	0.111** (0.052)	0.098* (0.050)
ΔlnCPI(t-1)	0.402*** (0.069)	0.391*** (0.074)	0.353*** (0.070)	0.269*** (0.072)	0.374*** (0.072)	0.380*** (0.073)	0.384*** (0.071)	0.292*** (0.071)	0.333*** (0.070)
ΔlnOG	0.011 (0.074)	0.009 (0.008)	0.007 (0.008)	0.002 (0.007)	0.010 (0.008)	0.009 (0.008)	0.010 (0.008)	0.009 (0.008)	0.015* (0.008)
lnREER	-0.022* (0.012)	-0.021* (0.013)	-0.023* (0.012)	-0.028** (0.011)	-0.024* (0.012)	-0.023* (0.012)	-0.023* (0.012)	-0.024** (0.011)	-0.021* (0.011)
ΔlnIR	0.007*** (0.002)	0.009*** (0.002)	0.008*** (0.002)	0.007*** (0.002)	0.008*** (0.002)	0.009*** (0.002)	0.007*** (0.002)	0.008*** (0.002)	0.007*** (0.002)
ΔlnOP	0.013*** (0.004)						0.010* (0.005)		0.010** (0.005)
ΔlnOP(t-1)		-0.003 (0.005)						-0.010** (0.005)	-0.014*** (0.005)
ΔlnCP			0.010** (0.004)				0.004 (0.006)		0.004 (0.005)
ΔlnCP(t-1)				0.018*** (0.005)				0.023*** (0.005)	0.020*** (0.005)
ΔlnGP					0.003 (0.003)		0.001 (0.004)		0.002 (0.004)
ΔlnGP(t-1)						-0.000 (0.004)		-0.004 (0.003)	-0.005 (0.003)
$dummy_{\_1}$	-0.032*** (0.006)	-0.033*** (0.007)	-0.027*** (0.012)	-0.024*** (0.006)	-0.031*** (0.007)	-0.032*** (0.007)	-0.029*** (0.007)	-0.027*** (0.006)	-0.026*** (0.006)
$dummy_{\_2}$	-0.016*** (0.004)	-0.017*** (0.005)	-0.018*** (0.004)	-0.018*** (0.004)	-0.017*** (0.005)	-0.017*** (0.005)	-0.016*** (0.005)	-0.017*** (0.004)	-0.016*** (0.004)
$dummy_{\_3}$	0.022*** (0.006)	0.020*** (0.006)	0.019*** (0.006)	0.019*** (0.006)	0.020*** (0.007)	0.020*** (0.007)	0.021*** (0.006)	0.021*** (0.006)	0.024*** (0.006)
$dummy_{\_4}$	0.022*** (0.006)	0.024*** (0.007)	0.022*** (0.007)	0.022*** (0.006)	0.024*** (0.007)	0.024*** (0.007)	0.022*** (0.007)	0.020*** (0.006)	0.019*** (0.006)
*R*2	0.70	0.67	0.69	0.72	0.67	0.66	0.70	0.74	0.77
DW	2.15	2.17	2.30	2.18	2.18	2.18	2.18	2.22	2.27

Source: Own elaboration; ***, ** and * denote significance at 1%, 5% and 10% respectively explanation, which we discussed earlier about the leading role of oil prices compared to other energy commodities. The correlation between this two variables is relatively high, thus they may carry the same information. Nevertheless, in models (5) and (6) we investigated only the impact of natural gas growth rate of prices and we find no significant relationship.

Models contains also several dummy variables. As we have argued, their presence results only from the need to achieve the normal distribution of residuals.

Concluding remarks

The aim of this study was to estimate the impact of energy commodity prices on inflation in Poland using quarterly data for the period from Q2 2000 to Q3 2023. The analysis made it possible to answer the research question: What role do energy commodity prices have in shaping inflation in Poland? Subsequently, the empirical analysis revealed several key findings.

Lagged changes in the CPI significantly affect current inflation growth rate, indicating persistent inflationary trends. The real effective exchange growth rate negatively affects inflation growth rate, highlighting the importance of currency strength in managing the price level. Higher growth rates of IR correlate with higher growth rate of inflation, emphasising the complex short-term effects of monetary policy.

Oil and coal prices growth rates significantly affect growth rate of inflation, reflecting Poland's energy dependency. Natural gas prices have shown a limited impact on inflation due to lower consumption and mitigating policy measures. An additional explanation may be the much more consistent demand for natural gas compared to the less stable demand for oil.

The findings underscore the importance of exchange rate management and monetary policy in controlling inflation. The significant impact of energy prices suggests that energy market developments need to be closely monitored for their inflationary potential. The findings provide a solid understanding of the dynamics between energy commodity prices and inflation in Poland, offering valuable insights for policymakers in their efforts to effectively manage inflationary pressures. All the more so as the study of the behaviour of energy commodities and the direct and indirect impact of energy prices is crucial from the point of view of consumers, other mineral commodities, and the economy as a whole (Sharma, Escobari, 2018).

A limitation of the presented research is providing only short-term analysis and not taking into account asymmetry in the inflation response under the influence of energy commodity prices. Limitation is also the lack of information about the causality and impulse responses of inflation, which can show the formation of inflation in response to impulses from the energy commodity market. It is worth considering a multi-equation approach, perhaps a VECM model, or a VECM threshold, which will give the opportunity to investigate both the long-run relationship and asymmetry in the inflation response. Also it is good idea to extend models presented in this paper by adding money supply variables or by using weighted commodity prices (e.g. the share of a given commodity in consumption) to better reflect the structure of the relationship in a given country. In the context presented, further research is recommended. With this in mind, we plan to extend the study to other EU member states. In addition, we plan to look at other mineral raw materials, especially critical raw materials, which are essential for the energy transition.

An interesting aspect that could be included in further research is climate uncertainty. Studies conducted so far indicate that climate uncertainty contributes to inflationary pressures on agricultural products, food, energy commodities or non-energy commodities (Lucidi et al., 2024; Nam, 2021). Hence, understanding the economic consequences of climate uncertainty in an era of striving for climate neutrality seems a necessary step.

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