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# EVALUATING THE IMPACT OF ENERGY PRICE SHOCKS ON EMERGING COUNTRIES FROM THE NON-EURO AREA: A MACROECONOMIC ANALYSIS

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***Abstract:***

*Exogenous shocks like the COVID-19 pandemic or the Russian conflict affected the global economy, but mostly emerging economies. Even though the critical moments have passed, the negative effects on the economy are still present in the current economic environment, characterized by high levels of uncertainty. Exogenous events, which have an uncertain likelihood of occurring, harm economies regardless of their development. In fact, a framework for unanticipated events is vital, as are steps to achieve low levels of national debt and increased authority stability. In this context, the objective of this paper is to examine the dynamic relationships between energy prices and certain macroeconomic variables, which were affected by the fact that the energy crisis triggered by the Russian-Ukrainian conflict overlapped with the accelerated transition to a green economy and the decarbonization process. The CEE countries are more vulnerable to the energy crisis, and their proximity to the front lines of military conflict can be an important fact to take into account. The research focuses on the Czech Republic, Hungary, Poland, and Romania. The empirical analysis was conducted on monthly frequency data and in order to present an effective method of modeling interactions between macroeconomic variables, the Bayesian technique was employed.*

***Key words:*** *oil price shocks, BVAR, non-Euro area*

## 1. Introduction

A comprehensive understanding of energy markets is essential for preserving price stability, managing risks, and budgeting resources, as oil prices have a considerable impact on macroeconomic indicators. The cyclical nature of the economy, whether it is growing or shrinking, can have a direct impact on the cost of energy products, as the economy heavily depends on oil and natural gas. Energy price volatility is correlated with disturbances in both

demand and supply, political instability, and potential economic risks. Rising prices can result in higher production expenses and lower profits, impacting consumers as businesses attempt to incorporate the increased costs into the final price, which in turn reduces demand and modifies the final product offer.

The COVID-19 pandemic resulted in substantial disruptions to market demand, which consequently prompted a drastic decrease in oil prices. During the period of lockdown from March to May 2020, there was a decline in economic activities in areas such as air transport, tourism, and durable goods production. Consequently, there was a swift decrease in prices, prompting companies to decrease production and engage in negotiations for supply reduction agreements. Following the reopening of economies and restart of activity, oil prices underwent a partial rebound. However, they remained more volatile due to uncertainty about the pandemic's evolution and economic recovery rate.

Energy price fluctuations have been impacted by recent developments, evolution, and a desire to return to pre-pandemic living conditions. This has led to a persistent adjustment and forced adaptation aimed at reducing oil dependence and preserving carbon emissions.

The volatile nature of oil prices is intensified by the uncertainty surrounding global oil demand and supply, as evidenced during the shutdown in 2020. The rapid recovery of economic processes and the growing tendency towards the green economy are other significant elements. Worldwide economies are affected by changes in energy prices, and central banks are unable to respond to supply shocks that occur outside of their monetary policy framework.

This article investigates the correlation between energy prices and economic factors in non-euro area countries such as the Czech Republic, Hungary, Poland, and Romania. It specifically focuses on industrial production, inflation rate, production prices, unemployment, and monetary policy interest rates, with the aim of providing future complementary methods.

The research uses a Bayesian VAR model to analyze macroeconomic variables' responses to exogenous shocks. It highlights the strong relationship between the economy and natural resources, specifically oil and natural gas, which impact economic growth, industrial prospects, and export earnings, contributing to long-term economic development.

The article aims to address the following research inquiry: (i) How does the fluctuation in pricing of energy goods impact rising economies outside the Euro area? and (ii) What steps might be implemented to diminish the economy's reliance on these imperiled resources and prevent future adverse economic incidences?.

The BVAR model allows non-stationary variables, consequently preserving important information about the changing nature of the variables across time. This model is utilized for precise examinations, incorporating impulse-response functions, historical decomposition, and forecast error variance decomposition, which are implemented specifically for research objectives.

## 2. Literature Review

Literature offers a variety of perspectives and methodologies for evaluating the exogenous shocks caused by the prices of energy-related goods and natural resources, but one thing is certain: their impact is felt by both the production chain and the final consumer.

The disruptions caused by their impact can have a substantial effect on economy, leading to changes in inflation rates, unemployment levels, and economic growth as a whole. In order to mitigate the potential negative effects of exogenous challenges, it is crucial for policymakers and businesses to closely monitor energy prices and natural resource markets, but also advise the governments to make investments in the renewable industry sectors in order to align with the new reality in which environmental security is essential for a sustainable economy from all points of view. Since the early 2000s, the impact of energy obstacles has been a subject of research, and further various viewpoints from the literature will be presented.

Baek (2022) categorized academic literature on oil price shocks into three groups: those examining how they impact economic growth, those asserting that increased crude oil prices trigger inflation, and those examining their impact across countries. Historically, studies assumed oil price fluctuations were endogenous, but recent research has questioned this assumption. Recent studies have examined the macroeconomic effects of crude oil supply disruptions, commodities-market-specific demand shocks, and innovations in the global business cycle-driven demand for industrial commodities.

First, it is essential to comprehend what a disturbance caused by an unfavorable evolution in the energy market entails and how it manifests. By understanding the nature of energy market disruptions, individuals and organizations can take appropriate steps to mitigate their impact and ensure continuity of operations.

Baumeister and Kilian (2016) describes an oil price shock in their study as an unanticipated component that leads in a shift in the price of oil. The magnitude of this shock can only be defined by examining the expectations of the main economic agents and the determinants of previous oil price movements. However, there is a paradox: when energy prices increase, households and businesses explore alternative sources of energy to meet their energy demands, but demand for oil does not decline drastically.

Kilian (2014) conducted many studies on oil price shocks, and one of his papers suggested that expectations about future scarcity or shortfalls in oil demand in the physical market for crude oil affect supply disruptions, particularly the real price of oil. This study's author claimed oil's price is endogenous to economic fundamentals.

Numerous studies, as well as this previous research by Baumeister and Kilian (2016), examined the 1973 energy crisis, which, just like present one, coincided with an economic and global market transition. At that time, the government made several adjustments that ultimately exacerbated the problem.

Understanding the impact of the energy shock on the key macroeconomic variables that describe the economies of nations is the next significant factor to consider. This includes analyzing how the energy shock affects factors such as production and consumption prices, GDP, employment, and trade balances. By examining these variables, policymakers and analysts can better understand the overall economic implications of changes in energy prices.

An older article in the literature written by Hanson and York (1988) suggested that oil price shocks can hurt many global economies, but they can help oil-exporting countries increase foreign exchange revenues and investment. Industrialization also boosts commercial energy demand. Business and consumer responses to price changes, which

prompt replacements, can directly influence responses to oil and other energy price shocks. High energy prices affect energy-importing countries, requiring indirect macroeconomic adjustments.

In the same time frame, Hamilton's studies (1983) identified the Granger-causal relationship between changes in oil prices and changes in macroeconomic variables such as unemployment and GNP in the United States. Remarkable is the fact that, in the year preceding the rise in oil prices, none of the macroeconomic variables examined demonstrated any unusual behavior, and only the series of import prices demonstrated statistically significant behavior that could have been used to forecast subsequent episodes of rising energy prices.

Moreover, Bohi (1991) also expanded on Hamilton's results on energy prices and GNP, arguing that energy price volatility caused worldwide recessions and lowered GNP growth rates in the 1970s. The author continued the study by assessing the degree of industrial activity in four industrialized countries using a production function. The negative correlation between higher energy intensity industries and industrial production implies that greater energy-intensive industries have a faster decline in output. As energy prices rise, the lower the level of energy inputs and productivity, resulting in a decline in real wages necessary to maintain employment levels.

Furthermore, Dhawan and Jeske (2006) highlighted the negative correlation between energy prices and productivity that existed before to 1985. The article demonstrates that rising energy costs had a negative impact on the economy's growth rates but also on total production, resulting in an inevitable recession as a result of these price accelerations. At the same time, in the absence of price controls and other market frictions, the price of oil provides an effective mechanism for allocating scarce resources, because the market assigns them to the most productive use. Without supply and demand laws, sluggish resource and energy misallocation result in less productive energy consumption, which manifests as decreased productivity.

As Lescaroux and Mignon (2008) pointed out, an increase in energy prices can result in a reduction in productivity, which is subsequently reflected in wages and employment, consumer prices and inflation, profits and investment, and stock market capitalization. The relationship between oil prices and GDP can be explained by supply and demand, which states that higher input prices suggest a reduction in production and consequently a drop in the available supply of potential output.

Moving on, the paper of Bednar et. al (2022) emphasized that energy consumption is increasing nowadays, but it is not accurately reflecting inflation in consumption baskets. This study examined inflationary pressures in Europe and found that renewable energy sources are associated with lower inflation. The energy price shock cannot be regarded as a one-time event; thus, a mix of public and monetary policies must be considered for future crises. The impact of renewable energy sources on inflation should be of interest to policymakers, particularly during times of high inflation, unstable fossil fuel supplies, and climate crisis.

More recently, Destek and Sarkodie (2020) examined the stationarity and linearity of series of coal, oil, and natural gas consumption in sixteen OECD nations from 1970 to 2018. The article's empirical findings show that energy price shocks and energy demand

shocks would temporarily affect coal, oil, and natural gas consumption in economies with structural breaks and nonlinear data. These findings suggest that policy implementation to reduce such energy inputs may be unsuccessful in regions where energy use is permanent.

In a different note is the article of Jawadi and Sellami (2021) emphasized that notable fluctuations and instability in oil prices starting from 2000, can be attributed to three major events: the global financial crisis, the shale revolution, and the COVID-19 epidemic. Moreover, the oil industry has undeniably witnessed substantial volatility in recent years, mostly driven by factors such as shifts in global demand, technical breakthroughs, and geopolitical conflicts.

Lippi and Nobili (2012) conducted an analysis of the global economy, categorizing it into two parts: the United States and the rest of the industrial world. The assumption was made that the consumption of goods is imperfectly substitutable, and both economies are subject to supply and demand shocks. A positive oil supply shock causes the actual oil price and oil quantities to move in opposing directions, resulting in an increase in industrial production in both economies.

In a similar manner, Aastveit et al. (2015) demonstrated that high energy prices typically lead to an increase in production costs and inflation, hence affecting aggregate demand, production, and trade in the economy. Additionally, an economy's degree of openness and its level of investment are critical factors in determining the relationship between energy costs and the global macroeconomy. Along with other studies, the authors demonstrated that when the price of crude oil is influenced by increased demand associated with a significant change in global activity.

Maintaining the same principles, the study of Punzi (2019) highlighted the impact of oil and energy prices on macroeconomic variables, with global demand shifts and disruptions slowing GDP growth and increasing inflation. Energy price volatility, influenced by uncertainty, has different effects on a small, open economies, signaling the fact that the development of a country is a key indicator in the assessment of energy price shocks.

Moving on, examining the stock market represent another essential factor and Mugaloglu et al. (2021) demonstrated that, while the relationship between oil prices and the financial sector is negative, it is transparent how this relationship benefits oil companies, indicating that not all industries are adversely affected or in the same manner by an increase in oil prices. However, when the COVID-19 pandemic period is taken into consideration, the results indicated that stock market shocks have enhanced their ability to explain index returns.

An article from the recent literature written by Yu et. al. (2021) stated that the natural resources commodity markets are more effective in sending a shock within other economic sectors. There is a visible correlation between oil and natural gas prices and macroeconomic activity and the COVID-19 crisis shed light on the contagion effects of volatility between commodity markets and macroeconomic indicators. The authors emphasize the necessity of developing a comprehensive and unified strategy to handle economic shocks and maintain stability in the aftermath of the pandemic.

Overall, the economic crises that arose over the years, with the COVID-19 pandemic being the most recent economic disruption, have had a significant impact on the global economy, especially in emerging economies. During these historical outbreaks, the spillover

effects of oil shocks were more persistent, causing significant volatility in other markets. Along with this, the volatility and returns of the energy market have been significantly impacted. As the world continues to grapple with the pandemic, it is currently uncertain how these effects will continue to play out in the long term.

## 3. Empirical analysis

Empirical analysis is essential for comprehending economic phenomena and in our case is focused on assessing the impact of energy price disruptions on non-euro area emerging countries. The research employs a Bayesian Autoregressive Vector model to analyse each country and the responses of macroeconomic variables to exogenous obstacles in the energy sector. Inflation rate, industrial production, production prices, 3-month interest rate, and unemployment rate are used as endogenous variables, while the exogenous variables include the prices of Brent crude oil, natural gas, and coal.

The investigation is focused on the four non-eurozone members of the European Union. The Czech Republic, Hungary, Poland and Romania are considered the emerging economies under analysis. The empirical examination was conducted using monthly data from 2007:1 to 2023:1.

The BEAR Toolbox developed by Dieppe et al. (2016) in MATLAB 2020 was employed for the entire estimation procedure, enabling the Bayesian VAR technique.

Sims (1980) introduced autoregressive models, which are extensively used in economic research to study shocks and impulsive behaviours. The VAR model is popular due to its adaptability, simplicity of estimation, and ability to characterize economic phenomena. To better explain dynamic behaviour and the relationships between endogenous variables and other factors, exogenous variables were introduced. Lutkepohl (2005) emphasizes the significance of exogenous variables in VAR models, emphasizing their substantial contribution to the model.

According to the article of Ciccarelli and Rebucci (2003), the Bayesian technique, which was introduced by Litterman (1980), aims to correct overfitting in classical VAR models. As Koop (2003) stated, it approaches each parameter as a random variable with a probability distribution and combines *a priori* and data information resulting in a distribution that takes into account both sets. In our case, the Independent Normal Wishart prior distribution was chosen.

By examining 10-period graphs for impulse-response functions (IRF), the historical decomposition of the endogenous series (HD), and the forecast error variance decomposition (FEVD), the BVAR model's evidence was deployed.

The most significant findings of the applied methodology will be presented in the sections that follow.

## 4. Results and discussion

In this section, we present our most significant findings. Overall, the results shed light on the linkage between the volatility of energy products' prices and the macroeconomic variables of the emerging economies that are not in the Euro area.

The sudden outbreak of the war between Russia and Ukraine coincided with the European Union's desire to make the transition to green energy and this turned out that finding new sources of renewable energy is more important than ever, not only to improve the climate context but also to diversify energy products.

As mentioned earlier, we implemented the impulse-response function, the historical decomposition and the forecast error variance decomposition for the purpose of examining the macroeconomic variables' responses to exogenous shocks, indicating their interconnectedness with energy price fluctuations. In our case, the increased prices of Brent crude oil, natural gas, and coal represent the exogenous shocks.

Each country was analysed separately, and the most important results of the implementation of each country's BVAR model will be presented progressively.

### 4.1 Implemented BVAR model for Czech Republic

The responses of macroeconomic indicators in the Czech Republic to an exogenous shock are consistent with economic literature, but also with the historical evolution. Table 1 illustrates how the chosen variables react to an exogenous disturbance.

**Table 1.** Variables' responses in the case of Czech Republic

| Variable | Brent crude oil price increase shock | Natural gas price increase shock | Coal price increase shock |
|---|---|---|---|
| Industrial production | Decline | Slight decrease | Slight decrease |
| Inflation rate | Does not change | Slight increase | Slight increase |
| Production prices | Does not change | Decline | Does not change |
| 3-month interest rate | Decline | Increase | Decline |
| Unemployment rate | Slight increase | Slight increase | Does not change |

Source: own calculations

The exogenous impulse response functions demonstrated that industrial production decreases, automatically the supply of durable goods, but inflation rate and production prices do not implicitly change at an exogenous shock represented by an increase in Brent crude oil prices. As industrial production declines, the unemployment rate slightly rises.

The other exogenous shocks, such as increases in the prices of natural gas and coal, have the same effect on industrial production as the increase in the price of Brent crude oil, but they also affect the inflation rate. During the examined period, the inflation rate increases modestly.

The variable represented by production prices responds significantly only to the shock caused by the increase in the price of natural gas, while its response to the other exogenous shocks is insignificant.

In addition to assessing impulse-response functions, the historical decomposition describes the behaviour of macroeconomic variables over time in terms of shocks.

The historical decomposition of industrial production indicates a slight upward trend until 2008, when the global financial crisis started to exert downward pressure on the volume of production in the industrial sector, with the exogenous shocks being felt at the level of the entire economy. Once the impasse was dissolved, the analysis reveals that both industrial

production and production prices increased consistently throughout the period, with lower energy costs providing direct support. During the analysed period, the National Bank of the Czech Republic implemented a carefully planned monetary policy, and the policy's key interest rate remained consistent without significant fluctuations. Unfortunately, as anticipated, the year 2020 was another stride back for the Czech Republic, with the level of industrial production being driven to historical minimum values and being directly impacted by the unemployment rate.

In the post-pandemic period, the exogenous factors represented by the increase in the prices of oil, natural gas, and coal become the main drivers of the increase in inflation, in the prices of industrial production, and for the decrease in the unemployment rate.

Given that the objective of the forecast error variance decomposition is to highlight the contribution of each shock to the volatility of a particular variable, the percentage size of the shock will determine the magnitude of the changes in each variable.

**Table 2.** Forecast error variance decomposition of the variables in the case of Czech Republic

| Variable | Brent crude oil price increase shock | Natural gas price increase shock | Coal price increase shock |
|---|---|---|---|
| Industrial production | 11% | 5% | 8% |
| Inflation rate | 9% | 9% | 12% |
| Production prices | 18% | 4% | 7% |
| 3-month interest rate | 22% | 13% | 16% |
| Unemployment rate | 15% | 5% | 8% |

Source: own calculations

In the case of Czech Republic, the percentages of each shock's contribution to the volatility of each variable can be found in Table 2, where it can be seen that the Brent crude oil price increase shock explains the volatility of production prices, the 3-month interest rate, and the unemployment rate most effectively.

The exogenous shock given by the increase in the price of natural gas contributes up to 13% to the volatility of the 3-month interest rate, while the shock generated by the increase in the price of oil contributes with 16%. At the same time, the last-mentioned shock contributes with 12% to the inflation rate, representing the biggest contribution to its volatility compared to the other exogenous shocks.

### 4.2 Implemented BVAR model for Hungary

The Hungarian economy is responsive to external factors and the results of the implemented model are consistent with economic literature. Table 3 illustrates how the chosen variables react to an exogenous shock.

**Table 3.** Variables' responses in the case of Hungary

| Variable | Brent crude oil price increase shock | Natural gas price increase shock | Coal price increase shock |
|---|---|---|---|
| Industrial production | Decline | Does not change | Does not change |
| Inflation rate | Slight decrease | Slight increase | Increase |
| Production prices | Slight increase | Slight decrease | Slight decrease |
| 3-month interest rate | Increase | Decline | Decline |
| Unemployment rate | Does not change | Does not change | Does not change |

Source: own calculations

Regarding industrial production, the response to the Brent crude oil price shock is significantly negative, whereas the response to the other examined exogenous shocks is unaffected. In contrast to the behaviour of industrial production, the increase in natural gas and coal prices produces an exogenous disturbance that causes the inflation rate to rise.

The unemployment rate is the only variable that doesn't respond to any exogenous shock, along with the production prices, which, despite decreasing in response to natural gas and coal price shocks and increasing in response to oil price shocks, have an exceptionally weak response.

The 3-month interest rate increases in response to an exogenous shock caused by the increase in the price of Brent crude oil, while the response to other exogenous shocks is negative.

Furthermore, the historical decomposition of industrial production reveals that production prices, as well as the price of coal, were significant throughout the examined time period. Although inflation contributed negatively to the evolution of industrial production, it is not a significant factor in this evolution.

In the case of the inflation rate, a rapid increase is directly supported by exogenous shocks, particularly the shock resulting from the increase in the price of coal, as well as the prices of industrial production. During 2015-2019, the price of Brent crude oil has a significant impact, which is also felt during the post-pandemic period.

The evolution of the unemployment rate is a special case because it attained its lowest levels in the last period, after the pandemic and it was influenced by all of the model's variables, primarily the inflation rate and the 3-month interest rate.

In the case of Hungary, the percentages of each shock's contribution to the volatility of each variable can be found in Table 4.

**Table 4.** Forecast error variance decomposition of the variables in the case of Hungary

| Variable | Brent crude oil price increase shock | Natural gas price increase shock | Coal price increase shock |
|---|---|---|---|
| Industrial production | 9% | 6% | 7% |
| Inflation rate | 9% | 33% | 43% |
| Production prices | 9% | 7% | 9% |
| 3-month interest rate | 19% | 36% | 40% |
| Unemployment rate | 9% | 12% | 14% |

Source: own calculations

It can be observed that the natural gas price shock and the coal price shock contribute to the explanation of the forecasted volatility of variables with higher percentages. The volatility of the inflation rate is explained in proportions of 33% and 43% by the exogenous shocks generated by an increase in the price of natural gas and coal. Also, the results showed high percentage contributions of the exogenous shocks mentioned above in the variance decomposition of the 3-months interest rate.

Regarding the volatility of the unemployment rate, increases in the price of natural gas and coal contribute by 12% and 14%, respectively.

### 4.3 Implemented BVAR model for Poland

The Polish economy is sensitive to external influences, and the model's results are consistent with economic literature.

In terms of impulse response functions, an exogenous shock represented by the increase in the prices of energy products leads to a decrease in industrial production, and implicitly in production costs as a consequence of the change in initial supply. The implemented model indicates that, the inflation rate does not respond to the disruptions caused by the increase in the price of oil or natural gas, but exhibits a decreasing dynamic in response to an increase in the price of coal.

The behaviour of the unemployment rate mirrors the movement of the inflation rate, which is supported by economic literature, but the response of these two variables within the model is weak. In addition, the response of the unemployment rate to an exogenous shock represented by an increase in the price of natural gas is insignificant, whereas the unemployment rate decreases in response to other exogenous shocks.

**Table 5.** Variables' responses in the case of Poland

| Variable | Brent crude oil price increase shock | Natural gas price increase shock | Coal price increase shock |
|---|---|---|---|
| Industrial production | Decline | Slight decrease | Slight decrease |
| Inflation rate | Does not change | Does not change | Decrease |
| Production prices | Decline | Slight decrease | Does not change |
| 3-month interest rate | Decline | Slight decrease | Decline |
| Unemployment rate | Slight increase | Does not change | Increase |

Source: own calculations

Along with that, the historical decomposition of industrial production reveals that Brent crude oil and natural gas were the primary factors influencing industrial supply during the examined time period. The steep decline in industrial production in 2020 was mainly caused by production costs, but the prices of energy products also played a significant role.

In the case of the inflation rate, the situation is different, and we can say that the periods in which it recorded significant increases were the result of exogenous shocks generated by the increase in the price of natural gas, but also of Brent crude oil, which registers significant values throughout the period under study.

The post-pandemic period reveals that coal prices played a significant influence in the dynamics of production prices, while natural gas prices had a countercyclical effect.

Beginning in 2007, Brent crude oil prices have exerted a strong influence on the evolution of the unemployment rate. This influence has diminished over time, but with the outbreak of the pandemic, it has re-emerged as a major factor in the evolution of the unemployment rate.

In the case of Poland, the percentages of each shock's contribution to the volatility of each variable can be found in Table 6.

**Table 6.** Forecast error variance decomposition of the variables in the case of Poland

| Variable | Brent crude oil price increase shock | Natural gas price increase shock | Coal price increase shock |
|---|---|---|---|
| Industrial production | 8% | 16% | 10% |
| Inflation rate | 14% | 43% | 32% |
| Production prices | 17% | 11% | 8% |
| 3-month interest rate | 46% | 20% | 30% |
| Unemployment rate | 10% | 7% | 11% |

Source: own calculations

As suggested previously, an increase in the price of coal contributes up to 32% to the volatility of the inflation rate as an exogenous shock. In the case of the shock represented by the increase in the price of natural gas, a proportion of 43% can be observed in explaining the error of the volatility of the inflation rate, while the shock represented by the Brent crude oil price accounts for only 14% of its volatility.

A significant part of the explanation for the volatility of the 3-month interest rate is attributable to the Brent crude oil shock, indicating the importance for a cautious monetary policy to sustain inflationary expectations regarding the general increase in prices.

In the case of industrial production, the exogenous shock caused by the increase in the price of natural gas explains 16% of its volatility, while the shock caused by the increase in the price of coal explains only 10%.

Similarly, the shock caused by Brent crude oil contributes up to 17% to the variance of the forecast error in the case of production prices.

### 4.4 Implemented BVAR model for Romania

Even though the responses of macroeconomic variables in Romania to an exogenous disturbance are consistent with historical development, they are weak and in certain cases do not respond to energy market changes. Table 7 demonstrates the response of the selected variables to an exogenous perturbation.

The econometric model reveals that industrial production and the inflation rate do not respond to the exogenous shocks caused by the price increase for Brent crude oil and natural gas, even though these variables are more vulnerable to changes in the energy markets. In spite of the shock caused by the increase in coal prices, there is a modest increase in industrial production.

Only the unemployment rate and the 3-months interest rate respond to variations in energy prices. In response to an increase in the price of oil, the unemployment rate decreases marginally, whereas it rises in response to an increase in the price of coal.

Contrary to expectations, it appears that the 3-months interest rate declines as a result of an exogenous disturbance resulting from the increased volatility of the energy market.

**Table 7.** Variables' responses in the case of Romania

| Variable | Brent crude oil price increase shock | Natural gas price increase shock | Coal price increase shock |
|---|---|---|---|
| Industrial production | Does not change | Does not change | Slight increase |
| Inflation rate | Does not change | Does not change | Does not change |
| Production prices | Does not change | Sligh decrease | Does not change |
| 3-month interest rate | Decline | Decline | Decline |
| Unemployment rate | Slight increase | Decline | Increase |

Source: own calculations

In addition, the historical decomposition of macroeconomic variables reveals that the price of Brent crude oil has been the most influential factor in determining their dynamics over time. Alongside with this exogenous change is the price of natural gas, which has a significant impact on industrial production, the inflation rate, and even unemployment.

During the period from 2015 to 2018, the coal and oil prices had the greatest impact on industrial production, playing a cyclical role in its dynamics. Despite the lowering of energy products prices during the COVID-19 pandemic, industrial production declined rapidly, with its return marked by a rebound of consumption as well as an increase in production costs.

As mentioned previously, the oil price played a cyclical role in the evolution of the inflation rate, with its influence intensifying in the post-pandemic period.

In the case of Romania, the percentages of each shock's contribution to the volatility of each variable can be found in Table 8.

**Table 8.** Forecast error variance decomposition of the variables in the case of Romania

| Variable | Brent crude oil price increase shock | Natural gas price increase shock | Coal price increase shock |
|---|---|---|---|
| Industrial production | 22% | 6% | 14% |
| Inflation rate | 18% | 31% | 39% |
| Production prices | 16% | 6% | 13% |
| 3-month interest rate | 39% | 17% | 40% |
| Unemployment rate | 8% | 6% | 14% |

Source: own calculations

As can be seen, the coal price surge serves to explain the forecasted error variance decomposition of variables with higher percentages. Exogenous shocks generated by an increase in the price of coal and natural gas account for 39% and 31% of the volatility of the inflation rate, respectively.

Regarding industrial production, its forecasted error volatility is heavily influenced by the increase in Brent crude oil price, which accounts for up to 22% of its volatility's explanation. Moreover, the exogenous shock induced by the change in the price of Brent oil

explains 18% of the forecasted error variance decomposition of the inflation rate and up to 16% of the forecasted error variance decomposition of the production prices.

The volatility of the 3-months interest rate variable is primarily explained by all exogenous shocks, being influenced by the energy market's fluctuations.

### 4.5 Research findings and discussion

The results of the study seek to respond to the questions that motivated the research, and the comparison of the responses of macroeconomic variables to a shock caused by an increase in the prices of different energy products reveals the extent to which the volatility in energy markets impacts the economies of emerging countries.

Comparing the Czech Republic, Hungary, Poland, and Romania, the results are slightly different in each case, but consistent with economic literature. Although there are many economic similarities between the examined countries, there is also a remarkable degree of heterogeneity, particularly in their responses to the exogenous energy disturbances. This is also supported by the fact that each country has varying quantities of reserves for each resource, and import dependence can be reduced for certain energy products.

In the case of the Czech Republic, even though the country has substantial natural gas reserves, they appear insignificant when compared to those of other countries, and the majority of domestic demand is met through imports of natural gas and energy products. Also, this could suggest that the analysis emphasizes the importance of the impact of exogenous difficulties for emerging economies, as well as the strong import-related relationship between the Czech Republic and other nations.

Moving forward, comparable to the Czech Republic, Hungary has limited natural resources and relies significantly on oil and coal imports, as demonstrated by the model results. As a result of the outbreak of war in Ukraine, the energy market suffered, and countries that relied on imports and the foreign energy market were adversely affected by the high increases in the prices of energy products. Hungary is in a more delicate geopolitical position than its peers, but this does not exempt it from potential supply and import-related issues. Additionally, Hungary is a transit country for energy resources, which helps it manage the prospective energy crisis. The model results indicate that the variables for Hungary do not alter visibly, but they are affected.

Among the most important results, one of the economic indicators that is directly influenced by exogenous factors is industrial production in the Czech Republic and Poland. The decline in industrial production, which in this case can be viewed as a decrease in the volume of manufactured goods, can be closely related to the supply chain issues that arose during the pandemic. Disruptions such as the stoppage of the supply of raw materials, a lack of resources, and logistical issues were the primary factors that led to a decrease in industrial production, and a rise in the price of petroleum as a result of these impediments was the main driver that maintained this scenario.

In the case of Poland, it appears that certain variables from the empirical model respond to changes in the price of coal, which provides evidence that the Polish economy relies heavily on coal for electricity production. Coal-based electricity accounts for more than

fifty percent of all economic energy consumption. Also, the results indicated that Poland is significantly dependent on imports of energy products. However, the inflation rate is not as influenced by fluctuations in the energy market as other specialized papers have suggested. This is because Poland has one of the largest coal reserves in Europe and a highly developed mining industry, giving it a competitive advantage over the other examined countries.

Beyond that, the model illustrated that, despite the fact that selected nations can be compared in terms of their economic and financial development, particular economies, such as Romania, may achieve various results. As an emerging economy with close economic ties to European Union members, but not exclusively, Romania was affected by the global price increases for oil, natural gas, and other energy products. However, due to the abundance of natural resources in Romania, the economic impact was less severe than in other countries.

Significant reserves of coal, oil, and natural gas helped Romania face the energy crisis, as evidenced by the fact that industrial production, inflation rate, and production prices were not affected by the cost of energy imports, such as these variables do not respond to exogenous shocks in the empirical model. This fact, coupled with the historical evolution of macroeconomic variables, demonstrates that although Romania is not highly reliant on energy imports, it is still affected by global market decisions and events.

Returning now to the second question of the research, not just the current article, but also recent literature in this field, demonstrates the importance of a highly varied energy market.

Moreover, renewable energy plays an important role for emerging nations and not only because the environmental issues, but also because the reliance on traditional natural resources such as fossil fuels may impede a country's development process by making it unsustainable for reducing carbon emissions and achieving the sustainable goals of transitioning to green energy over the long term.

To reduce reliance on endangered natural resources and promote transition to green energy, nations can advocate for diversification of energy sources, implementing energy efficiency measures in industrial, commercial, and transportation sectors, encouraging investments in renewable energy and implement fiscal incentives. This will encourage investments in renewable energy, energy-efficient technologies, and sustainable practices. Additionally, policies and regulations should discourage the use of traditional resources and promote sustainable alternatives. Long-term planning and consistent policy development are essential for promoting sustainability and reducing resource reliance, ensuring policy coherence across all sectors.

## 5. Conclusion

Starting with the research questions, the article aims to investigate the impact of energy products' price volatility on emergent economies outside the Euro area and recommends measures to reduce reliance on threatened resources and prevent future negative economic episodes.

The study shed light on the impact of exogenous disruptions regarding energy prices on emerging economies outside the Eurozone, specifically on the Czech Republic, Hungary, Poland, and Romania. The findings revealed that the responses to an exogenous shock induced by an increase in the price of Brent crude oil, natural gas, and coal can lead to a variety of consequences, including weak responses. However, this does not imply that the countries that did not exhibit significant responses are unaffected by the abrupt shifts in the global energy market. The historical decomposition of the data reveals that over time, the economic indicators have been impacted both by the price declines of oil, natural gas, and coal as well as their price increases.

The influence of energy prices was analysed using a Bayesian VAR model that was implemented separately for every country. Subsequently, the impulse-response function, historical decomposition, and forecasted error variance decomposition were implemented to determine the relationship between emerging countries and the exogenous shocks resulting from the increase in the price of energy products, inferring an increase in production costs.

Therefore, it can be argued that energy products' prices, especially the price of Brent crude oil, natural gas and coal have an important impact on various economic factors such as general prices from economy, production costs, and implicitly production output from industries, unemployment rate and 3-months interest rate. These relationships between energy price shocks and the whole economy are mainly determined by the supply and demand dynamics and the analysis suggest that the direction of causality typically runs from resources prices to other variables, being also influenced by the economic conditions, recessions or economic expansions.

Regarding the measures that can be taken in order to reduce the economy's dependence on these endangered resources and promote transition to renewable energy, we can mention implementing diverse energy sources, adopting energy efficiency measures in sectors that pollute excessively and encouraging investments in green sectors by enacting attractive fiscal practices.

Because the recent episode regarding the volatility of energy prices has resulted in unprecedented events, but also considering the topic of the impact of energy costs is very important in specialized literature, not only from the standpoint of providing valuable knowledge and insights into the causes, dynamics, and consequences of energy price shocks, this article aims to align with the rest of the economic research, thereby providing in-depth analysis and empirical evidence, contributing to scientific discussion.

Certain counterintuitive results and the fact that some variables do not react to an exogenous shock within the model despite the historical decomposition analysis indicating their exogenous influence may be viewed as limitations of this empirical model.

A future study on how governments utilized the funds that they received from the European Union for the transition to green energy, as well as how they encouraged or failed to motivate the economic environment to switch to energy from renewable sources, could be deemed a worthy topic for further research.

## 6. References


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