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DOES USING RENEWABLE ENERGY PREVENT GLOBAL ENERGY PRICES' EFFECTS ON INFLATION?

Muhammet KUTLU[1]

Abstract

Global energy price fluctuations caused by political, economic, and many other reasons create inflationary impacts, especially in importing economies that do not have fossil energy reserves. The motivation of this study is the proposition that the use of renewable energy, which reduces dependence on fossil energy sources, can provide a protective alternative against these price shocks, in addition to its environmental advantages. The aim of the study is to test whether the use of renewable energy is effective in preventing the effects of shocks in global energy prices on inflation. To this end, the effects of global energy prices on inflation for nine selected OECD countries with different levels of renewable energy use were analyzed using the structural vector autoregressive (SVAR) model. Thus, evidence is presented about the effect of differences in the level of renewable energy use on the pass-through of energy price shocks to domestic prices. Findings are presented as evidence for the proposition that the use of renewable energy will limit the effects of global energy prices on inflation.

Keywords: Renewable Energy, Global Energy Prices, Inflation, Structural VAR Model

JEL Codes: Q43, E31, C32

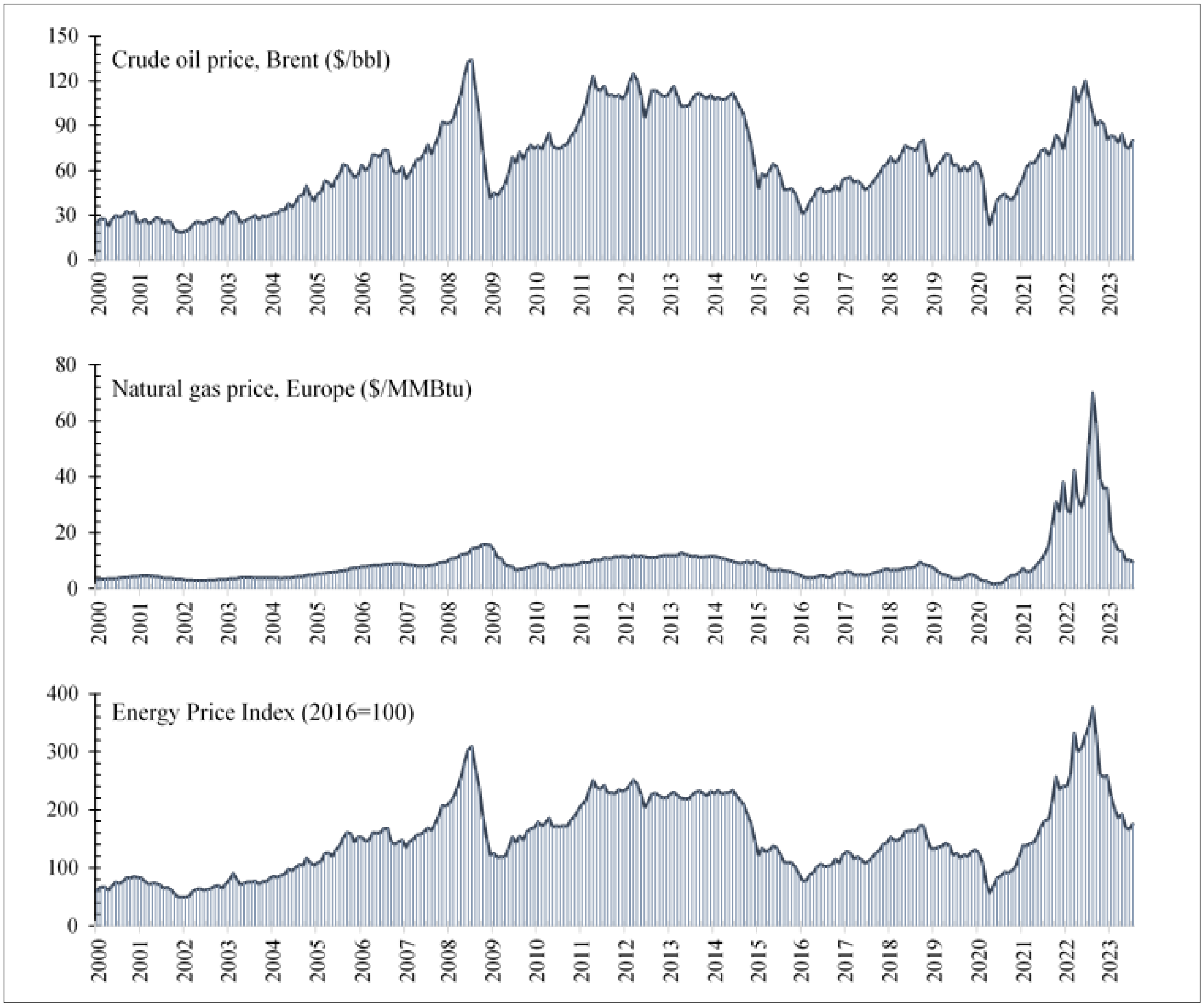
[1] Asst. Prof., Bandırma Onyedi Eylül University, Gönen Vocational School, mkutlu@bandirma.edu.tr, https://orcid.org/0000-0002-1739-5366

INTRODUCTION

The science of economics works in an effort to produce effective solutions to meet human needs with limited resources. Today, the most important of these limited resources is energy. Energy has limited reserves. A significant portion of these limited reserves is controlled by a small number of countries. This leads to recurring problems related to energy supply and significant fluctuations in energy prices due to political and economic reasons. This makes energy a direct subject of study in economics. Moreover, the relationship between energy-related variables and other economic variables has received increasing attention in the literature. The most important of these variables is energy prices. In economic terms, energy can refer to raw materials, intermediate goods, and final goods. Hence, changes in energy prices have direct and indirect effects on many other economic variables. Changes in energy prices may occur depending on economic, political, physical, and many other factors. The common aspect of these factors is their potential to affect energy supply. With an increasing demand for energy due to factors such as population growth, industrialization, production, urbanization, and many other socio-economic reasons, energy supply with limited resources is the key determinant of prices in the market. Therefore, any change affecting energy supply or shipment can cause significant price fluctuations in the energy market. While economic and political shocks like the 1973 Oil Crisis, the Gulf War, the 9/11 attacks, and the 2008 global crisis can exemplify this, the most recent instances are the Covid-19 pandemic and Russia’s invasion of Ukraine.

Following the declines in energy demand during the Covid-19 pandemic, economies entered a rapid recovery process as the pandemic lost its impact in 2021. This process led to a significant increase in energy demand. Additionally, the energy supply problem that started with Russia’s invasion of Ukraine in February 2022 turned it into a global energy crisis. In August 2022, the price of natural gas in Europe reached the highest level at 70.04 ($/MMBtu), while in June of the same year, oil prices reached their highest level since 2008, with the Brent oil price reaching 120.08 ($/bbl) (World Bank, 2023). Figure 1 shows the changes in oil and natural gas prices. The price changes in fossil fuel prices can be analyzed using the Energy Price Index (EPI) as well. The index value peaked in 2022, reaching 376.4. The most important outcome of this rise in energy prices is the significant increase in inflation levels. Moreover, economic growth in some countries slowed down to a level that can be described as stagnation due to reasons such as price increases, supply problems, and the reduction of production in factories (International Energy Agency, 2022).

Figure 1: Crude oil, natural gas prices, and Energy Price Index (EPI)



Source: World Bank, 2023; IMF, 2024

Energy prices have direct and indirect effects on inflation. Since fuel oil and gas are direct components of headline inflation, the increase in prices has a direct effect on inflation. The indirect one involves the effect of the change in energy prices on production costs (Özmen & Özşahin, 2023). The pass-through from energy prices to inflation has been confirmed by many studies (He & Lee, 2022; Kečak, 2023; Mirza et al., 2023; Özmen & Özşahin, 2023; Talha et al., 2021; Valadkhani et al., 2014). Tiwari et al. (2019) and Živkov et al. (2019) reported that the pass-through from energy prices to inflation is low and that the pass-through is higher in the long term than in the short term. The findings from these studies specifically focusing on oil prices allow us to infer that energy price fluctuations have a greater indirect effect on inflation. Similarly, Choi et al. (2018) emphasized that the pass-through is low for developed and developing countries, and the effect in question is a direct one. Moreover, there are studies highlighting that the possible duration of the effect (Choi et al., 2018; Skare et al., 2022) and the degree of pass-through from energy prices to inflation (Clark & Terry, 2010; Rafiq, 2014) may vary over time. Jawadi et al., (2023), who find inflation's response to energy prices significant, also emphasize the non-linear effects of energy prices on the real and financial sectors. Evaluating the impact of energy crises on inflation, Munteanu & David (2023) emphasized the place of energy products in the consumption basket. Munteanu & David (2023) suggested that other variables that have an impact on inflation should be taken into account when considering the relationship between energy prices and inflation. Bigerna (2023) reveals that the pass-through of energy prices is related to the duration and direction of the price shock. At this point, it is important for policymakers to combat inflation arising from energy prices. However, inflationary pressures stemming from energy prices may require different considerations. It is stated that monetary tightening policies, often used against inflation, may have adverse effects when applied to energy price-induced inflation (Atiq-ur-Rehman, 2014). While it is important whether the country is an energy importer or exporter, alternative energy sources are recommended for countries to maintain price stability (Thoresen, 1983). The motivation of this study is to determine if renewable energy sources are a viable alternative in this context.

Increasing the use of renewable energy and renewable energy incentives create economic and environmental benefits. Economic and environmental gains such as reducing environmental pollution (IEA, 2016; Zhang & Yan, 2022; Zhao et al., 2014), decreasing the cost of environmental damage (Owen, 2006), guaranteeing energy security, and promoting economic development (Zhao et al., 2014) encourage countries to invest in renewable energy (Hanna et al., 2011). This study discusses renewable energy as a determinant of the pass-through of energy price shocks to countries' inflation levels and tests if price stability can be offered as an economic benefit of using renewable energy. Studies discussing the effects of renewable energy on inflation are quite limited. Schnabel (2022) expressed her expectation that the transition of more industries to low-emission technologies would put upward pressure on the prices of a wide range of products. This expectation was empirically confirmed for Mexico by Deka & Dube, (2021). However, this effect is expected to disappear after a certain level of investment in renewable energy is made. As a matter of fact, in their study for Brazil, Deka et al. (2022) could not reach a significant result about the effect of renewable energy use on inflation. At this point, the fact that Brazil has approximately four times more renewable energy use than Mexico supports the expectation that the inflationary impact of renewable energy will disappear after a certain level of investment. The mitigating effect of renewable energy use on inflation is based on the idea that fossil fuel-importing countries will not be affected by energy price shocks as they reach higher levels of renewable energy use. Dinçer et al. (2023) and Krozer (2013) confirmed the mitigating effect of increasing renewable energy use on domestic prices. Markowski & Kotliński (2023), confirmed the reducing effect of renewable energy on inflation. Lu et al. (2023) express inflation as a cause of renewable energy investments. Considering inflation and the use of renewable energy from another perspective, Akan (2023) concluded that renewable energy suppresses the environmental effects of inflation and interest rates.

This study aims to make inferences about whether the use of renewable energy is a protection against inflation caused by energy price shocks. In fact, the null hypothesis tested is that there is no pass-through from energy prices to inflation in the countries considered. However, it is clear that this hypothesis can be rejected for most countries. At this point, inferences are aimed at whether the use of renewable energy affects the decision to be made about the hypothesis in question. To this end, analyses were conducted on certain selected OECD countries covering the 2004-2023 period. Quarterly data were used. In the study, the effect of energy prices on inflation was tested using the structural vector autoregressive (SVAR) model for countries with different renewable energy use amounts. Thus, the discussion centered on whether the level of renewable energy use is a determinant of the existence and severity of the relationship in question.

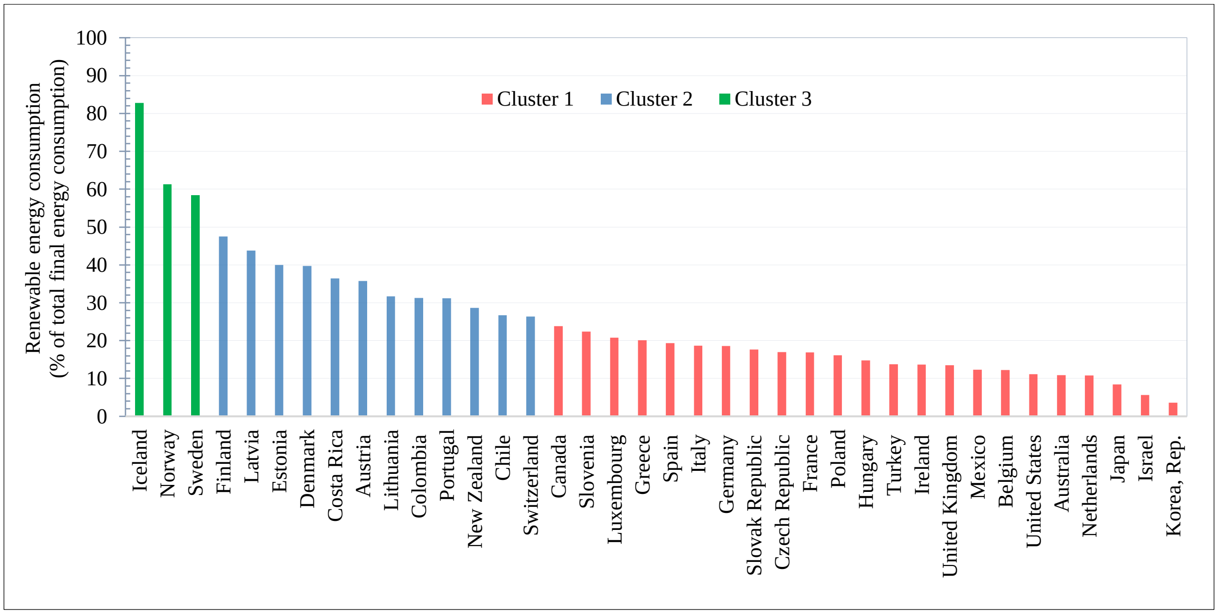
DATA AND METHODOLOGY

The study investigates whether renewable energy is a protective alternative against the effects of fluctuations in energy prices on domestic prices. To this end, the relationship between energy prices and domestic prices was examined for nine economies with different levels of renewable energy use. Renewable energy use was not directly included in the model since data on renewable energy is limited and published with an annual frequency. OECD countries were divided into three clusters based on renewable energy use level. The country closest to the cluster center, as well as the countries furthest from the cluster center both at the top and bottom, were selected from each cluster. Care was taken to ensure that the countries discussed were from the European continent. This is because they do not have significant fossil fuel reserves and are most impacted by energy crises. Figure 2 shows the use of renewable energy in OECD countries and their classification of renewable energy use through k-means clustering. The k-means clustering algorithm was used to group OECD countries according to their levels of renewable energy use. The algorithm developed by McQueen (1967) is based on the principle of dividing the dataset into sections according to the midpoint or the nearest center. This method minimizes the variation between data within the same cluster and maximizes the variation between data in different clusters. The dataset is divided into a determined number of clusters by calculating the distance of each data point to the cluster centers (Saplioğlu & Acar, 2020).

Based on the above-mentioned selection criteria, Slovenia, Hungary, and the Netherlands were selected from the first cluster; Finland, Austria, and Switzerland were selected from the second cluster; and Iceland, Norway, and Sweden were selected from the third cluster. Thus, the study covers these nine selected

OECD countries and examines if global energy price fluctuations affect domestic prices differently in countries with varying levels of renewable energy consumption. As mentioned before, three countries were selected from each cluster: the country closest to the cluster center and the countries furthest from the cluster center, both at the top and bottom. The third cluster represents the highest level of renewable energy use, and Iceland has the highest level of renewable energy use in this country group, with a rate of 82.7%. It is followed by Norway and Sweden with rates of 61% and 58%, respectively. Korea has the lowest level of renewable energy use in OECD. The share of renewable energy in total energy consumption in Korea is 3.6%. This is followed by Israel and Japan with rates of 5.6% and 8.4%, respectively. Since the study's selected OECD countries were limited to Europe, the Netherlands was taken as the country furthest from the first cluster center at the bottom. The share of renewable energy in total energy consumption in the Netherlands is 10.8%. The country with data closest to the center of the first cluster is Hungary with a rate of 14.7%. The European country furthest from the top to the first cluster center is Slovenia with a renewable energy use rate of 22%. These data show a significant variation in the proportion of renewable energy in total energy consumption. Hence, countries' levels of dependence on fossil energy show variation as well. The limitation and geographical distribution of fossil energy resources lead to energy price fluctuations influenced by many social, economic, and political developments. These price fluctuations inevitably affect the inflation rates of economies. In this regard, the study discusses whether reduced fossil fuel dependence through increased renewable energy use is protective against inflation caused by global energy prices.

Figure 2: Renewable energy in OECD countries (% of total final energy consumption, 2020)



Source: World Bank, 2023

The alternative hypothesis of the study is that increased renewable energy use makes domestic prices resilient to global energy prices. This is because the need for fossil fuels will decrease thanks to the use of renewable energy. Thus, it is expected that the effect of energy price fluctuations on inflation will be eliminated. To sum up, this study investigates the contribution of renewable energy to price stability in addition to its environmental benefits. The effect of changes in global energy prices on inflation for each selected country was analyzed using the SVAR model. The constructed model includes not only the global energy prices and inflation variables but also the exchange rate variable, following the examples of Deka & Dube (2021) and Deka et al. (2022). The exchange rate is one of the important variables in the pass-through of energy prices to inflation. Fluctuations in energy prices are expected to affect exchange rates. This expectation has been confirmed by many studies, especially on oil prices and inflation nexus (Beckmann et al., 2020; Louka & Michail, 2024; Reboredo et al., 2014). In addition, exchange rate fluctuations emerge as a factor affecting energy prices for energy-importing countries. It should be noted that the exchange rate variable is an important determinant of inflation, a finding that has been confirmed many times (Ha et al., 2020; Ozer & Kutlu, 2022; Sumba et al., 2024). Therefore, the inclusion of the exchange rate variable in the models testing the pass-through from energy prices to inflation is expected to contribute to the study findings.

Global energy prices are represented by the data from the Energy Price Index (EPI) of the International Monetary Fund (IMF). Consumer Price Index (CPI) data for the inflation variable were obtained from the OECD database. Real Effective Exchange Rate (REER) data were used for the exchange rate variable, and the data were compiled from the IMF. Table 1 summarizes the definitions of the variables and datasets included in the study. The study covers the 2004Q1-2023Q2 period and uses quarterly data. This period was chosen to maximize the number of observations meeting the economic requirements of the models. The variables were incorporated into the models in logarithmic form and at stable levels.

Table 1: Variables included in the SVAR model

Variable Name	Symbol	Variable Definition	Source
Energy Price Index	EPI	Global Price of Energy Index, Index 2016 = 100	International Monetary Fund
Real Effective Exchange Rate	REER	Effective Exchange Rate, Broad Indices, Index 2020 = 100	Bank for International Settlements
Consumer Price Index	CPI	Consumer Price Index, all items, Index 2015 = 100	OECD

The SVAR model was used to determine the effect of global energy prices on domestic inflation. This model is important both for determining the effects of energy price shocks on inflation and for allowing constraints to be placed on the simultaneous coefficient matrix. The SVAR model can be written as follows:

$$Av_t = A_0 + A_1(L)v_{t-1} + \varepsilon_t \tag{1}$$

where A refers to structural coefficient matrix, v_t refers to the vector of endogenous variable, A_0 refers to constant vector, $A_1(L)$ refers to the coefficient matrix (nxn) at lag length L, v_{t-1} refers to the vector of lagged endogenous variable, and ε_t refers to the vector of structural shocks. However, if the simultaneous effect coefficients are different from zero, the error terms will be related to the independent variables. In this case, the SVAR model is estimated in reduced form. When the model in Equation (1) is multiplied by A^{-1}, the reduced form of SVAR equation can be written as in Equation (2):

$$v_t = \theta + \beta(L)v_{t-1} + u_t \tag{2}$$

with $\theta = A^{-1}A_0$, $\beta(L) = A^{-1}A_1(L)$ and $u_t = A^{-1}\varepsilon_t$,

where u_t represents the shock vector in reduced form, which does not incorporate a serial relationship and is normally distributed and can have simultaneous relationships with each other. Equation 3 below defines the relationship between reduced form shocks and structural form shocks.

$$Au_t = \varepsilon_t \tag{3}$$

The model works on the principle of determining structural shocks through constraints put on simultaneous coefficient matrix A. This study, using quarterly data and considering the structure of energy price shocks having a direct reflection on consumer prices, does not constrain the simultaneous effect of energy prices on inflation. The equation $Au_t = \varepsilon_t$ regarding the SVAR model estimated in the study can be written as follows:

$$\begin{bmatrix} 1 & 0 & 0 \\ a_{21} & 1 & 0 \\ a_{31} & a_{32} & 1 \end{bmatrix} \begin{bmatrix} u_{EPI_t} \\ u_{REER_t} \\ u_{CPI_t} \end{bmatrix} = \begin{bmatrix} \varepsilon_{EPI_t} \\ \varepsilon_{REER_t} \\ \varepsilon_{CPI_t} \end{bmatrix} \tag{4}$$

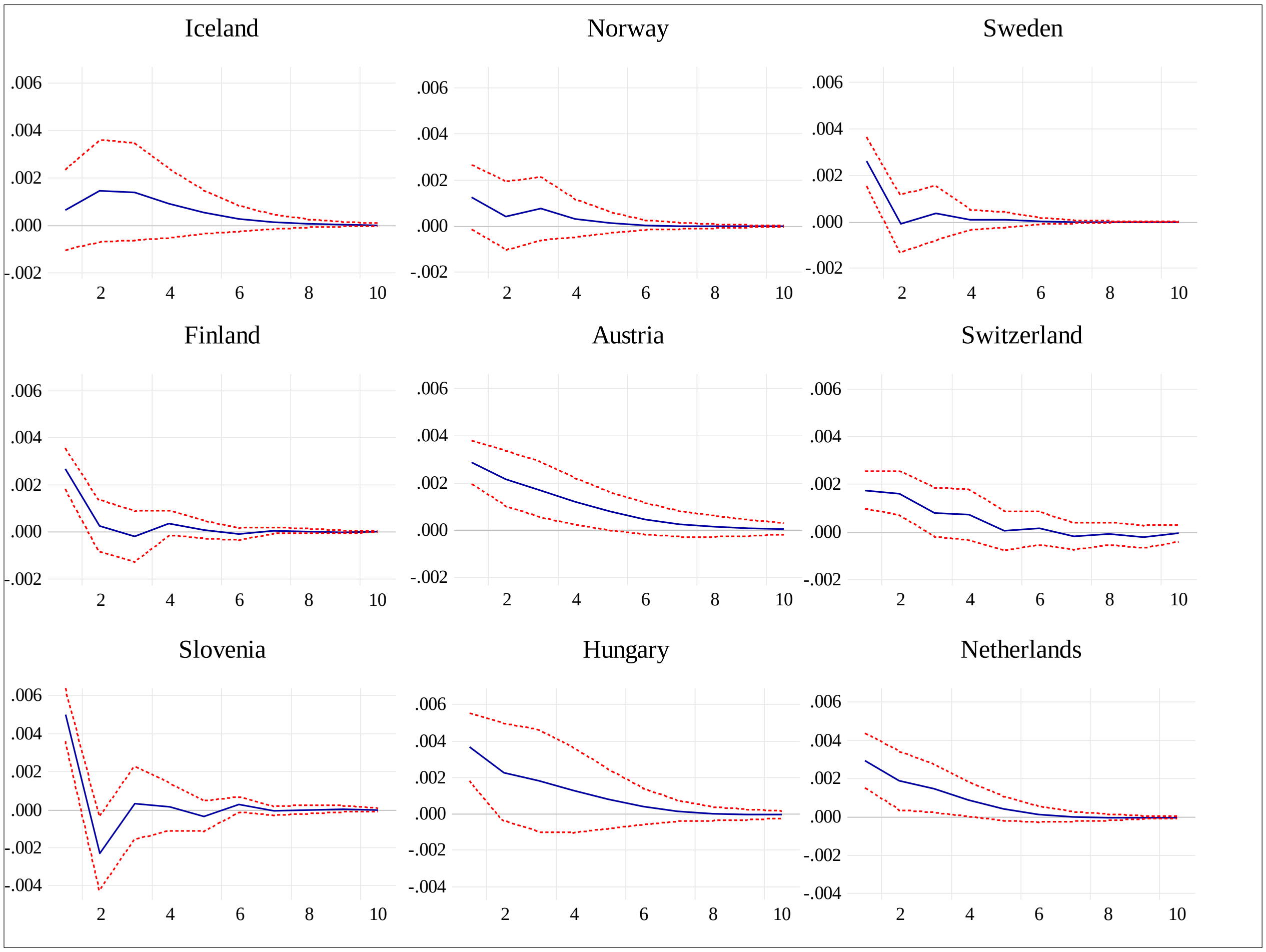
Interpreting the coefficients is not preferred when analyzing results from VAR models. Instead, evaluations are frequently based on impulse-response functions. These functions refer to the response of other relevant variables to a one-unit standard deviation shock occurring in the error terms of the endogenous variables. Considering the differences in the units of measurement of the variables, standard deviation shocks, rather than unit shocks, are used at this point. In the study, inferences were made based on impulse-response functions obtained in the SVAR model.

RESULTS

OECD countries were divided into three clusters based on their renewable energy consumption levels. Three countries were selected from each cluster, and nine countries representing different renewable energy consumption levels were covered in the study. The effect of energy prices on inflation within each country's economy was tested using the SVAR model. The variables were incorporated into the models at their stable levels, and, for brevity, they are not tabulated in this article. The results obtained from the SVAR models, which did not constrain the simultaneous effect of energy prices on inflation, were analyzed in terms of impulse-response functions.

Figure 3 shows the effects of structural shocks in energy prices on CPI, which represents the inflation variable. The first row of the figure shows the impulse-response functions of the countries in the third cluster. This group consists of the countries with the highest renewable energy consumption levels. The second row displays the impulse-response functions of the countries in the second cluster, and the third row presents the impulse-response functions of the countries in the first cluster. In other words, the level of renewable energy consumption decreases from top to bottom in the figure. In addition, the renewable energy use level of each country in the figure is higher than that of the country or countries to its right in the same column.

Figure 3: IRF functions: Response of CPI to EPI



The findings obtained from impulse-response functions show that the effect of changes in energy prices on CPI in Iceland and Norway, the two countries with the highest renewable energy consumption levels, is not statistically significant. In Sweden, which is in the third cluster but has a lower amount of renewable energy use compared to the other two countries, the positive effect of a shock in energy prices on CPI was found to be significant for the first period. In other words, it can be stated that fluctuations in global energy prices result in a pass-through to domestic prices within the Swedish economy, which is the country with the lowest level of renewable energy use in the third cluster. However, the model could not confirm this relationship for Iceland and Norway. The countries in the second cluster are Finland, Austria, and Switzerland. The positive effect of shocks in energy prices on inflation was found to be statistically significant for the three countries in this cluster. The shock lost its effect after the first period in Finland and after the third period in Austria and Switzerland. In Slovenia, Hungary, and the Netherlands, from the first cluster with the lowest renewable energy consumption, the positive effect of EPI on CPI was found to be statistically significant. The countries in the first cluster exhibited a more severe response to inflation induced by shocks in global energy prices compared to those selected from the other clusters. The inflation responses to global energy price changes in countries within the first cluster were seen to be more severe than those in the second cluster.

The findings offer crucial implications regarding the relationship between renewable energy use and the pass-through of energy prices to inflation. In Iceland and Norway, the two countries with the highest levels of renewable energy use, no significant results were obtained regarding the effect of global energy price shocks on inflation. This allows inferring those domestic prices are more resilient to global energy price shocks in countries with less fossil energy dependence. Moreover, it was observed that the response of inflation to shocks in global energy prices in the countries in the first cluster, having the lowest levels of renewable energy consumption, was higher than that in the countries in the second and third clusters. It is clear that fluctuations in global energy prices are mainly driven by fossil fuel prices. This can also be observed in Figure 1. The findings of the study support the inference that the increase in renewable energy use will reduce the sensitivity of economies to global energy prices, by excluding fossil fuels. The impulse-response functions suggest that the effects of shocks in global energy prices on inflation generally disappear within one to three periods. This implies that energy price shocks are usually transmitted to inflation through consumable energy products such as those for cooking and heating. Moreover, the short-term effects of shocks can be explained by policy measures as well as structural measures in the countries analyzed. In this sense, the fact that the selected countries have similar characteristics in terms of energy reserves, are located in the same geographical region, and do not show significant differences in terms of economic perspective is important for the inferences made in the study.

CONCLUSION

One of the crucial and strong effects of energy prices is on countries' inflation levels. As emphasized earlier, energy is classified as a direct consumption good for households and serves as an intermediate good and raw material for industry and other sectors. Energy, both as a consumption good and as an input, has an effect on domestic price levels. Therefore, a pass-through from shocks in global energy prices to inflation is expected in energy-importing countries that cannot meet their energy needs from their own reserves. The relationship between energy prices and inflation rates of economies has been confirmed by many empirical studies for various countries. Departing from this, the present study proposes that the use of renewable energy, which constitutes an alternative to fossil energy sources with many environmental benefits, will reduce the effects of global energy price shocks on inflation. This proposition was tested through the SVAR model using data for nine OECD countries with different levels of renewable energy use from the European region, which does not have significant fossil fuel reserves. The study evaluated the differentiation in the effect of global energy prices on inflation depending on the levels of renewable energy use.

The SVAR model was separately estimated for each cluster of selected OECD countries, grouped by their renewable energy use level. The relationship between global energy prices and inflation was evaluated through impulse-response functions obtained from the estimated models. The findings revealed that the effect of global energy prices on inflation was not confirmed in the two countries with the highest levels of renewable energy use. However, in the first cluster, representing the lowest level of renewable energy use, the response of inflation to shocks in global energy prices was higher than in the second cluster. Based on the findings, it can be argued that the sensitivity of domestic prices to shocks in global energy prices decreased due to the increase in the level of renewable energy use. This serves as confirmatory evidence for the proposition of the study.

The relationship between energy prices and inflation was confirmed for seven of the nine countries analyzed in the study. These findings are consistent with He & Lee (2022), Keček (2023), Özmen & Özşahin (2023), Talha et al. (2021), and Valadkhani et al. (2014). The findings of the study also confirmed that the relationship in question may vary across periods for different economies and that the level of the relationship does not remain the same (Choi et al., 2018; Tiwari et al., 2019). In the two countries with the highest levels of renewable energy use, the relationship between energy prices and inflation could not be established. However, the effect of global energy prices on domestic prices in the second cluster, representing a higher level of renewable energy use, was found to be smaller than in the first cluster. These findings suggest that the use of renewable energy mitigates the effect of global energy price shocks on inflation. Based on these results, the study supports the findings of Dinçer et al. (2023) and Krozer (2013). The results emphasize that renewable energy provides an alternative to fossil energy sources to make countries' domestic prices more resilient to economic, political, and other energy price shocks. The policy recommendation of the study is to increase the level of renewable energy use as it is a support against price shocks in addition to its environmental benefits. Substituting fossil fuels with renewable alternatives is essential in controlling the pass-through of global energy price fluctuations to domestic prices, especially in fuel-importing countries.

Another noteworthy contribution of the study's findings is that it provides inferences for the non-linear relationship between the level of renewable energy use and the pass-through of global energy prices to domestic prices. The results from Deka et al. (2022), Deka & Dube (2021), and Schnabel (2022) suggest that high-cost renewable energy infrastructure investments may create inflationary pressure up to a certain level, but this effect will disappear after a certain level. Therefore, it is possible to infer that the use of renewable energy cannot prevent the pass-through of energy price shocks to inflation up to a certain level.

The findings of the present study support this inference. This is because the inflationary impacts of energy price shocks were not confirmed for countries with the highest levels of renewable energy use. However, this inference needs to be supported with more evidence. Thus, this study suggests investigating the determinant role of the level of renewable energy use in the relationship between energy prices and inflation through non-linear models.

AUTHOR STATEMENT

Researcher declared that all contributions to the article were his own. Researcher have not declared any conflict of interest.

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