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Inflation effects of oil and gas prices in the UK: Symmetries and asymmetries

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ABSTRACT

The United Kingdom is among the countries experiencing a cost-of-living crisis believed to be influenced, at least in part, by the dynamics of the international oil and gas markets. To this end, this study aims to achieve to achieve two objectives. Firstly, the dynamic association between the UK's inflation and oil and gas prices is examined. Further, the study examines whether the response of the UK's inflation to energy price dynamics is (a) symmetric. This study adopts wavelet coherency to determine the dynamic co-movement between energy prices and inflation. In addition, the dynamic simulated autoregressive distributed lag model (DS-ARDL) is used to examine the dynamic response of inflation to energy price changes. The estimation results reveal a symmetric response of inflation to gas price shocks. Further, the response of inflation to oil price shocks is asymmetric. Interestingly, the effect of gas price dynamics passes more strongly to inflation than to oil price dynamics. These findings suggest that a more diversified energy mix could help prevent substantial energy price pass-through to inflationary pressures.

1. Introduction

Economies globally are facing the challenge of rising inflation; the United Kingdom (hereafter, the UK) is no exception. The high level of inflation in the UK recently (up to 11.1% in October 2022) is dubbed the highest over three decades. To stem the upward inflation trajectory, the Bank of England (BoE) consistently raised the policy rate from 0.25% in January 2022 to 4% by February 2023 (BoE, 2023). Despite this, inflation in the UK has remained significantly high.

The high inflation in the UK is attributed mainly to the significant increase in energy prices and the disruption of supply chains due to COVID-19 (BoE, 2022b). This situation is further compounded by the Russia-Ukraine crisis, which has led to higher food and energy prices, especially gas prices. The rise in wholesale gas prices was enhanced by the decline in Russia's gas supply to Europe, leading to an acute gas shortage in the continent. Further, the crisis in Ukraine increased oil prices, exacerbating the rise in energy prices and transportation costs, among others.

The effect of rising energy prices on inflation cannot be overemphasised. According to the Bank of England (BoE, 2022a), energy and food prices accounted for over 80% of the offshoot of inflation over its 2% target. A rise in energy prices influences the general price level of goods and services (Dornbusch et al., 2001; Nasir et al., 2018). There are three key channels of energy prices pass-through to inflation. The first channel of energy prices that passes through to inflation is the increase in the production cost of goods and services, considering that energy can be a major input in the production process. The increase in the cost of production is reflected in higher prices for goods and services, leading to an upward movement of inflation – a phenomenon referred to as cost-push inflation (Li and Guo, 2022). The second channel is the increase in household energy bills, which feeds directly into CPI inflation.

Interestingly, despite the increasing share of renewable sources in the UK energy mix, electricity price is determined by the price of gas (Grubb, 2022). Consequently, household energy bills are influenced

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mainly by natural gas prices, compounded by the fact that the UK is a net gas importer, importing about 60% of its natural gas needs (Patel and Paul, 2022), making the country susceptible to changes in international gas prices. For instance, the UK imported £4.5 billion worth of energy resources in 2021, composed of 2% of the gas used in the UK, 27% of coal and 9% of oil. This level was reduced to £2.2 billion in 2022 and further to 1.3 by January 2023 (Paul, 2023). Another channel of pass-through of energy prices to inflation is the price of fuel for transportation, which feeds into CPI inflation. An increase in the price of crude oil feeds into higher diesel, petrol, and jet fuel prices, among others. Considering that transportation is allocated the second highest weight in the UK's CPI basket (ONS, 2022), an increase in fuel prices feeds into CPI inflation.

Given the energy crisis in Europe, caused partly by geopolitical tensions, investigating the transmission of energy prices to domestic inflation would provide policymakers with further insight into ways to solve the current cost of living crises experienced in the UK. The need for this insight is further supported by the fact that firms are passing the costs on to the final consumers as one of their coping strategies (Sharon, 2022). Interestingly, although the relationship between oil price and inflation has been widely examined, except for studies such as Vatsa and Mixon (2022) and He and Lee (2022), the effect of the price of other energy sources such as natural gas on inflation has not received much attention despite being the key energy source for many countries. Kilian and Zhou (2022) observed that rising oil prices have a significant short-term effect on headline inflation; the impact on core inflation and long-term inflation expectations is relatively insignificant, revealing the transient nature of oil price shocks on inflation. On the other hand, Kpodar and Liu (2022) found that the response of consumer price inflation to gasoline price shocks is relatively smaller but more persistent in developing countries than in advanced economies. Interestingly, a rise in gasoline prices reduces the real income of households, with the distributional effect being progressive but short-lived. Thus, the current cost of living crisis shows that energy sources are relevant determinants of inflation and have a deleterious pass-through effect on social welfare.

This study contributes to the energy inflation literature by aiming to examine the asymmetric effect of energy prices (oil and gas) on inflation in the UK. Specifically, this study answers the following research questions: does inflation in the UK respond asymmetrically to oil and gas prices? How do positive oil and gas price shocks affect inflation dynamics in the UK? What is the effect of negative oil and gas price shocks on inflation dynamics in the UK? Answering these research questions is imperative because of the potential implications of asymmetries on policy decisions, given that the response of inflation to increasing energy prices might differ from that of decreasing energy prices. The study is also timely due to current uncertainty in the energy market and the UK being a net oil and gas importer with cost-of-living challenges attributed to energy prices, at least in part.

2. Related literature

The theoretical literature underscores several linkages in the production cost, prices of output, and cost of living. Schneider (2004) identifies demand and supply channels of the effect of oil price shocks on the economy. The supply side is often linked with Taylor (2000), whose theoretical framework postulates that firms tend to transfer their costs to consumers in an inflationary environment. In addition, the decision of firms to raise workers' wages could further increase inflation; this is often referred to as the second-round effect. On the other hand, the demand side (first round effect) channel occurs when oil price shocks increase the general price level, resulting in reduced real disposable incomes and a corresponding reduction in demand (Schneider, 2004). Fig. 1 depicts these channels. Moreover, when the energy component of CPI carries a high weight, the effect is usually more apparent.

The structural oil market model (Kilian and Murphy, 2014) illustrates how fluctuations in oil prices can be traced back to distinct

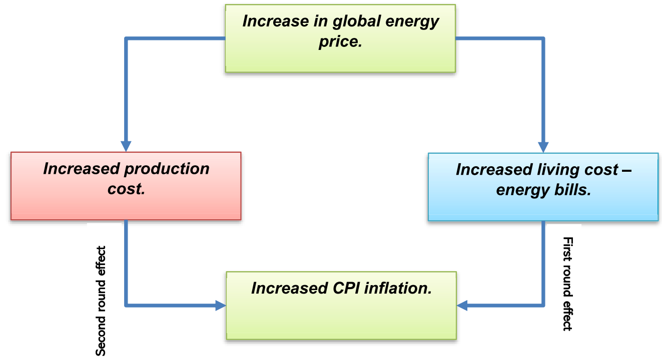

Fig. 1. Transmission channel of energy prices to inflation.
Source: Authors' conception

structural shocks with various economic interpretations. The model links fluctuations in oil prices, oil production, oil consumption, and global GDP growth with four types of shocks, each with its economic interpretation: oil supply shocks, oil-market-specific demand shocks, storage demand shocks, and global economic growth shocks.

The relationship between oil price and inflation has been widely studied in the literature with varied outcomes (see, for instance, Dedeoglu and Kaya, 2014; Tang et al., 2010; Castro and Jiménez-Rodríguez, 2017; Nasir et al., 2018; Zaremba et al., 2019; Giri, 2022). Studies that examined the pass-through of oil price to inflation focusing on the UK include Rafiq (2014) and Renou-Maissant (2019). Pass-through of high energy prices to domestic prices leads to inflationary pressures, especially in advanced and emerging economies (Abbas and Lan, 2020; Chen et al., 2020; Lin and Xu, 2019). Cecchetti and Moessner (2008) also found that food and energy prices increase inflation. A part of the literature also indicates an asymmetric effect of oil prices on inflation (Choi et al., 2018; Goh et al., 2022; Hooker, 2002; Harvey et al., 2017; Raza et al., 2017; Salisu et al., 2017; Sarwar et al., 2020; Shitile and Usman, 2020; Çatik and Önder, 2011; and more recently Goh et al., 2022; Altunöz, 2022). In addition, Choi et al. (2018), Harvey et al. (2017), and Sarwar et al. (2020) have found that positive energy price shocks have a greater impact on inflation than negative shocks.

Shocks in energy prices usually have short-run and long-term dynamics (Calmfors, 1982). The transmission of the short-term impact to the long-term depends on the factors that trigger the shock, macroeconomic structures, and policy responses (Amaglobeli et al., 2022; Dressler, 2016). Unalmis et al. (2008) show that the effect of oil supply and oil demand shocks could differ in small open economies. Kilian (2008) estimates the effect of global oil supply shock on industrial economies and finds similarities across the countries - oil supply shocks reduce real output growth in the second year after the shock. However, inflation responses to oil price shocks vary; oil supply shocks immediately affect sustained consumer price inflation, which peaks in the third to fourth quarters after the shock. Baba and Lee (2022) demonstrate that the shock to oil price pass-through effect on consumer price inflation depends on country-level structures and is high when the prevailing inflation rate is higher. The effect wanes faster in advanced countries compared to emerging market economies.

Inflationary responses to oil market shocks could also vary depending on whether the shock is triggered from the supply or demand side. Chen (2009) argues that supply shock has the largest pass-through effect on oil prices among the three main shocks in the crude oil market (supply shock, global aggregate demand shock, and oil market-specific shock). Cashin et al. (2014) find that oil-importing countries experience long-lived declining economic activities in response to oil prices due to supply-side shocks, while oil-producing countries benefit from the shocks. However, demand-side shocks increase inflationary pressures and interest in all countries. Lorusso and Pieroni (2018) find that movement in oil prices in the UK is associated with oil demand shocks rather than supply shocks, while the macroeconomic effects depend on the type of oil price shocks. A shortfall in energy supply has an immediate short-term negative effect on GDP growth, while inflation also increases in response to an increase in real oil prices. Van De Ven and Fouquet (2017) also identify supply, aggregate demand, and residual shocks to energy prices in the UK and estimate that the economy is increasingly vulnerable to supply shocks as it transitions toward coal and less vulnerable with the partial transition to oil. However, the transition from exporting coal to importing oil increases the vulnerability of the UK economy to demand shocks.

Policy responses to inflationary pressures have been mixed across countries (Baffes et al., 2015). For countries with an inflation-targeting monetary framework, increasing the short-term policy rate is usually the first step, as in the case of the UK (Her Majesty Treasury, 2013). Barwell (2007) argues that rising energy prices impact the prices of energy-intensive goods in the UK, but the impact on inflation depends on policy response and inflationary expectations. Barrel and Pomerantz (2014) argue that the effect of oil price shock on short-term output growth can be ameliorated by policy response, but this could be at the expense of higher inflationary pressures. Natal and Bank, 2009 show s that inflation-stabilising policies in a non-competitive economy could have substantial welfare effects because energy is used for both production and consumption. A meaningful policy trade-off between stabilising inflation and the relevant output gap could be evident because energy is not easily substitutable in production in the short run.

The effect of cost-of-living crises on social welfare in the UK is not far-fetched. Several households are already reeling in debt and mounting bills. Tetlow (2022) estimates that the current declining living standards in the UK could be the worst in a century. Household incomes have come under severe pressure due to the combined effect of slowed economic growth due to the COVID-19 pandemic and the cost of living crises leading to declining consumption expenditure and aggregate social welfare (Keep et al., 2023; Leslie and Holdsworth, 2022). Gajdzik et al. (2024) assert that although higher energy prices feed into higher inflation, leading to lower living standards, a possible silver lining is its tendency to enhance the transition to cleaner energy sources. The preceding review of the empirical literature reveals the absence of consensus on the effect of energy prices on inflation and, by extension, social welfare. This gap necessitates further exploration of the relationship between energy prices and inflation. Further, the possible non-linearities on the effect between the variables have not received much attention in the literature. In addition, while the effect of oil prices has been widely explored, the inflation effect of gas prices has not been examined widely. This study fills these gaps in the literature.

3. Materials and methods

3.1. Estimation strategy

The analysis strategy of this study is twofold. In the first step, Wavelet Coherency is applied to examine the dynamic association between energy prices and inflation in the UK. The next step in the analysis entails applying the Dynamic Simulated Autoregressive and Distributed Lag (DS-ARDL) model to examine the asymmetric response of inflation to energy prices.

3.1.1. Wavelet coherency

The Wavelet Coherency is a correlational analysis that captures the association between variables, which might vary with time and at different frequencies (Shahzad et al., 2021; Tiwari et al., 2022). It also identifies the frequencies influencing changes in the overall correlation between variables (Giri, 2022). Unlike the correlation and Fourier analysis, which measures the association between two variables either in the time and frequency domain respectively, Wavelet Coherency concurrently extracts local spectral and temporal information from time-differing signals using a range of wavelets, and it can be applied to stationary and heterogeneous objects (Aguiar-Conraria et al., 2018; Vacha and Barunik, 2012). By analysing the phase differences, we can infer whether one time series leads or lags the other, which can be crucial for understanding causality or the sequence of events. It also helps to filter the coherency between two variables by removing the influence of other confounding variables. This approach leads to a more accurate understanding of the direct relationship between the two primary variables of interest. The noise filtering and focusing on the significant components of the signal is essential for clear interpretation and decision-making. Given the complexities of inflation in the UK, it is essential to fully understand the co-movement of energy prices and inflation, considering other confounding factors. In this regard, this technique surpasses traditional correlation analysis, which fails to capture such complexity.

Moreover, wavelet coherency can identify phase-based relationships during varying shock phases, offering an advantage over bivariate correlation analyses like the cross-quantilogram, which primarily assesses directional predictability and quantile dependence between two series. The application of this method provides insight into the strength, frequency, and length of correlation between energy prices and inflation in the UK. For a detailed survey of the Wavelet method, see Aguiar-Conraria and Soares (2014). The wavelet is a square-integrable function with real values, $\psi \in L^2(R)'$.

$$\psi_{u,s}(t) = \frac{1}{\sqrt{s}}\psi\left(\frac{t-u}{s}\right) \tag{1}$$

where $\frac{1}{\sqrt{s}}$ is a normalization factor that ensures the unit variance of the wavelet $\|\psi_{u,s}\|^2 = 1$. Consequently, the wavelet possesses two control parameters, U and S. The location parameter U provides the precise location of the wavelet, whereas the scale parameter S specifies the degree to which the wavelet is stretched or dilated. The scale has an inverse relationship with frequency; therefore, a greater scale corresponds to a less compressed wavelet.

A core tenet for wavelet is the admissibility condition. This condition is stated as:

$$C_\psi = \int_0^\infty \frac{|\Psi(f)|^2}{f} df < \infty \tag{2}$$

where $\Psi(f)$ is the Fourier transform of a wavelet $\psi(.)$.

The criterion implies that the wavelet has a non-zero frequency component with a mean of zero, i.e., $\int_{-\infty}^{\infty} \psi(t)dt = 0$. In addition, the wavelet is often normalized to have unit energy, $\int_{-\infty}^{\infty} \psi(t)dt = 1$, implying that the wavelet deviates from zero. The bivariate framework, Wavelet Coherence, is introduced to examine the interaction between two time series. Cross Wavelet Transform (CWT) and Cross Wavelet Power (CWP) are first given to comprehend Wavelet Coherency.

Following Torrence and Compo (1998), the CWT of two time series, say fuel price p(t) and inflation π (t), may be defined as follows:

$$W_{p\pi}(u,s) = W_x(u,s)W_\pi^*(u,s) \tag{3}$$

where $W_{p\pi}(u,s)$ and $W_\pi(u,s)$ are Continuous Wavelet Transforms of $p(t)$ and $\pi(t)$ respectively, U is a position index, and S denotes the scale, while the symbol * denotes a complex conjugate. The Cross-Wavelet Power can easily be computed using the Cross Wavelet Transform as $|W_{p\pi}(u,s)|$.

The CWP reveals areas in the time-frequency space where the time series show a high common power, i.e., it represents the local covariance between the time series at each scale. The Wavelet Coherence can detect regions in the time-frequency space where the examined time series comove but do not necessarily have a high common power. Following the approach of Torrence, the squared Wavelet Coherence coefficient is defined as:

$$R^2_{u,s} = \frac{\left|S\left(s^{-1}W_{p\pi}(u,s)\right)\right|^2}{S\left(s^{-1}\left|W_p(u,s)\right|^2\right)S\left(s^{-1}\left|W_\pi(u,s)\right|^2\right)} \quad (4)$$

where S is the smoothing operator. The squared Wavelet Coherence coefficient range is $0 \leq R^2(u,s) \leq 1$. Values close to zero indicate a weak correlation, whereas values close to one suggest a strong correlation. The squared Wavelet Coherence thus evaluates the local linear correlation between two stationary time series at each scale and is comparable to the squared correlation coefficient in linear regression.

3.1.2. Dynamic simulated ARDL model

Dynamic Simulated-ARDL (DS-ARDL) was developed by Jordan and Philips (2018) to dynamically simulate the results of the ARDL model via meaningful counterfactual scenarios. Due to the complexity of the lag structure of the ARDL model, it might be challenging to draw short, medium, and long-run inferences from the estimates of the model. Using stochastic simulation techniques, DS-ARDL visualises the counterfactual change in a regressor at a point in time (Jordan and Philips, 2018a). In addition, the method estimates and plots forecasts of counterfactual changes in a constant independent variable. Further, the technique estimates and plots graphs to predict negative and positive responses of variables in the long and short run.

Regarding integration order, the approach has fewer restrictions than conventional ARDL. For instance, it can handle variables of the same or mixed order of integration. Jordan and Philips (2018b) noted that the ARDL has the advantage of being flexible, but this can also be a drawback because it makes it difficult to detect the entire effect of any independent variable. This challenge is compounded by the possibility that these variables may have short and long-term effects. In other words, an immediate change in an explanatory variable may have an immediate effect in the contemporaneous period *t*, but if lagged values of the explanatory variable are also included in the model, the effect will continue throughout many periods.

Moreover, if the dependent variable is entered into the model with a lag, the effects of the independent variable at a particular period *t* remain over time. Given a change in an explanatory variable in a single period, there is a cumulative or long-run effect over time. Jordan and Philips (2018) argued that DS-ARDL circumvents this issue by leveraging stochastic simulations instead of directly interpreting coefficients to demonstrate statistical and substantive significance. The dynamic stochastic simulations offer an alternative to direct hypothesis testing of coefficients, focusing instead on repeatedly simulating relevant counterfactuals from model coefficients and extracting inferences from the simulations' main tendencies. In line with the above, the DS-ARDL's advantage over the traditional ARDL model further includes the possibility for dynamic multi-step forecasting, which can be particularly useful for policy simulation and scenario analysis. In this regard, the model can provide more accurate short-term forecasts, as it accounts for the time-varying nature of the relationships between variables. The model is also flexible in dealing with non-linearities and asymmetries in the relationships between the variables. Furthermore, the model is deemed to accommodate structural breaks in the data more effectively; this is crucial for obtaining reliable short- and long-term coefficient estimates.

3.2. Model

In examining the relationship between energy prices and inflation in the UK, the empirical model includes the interest rate as an explanatory variable and controls the crisis in Ukraine and COVID-19. The interest rate in the inflation rate-energy nexus can directly influence inflation through the cost of borrowing and indirectly by affecting economic activity. For instance, higher interest rates can dampen demand for money due to the high cost of borrowing, slowing down inflation from a demand management perspective. On the other hand, lower interest rates can boost monetary circulation, potentially raising the inflation rate. Thus, the UK base rate is used as a proxy for interest because of its use as a policy tool to control inflation by the BoE. A rise (tightening) in the policy rate is expected to reduce inflation. The impact of war/crisis can lead to uncertainty in energy supply, which can cause volatility in energy prices. For instance, conflicts in oil-producing regions or countries can disrupt supply and drive up prices, contributing to inflation. Thus, this factor helps isolate the specific impact of energy prices on inflation from these external supply shocks. More so, the conflict in Ukraine has disrupted the supply of commodities (such as agricultural products and energy products), which is expected to influence inflation positively. Lastly, the COVID-19 pandemic has profoundly impacted supply and demand across the global economy (see Vasquez, 2023). This effect could stem from both the demand and supply side. For instance, from the demand side, the changes in consumption patterns during the pandemic significantly affected energy demand and prices.

On the other hand, a disruption in the supply chains can lead to higher production costs and, consequently, higher energy prices. Therefore, the effect of Covid-19 on inflation depends on the strength of the two opposing factors. Based on the preceding, the empirical model of this study is specified as:

$$\text{Inflation} = f\,(\text{Energy Prices}, \text{Interest rate}, \text{War}, \text{Covid}-19) \quad (5)$$

The empirical model can be specified as an ARDL model that takes the form of:

$$\Delta infl_t = \alpha_0 + \alpha_1 infl_{t-1} + \alpha_2 eng\_pr_{t-1} + \alpha_3 intr_{t-1} + \alpha_4 war_{t-1} + \alpha_5 covid_{t-1} + \sum_{i=1}^{p}\beta_{1i}\Delta infl_{t-i} + \sum_{j=0}^{q}\beta_{2j}\Delta eng\_pr_{t-j} + \sum_{j=0}^{q}\beta_{3j}\Delta intr_{t-j} + \sum_{j=0}^{q}\beta_{4j}\Delta war_{t-j} + \sum_{j=0}^{q}\beta_{5j}\Delta covid_{t-j} + \mu_t \quad (6)$$

where *infl* is inflation, *eng_pr* is energy prices, *intr* is policy rate, *war* is a dummy variable that controls for the effect of the Russian-Ukraine crisis, and *covid* is a dummy variable that controls for the Covid-19 pandemic. Energy prices in the above model are classified into two components: oil prices and gas prices.

3.3. Data

The description of the data is presented in Table 1.

Monthly data on the variables cover the period April 2012 through December 2022. The data on gas and oil prices are converted to their logarithmic form before being used for analysis.

Table 1
Description of variables.

Variable	Definition	Source
Inflation (*infl*)	Monthly rate of consumer price inflation in the UK	UK ONS
Gas prices (*gas*)	Average monthly day-ahead gas price	UK Ofgem
Oil Prices (*oil*)	Average monthly crude oil price	EIA
Interest rate (*intr*)	Monthly policy base interest rate	BOE
War (*war*)	Dummy variable that takes the value of 1 for periods of the crisis in Ukraine and 0 if otherwise.	Formal Declaration in the Media.
Covid-19 (*covid*)	Dummy variable that takes the value of 1 for periods of Covid lockdown and 0 if otherwise.	UK Government Announcement.

Note: UK ONS – Office of National Statistics Inflation Reports; UK Ofgem – Office for Gas and Electricity Markets Statistics; EIA – US Energy Information Authority; BOE – Bank of England.

3.4. Dynamics of inflation and energy prices in the UK

The UK witnessed a substantial increase in inflation since the beginning of 2021. The data presented in Fig. 2 shows a significant rise in inflation from about 0.7% in March 2021 to a peak of about 11.1% in October 2022 before falling slightly to about 10.5% in December 2022. It shows a significant jump from October 2021 up to the end of the study period.

Energy prices have also significantly increased with inflation, as presented in Fig. 3, with gas prices having a more significant and unstable increase than the oil price. Fig. 3 indicates a historically close association between oil and gas prices with minimal deviation since 2012. However, from 2021, gas prices have significantly deviated from oil prices with substantial fluctuation. Although oil prices have also increased, they have been less aggressive than gas prices. The fluctuation in oil prices is also lesser. The trends of gas prices closely match the trends of inflation in Fig. 2, especially during the COVID-19 pandemic and the Russia-Ukraine crisis.

In response to the upward inflation trajectory, the BoE's first intervention was to increase the policy rate to stabilise the increasing prices. Since energy prices are exogenously determined, the policy rate may not directly influence these variables but can influence inflation dynamics through aggregate demand. The BoE Policy rate was 0.1 from April 2020 to December 2021. In January 2022, the BoE began to increase the policy rate to help address the increasing inflation rate, which increased to 5.5%, the highest over a decade. However, inflation did not immediately respond to the increased policy rate as inflation continued to increase, reaching 11.1% by October 2022. It is important to note that oil and gas prices continuously increased and fed into inflation during this period, possibly explaining why the increased policy rate might not have helped to reduce inflation. In November 2022 the policy rate was 3.0% and 3.5 in December 2022, from 0.25% in January 2022. Interestingly, inflation declined from 11.1% in October 2022 to 10.7% in November 2022 and 10.5% in December 2022. Given that the effect of monetary policy manifests with a time lag, the gradual decline in inflation may be due to earlier monetary tightening in 2022. However, it is worth noting that average energy prices also reduced towards the end of 2022.

4. Results and discussion

4.1. Wavelet coherency results

As a first step in time series analysis, the data on all the variables are subjected to a stationarity test using the Augmented Dickey-Fuller (ADF) unit root test. The results (Table 2) indicate that all the variables are integrated of order one. This implies that they need to be different to become stationary. Consequently, the variables were differenced before being employed for the Wavelet Coherency analysis.

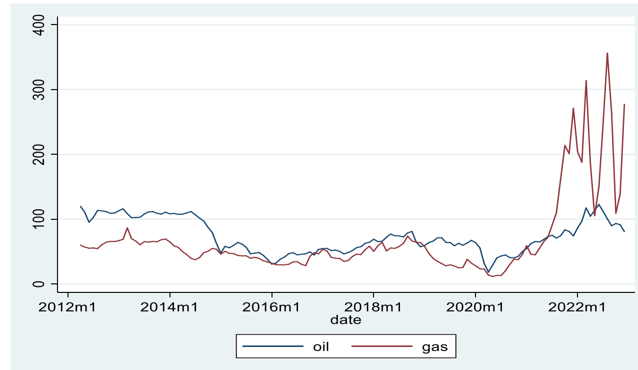

Fig. 3. Energy prices.
Source: Authors' Computation using data from the UK Office for Gas and Electricity Markets

Table 2
Stationarity test result.

Variables	Level		First Difference		Order of Integration
	Intercept	Intercept and Trend	Intercept	Intercept and Trend	
Inflation	−2.572	0.984	−1.979	−10.462[a]	I(1)
Gas	−0.606	−0.956	−9.798[a]	−9.913[a]	I(1)
Oil	−1.965	−1.843	−8.894[a]	−8.890[a]	I(1)
Interest rate[b]	3.541	4.270	−5.662[a]	−6.277[a]	I(1)

[a] indicates statistical significance at 1%.
[b] The Philips-Perron test was used.

Figs. 4 and 5 present the Wavelet Coherency plot, which shows the association between energy prices and inflation. In the plots, the darker (red) area represents the combination of frequency and period with a strong local correlation, while the colder (blue) area represents the combination with a weaker local correlation. The black contour lines denote statistical significance at 5%.

The Wavelet Coherency plot of inflation and oil prices from April 2012 to December 2022 is presented in Fig. 4. From the plot, apart from the few episodes of low period scales co-movement witnessed in 2012 and 2016, the inflation and oil price nexus appeared to be weak and insignificant until around 2018 onward, when a strong coherency between the variables was witnessed mainly in medium and high period scales. Interestingly, in recent times, a strong oil price and inflation nexus was witnessed in low period scales, especially in 2022. This

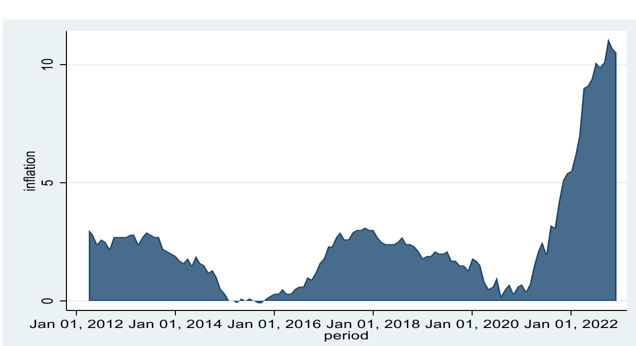

Fig. 2. UK inflation rate.
Source: Authors' Computation using data from the UK Office of National Statistics

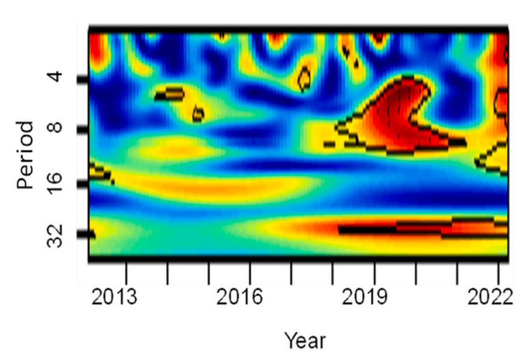

Fig. 4. Wavelet Coherency Plot of Inflation and Oil Prices. Note: Wavelet coherency plot from April 2012 to December 2022. Darker (red) area depicts high coherency, while colder (blue) areas depict low coherency. Black contours represent statistical significance at 5%.

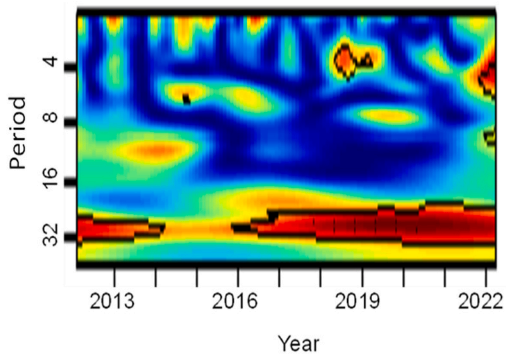

Fig. 5. Wavelet Coherency Plot of Inflation and Gas Prices
Note: Wavelet coherency plot from April 2012 to December 2022. Darker (red) area depicts high coherency, while colder (blue) areas depict low coherency. Black contours represent statistical significance at 5%.

finding might not be unconnected with the Russia-Ukraine crisis-induced oil price jump. These findings imply that the strong relationship between oil price and inflation in the UK is mainly in the long run, except in recent times when a short and medium-run relationship is experienced.

As regards the relationship between inflation and gas prices presented in Fig. 5, a strong coherency is exhibited in high period scales between 2012 and 2014 and from 2016 onward. In addition, two episodes of a strong relationship in low period scales are witnessed in 2019 and 2022. The strong inflation and gas price nexus in high frequency witnessed in 2022 could be attributed to the influence of the heightened geopolitical risks associated with the crisis in Ukraine. The inference drawn from this finding is that the relationship between gas prices and inflation is mainly in the long run, although a few episodes of short-run relationship have been witnessed, especially in recent times. The strong coherence between variables points to the potential significance of energy prices in influencing inflation in the UK.

4.2. Asymmetric response results

The DS-ARDL plots depict the response of inflation to energy price dynamics. Specifically, the plots show the predicted inflation values following a 1.0 standard deviation positive and negative shocks in oil and gas prices. The dynamic simulated plots are presented in Figs. 6–9. The model's variables are cointegrated (i.e., have long-run association) after being subjected to the Pesaran, Shin, and Smith (PSS) Bound Test.

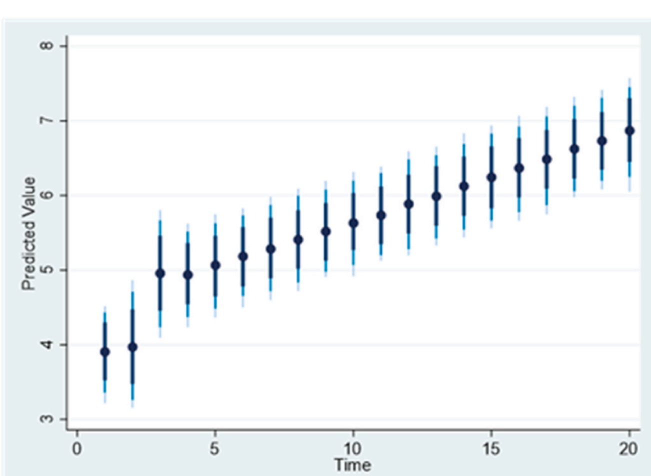

Fig. 6. Response of inflation to 1.0 S.D. Positive Oil Price shock.

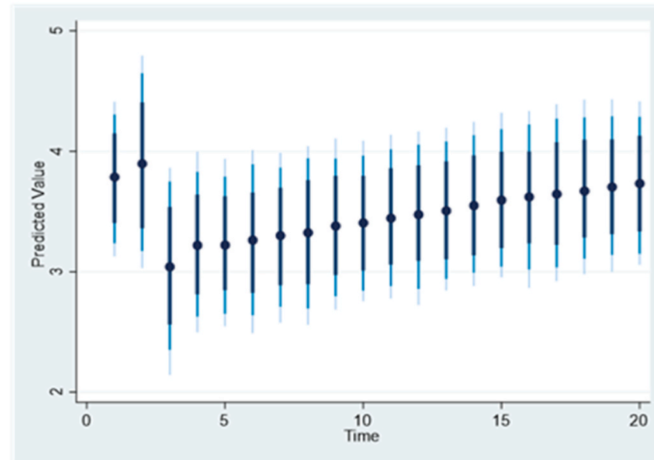

Fig. 7. Response of inflation to 1.0 S.D. Negative Oil Price shock.

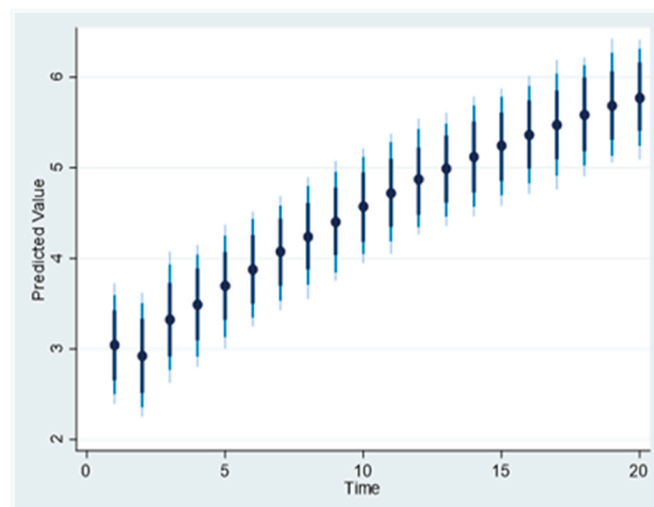

Fig. 8. Response of inflation to 1.0 S.D. Positive Gas Price shock.

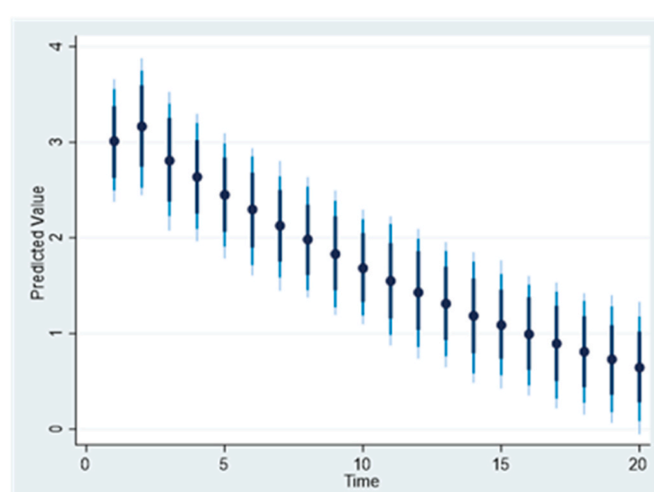

Fig. 9. Response of inflation to 1.0 S.D. Negative Gas Price shock.

From the result (Table 3), the test statistic in the two models is greater than the upper bound critical value at a 5% significance level, indicating a cointegrating relationship between the variables.

Figs. 6 and 7 present the predicted inflation values following a 1 standard deviation positive and negative shocks in oil prices, respectively, which occur in the second period. The spikes on each plot represent the confidence interval at 75%, 90%, and 95% (from the darker to lighter colours). From the plots, inflation responds asymmetrically to oil price shocks; this is evident in the stark difference between Figs. 6 and 7. A positive oil price shock, which occurs in the second period, leads to a significant contemporaneous jump in inflation from about 4% in the second period to 5% in the third period. After that, inflation gradually rose and reached about 6.9% by the twentieth-period horizon.

However, following a 1.0 standard deviation negative shock in oil prices in the second period, inflation fell contemporaneously from about 3.9% in the second period to 3.1% in the third period. Interestingly, inflation rose again, reaching about 3.7% in the twentieth period. This finding indicates that inflation responds asymmetrically to oil price dynamics. The implications of these findings are threefold. The first is that the response of inflation to a positive oil price shock is significantly higher than to a negative oil price shock. Secondly, a positive oil price shock has a long-run positive effect on inflation; however, the depressing effect of a negative oil price shock on inflation is short-lived. Finally, the effect of a negative oil price shock passes on more sluggishly than a positive oil price shock.

Figs. 8 and 9 present the predicted inflation values following a 1.0 standard deviation positive and negative shocks in gas prices, respectively, which occur in the second period. From Fig. 8, inflation responds to a 1.0 standard deviation positive shock in gas prices by rising from about 2.9% when the shock occurred in the second period to about 3.3% in period three. The increase in inflation continues gradually, reaching about 5.6% in the twentieth period. Similarly, inflation responds to a negative shock in gas prices by falling from 3.2% in period two to 2.8% in the third period (Fig. 9). The fall in inflation continues, reaching about 0.7% in the twentieth period. The findings imply that the response of inflation to gas price dynamics is symmetric because the effect of both positive and negative gas price shock passes onto inflation in almost equal measures. The findings are contrary to the response of inflation to oil price shock, which is asymmetric. Inflation appears to be more responsive to gas prices than oil prices. This finding is not surprising considering that gas is the primary energy source and determines electricity prices in the UK. The finding also mirrors the inference from the Wavelet Coherency analysis, where gas prices are highly correlated with inflation.

Interestingly, the significant influence of energy prices on inflation dynamics is not limited to the UK. For instance, Fitchner et al. (2022) found that energy prices drag inflation in Germany. Further, Bigerna (2023) found an asymmetric contagion effect of energy price shocks on inflation in the case of Italy and Germany, among others. In addition, Kudayeva et al. (2024) reveal a significant effect of oil price shocks on inflation in France and Italy. It is worth noting that although a significant influence of energy prices on inflation is witnessed across these countries, the inflation dynamics differ. For instance, over a period of significant increases in energy prices, inflation in the UK almost doubled between January and October 2022. It increased from 5.5% in January to a peak of 11.1% in October (OECD, 2024). Interestingly, inflation in France, Germany, and Italy more than doubled from 3.3%, 5.1%, and 5.1%, respectively, in January 2022 to a peak of 7.1%, 11.6% and 12.6% in October 2022 (OECD, 2024). Thus, inflation dynamics might be relatively sluggish in the UK compared to its G7 neighbours.

Considering that inflation in the UK responds sluggishly to energy price changes, as evidenced by the DARDL results, policymakers should consider allowing cost-of-living support programmes to run for extended periods even if energy prices fall to allow a robust economic recovery and a stabilised inflation. In addition, policy measures to facilitate a quicker transition of the UK energy mix in favour of renewable energy would mitigate the pass-through of oil and gas price shocks to inflation.

Table 3
Cointegration test result.

Models	PSS Statistic
Oil Price	4.843[a]
Gas Price	4.885[a]
Critical Values (5%)	
Lower Bound	2.860
Upper Bound	4.010

[a] indicates statistical significance at 5%.

5. Conclusion

This study examines the response of the UK's inflation to energy price dynamics. The result of the Wavelet Coherency analysis shows periods of a strong relationship between energy prices and inflation predominantly in low frequency (for gas prices) and a combination of low, medium, and high frequency (for oil prices). This result implies that the relationship between the variables is mainly long-term; however, recent episodes of short- and medium-term association between energy prices and inflation have been witnessed. These findings point to the significance of oil price dynamics in influencing inflation in the UK.

The results of the DS-ARDL analysis point to the asymmetric response of inflation to oil prices; however, the response to gas prices is symmetric. While an increase in oil prices has a long-term positive effect on inflation, a decrease in oil price has a short-term depressing effect on inflation and then begins to wane off. In addition, the effect of gas price changes passes more strongly than oil price changes. Consequent to these findings, policymakers should consider the asymmetry in the relationship between oil prices and inflation in monetary policy decisions. Considering that inflation responds sluggishly to energy price changes, policymakers should consider allowing the cost-of-living support programmes to run for extended periods even if energy prices fall to allow a robust economic recovery and a stabilised inflation. This policy could help keep households on fairer living standards and guarantee minimum consumption distortions. In addition, because of the stronger influence of gas prices on inflation, policymakers should consider interventions to keep gas prices down in the domestic market. Further, these findings stress the need for a faster pace of diversification of the UK's energy sources in favour of more renewable energy; this is good for the environment and will go a long way to reduce the influence of energy prices on inflation in the country.

6. Limitations and Suggestions for future research

This study is limited because it focuses on the UK economy; hence, generalisation to other economies should be approached cautiously. Future studies could explore the role of energy mix diversification on energy prices and inflation nexus. The effect of government energy market interventions (such as subsidies and energy price caps) on the pass-through of energy prices to inflation could be examined by future studies.

CRediT authorship contribution statement

Attahir B. Abubakar: Writing – review & editing, Writing – original draft, Supervision, Methodology, Formal analysis, Data curation, Conceptualization. **Suale Karimu:** Writing – review & editing, Writing – original draft, Formal analysis, Conceptualization. **Suleiman O. Mamman:** Writing – review & editing, Writing – original draft, Visualization, Methodology, Formal analysis, Conceptualization.

Declaration of Competing interest

The authors declare no conflict of interest.

Data availability

Data will be made available on request.

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