

Reactions of Energy Futures Market to Monetary Policies in UK

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Abstract. One of the principal factors influencing the direction of energy futures prices is frequently thought to be a nation's monetary policy. Between January 1993 and December 2023, this article intends to empirically examine the energy futures market's affiliation with monetary policy in the UK and the extent to which monetary policy shocks affected specific energy futures. As a start, monthly data on relevant macroeconomic indicators such as interest rates and the global energy price index are gathered to create a basic VAR model for identifying monetary policy shocks. Single energy futures prices are separately and independently added to the model as the last variable, and the influence of monetary policy on the energy futures market is subsequently inspected sequentially and independently. The influence of monetary policy shocks on energy futures prices is investigated using impulse response and variance decomposition analytic methods. Ultimately, the findings suggest that the prices of energy futures and monetary policy are positive correlated. Price fluctuations in energy futures are significantly and persistently influenced by monetary policy disruptions. However, it makes a minor contribution to the explanation of changes in the price of energy futures. The results offer empirical evidence that could be utilized to investigate energy futures markets through the lens of monetary policy.

Keywords: Monetary policy shock, energy futures market, VAR, impulse response function.

1. Introduction

Monetary policy has consistently been the primary focus of economists and policymakers as the main means of macro-control. In the post-epidemic age, the monetary policy of the UK is targeted and dominant, thereby establishing a milieu that is optimal for the rebounding economy of a nation from a monetary and financial standpoint. It is unlikely that the hyperlink between monetary policy and energy futures prices will remain stagnant as the globe persists in industrialization and financialization. Hence, it is crucial to analyze the dynamic influence of monetary policy on the energy futures market as well as the trajectory of energy financialization. The decision-makers at the forefront of monetary policy and investors might gain insight and benefit from experiencing a stronger grasp of these tendencies.

Currently, numerous experts and scholars have undertaken broad research based on energy futures. The prediction of energy futures was the primary emphasis of Chinn, LeBlanc and Coibion [1]. And in Chinn and Coibion the research broadened the scope of the investigation to include all commodity futures as well [2]. According to research, futures prices are highly predictable and trustworthy in financial markets, and utilizing futures prices to forecast spot price performance provides a more precise random walk. Upcoming information is deemed to be highly stochastic, as postulated by the random walk hypothesis. Serletis conducted a new analysis of the random walk pattern exhibited energy futures prices [3]. Following that, Elder and Sweletis provided empirical evidence for random walk-type behaviours in energy futures prices, revealing that energy futures prices sport long-term memory features [4]. These findings reveal that utilizing futures prices could result in the efficient capture of energy market information. Meanwhile, Gorton and Rouwengorst performed an inquiry on the basic characteristics of commodity futures as a type of investment and showed a positive correlation between commodity futures and inflation [5]. Based on prior research, Bhardwaj, Gorton and Rouwenhorst extended the study's sample size and discovered that the correlation between commodity futures continues to strengthen with the financialization of the commodity markets [6]. Recently, the dynamic linkage between energy and non-energy commodity futures markets has been

further explored by Behmiri, Manera and Nicolini [7]. Additionally, certain academics have directed their attention towards energy futures as a crucial metric for assessing the interplay between the macroeconomy and the financial system. Sadorsky offered concrete proof to support the long-term equilibrium link between energy futures prices and exchange rates [8].

The earlier literature contains the preliminary results of an immense number of researchers who explored monetary policy and energy sectors. Unfortunately, there is a deficiency of literature that addresses the implications of monetary policy on movements in the energy futures market. The ramifications of the government's policy decisions from January 1993 and December 2023 on the different energy futures prices are evaluated by adopting a conventional VAR model to fill the research gap in this paper. More specifically, this study's primary ingredient is that it explores the idea of a correlation between oscillates in energy futures prices and monetary policy tweaks. The reverberations of using VAR parameter estimates reveal that energy futures prices are influenced advantageously by monetary policy. Energy futures prices are susceptible to the relatively long-term impacts of monetary policy, judging from the findings of the impulse response analysis. Moreover, variance decomposition research reveals that in longer-term energy futures price changes, only 10%-20% are caused by monetary policy shocks. Among them, monetary policy shocks are the least effective in explaining variations in natural gas futures prices.

Given below is the paper's hierarchy of organizations. Sections 2 and 3 provide an overview of the data being presented as well as the VAR basis model. The empirical findings on the repercussions of monetary policies on four kinds of energy futures contracts-for-differences (CFDs) prices are outlined in Section 4. Concluding observations and limitations are included in the ultimate section.

2. Data

This paper compiles data on the local monetary supply (MS) and the interest rates for monetary policy (MP) from the Bank of England (BoE). Converting currencies incorporates the Federal Reserve Bank (FRB) period end market exchange rate. The OECD provides data on the index of Industrial Production (IPI) and the Consumer Price Index (CPI). The trend in inflation levels locally is measured via the CPI. IPI gathers data from the entire sector of industry, omitting construction in the UK. The global price of energy index (GPEI) signifies guideline pricing that reflects the energy market situation globally. The data for GPEI is collected from the International Monetary Fund (IMF). Hamilton emphasized that utilizing high-frequency market data could effectively detect monetary policy shocks in traditional VAR models and quantify the efficacy and adaptability of policies [9]. For that reason, this piece compiles data on the prices for four energy futures CFDs offered by Investing, which include Brent crude oil (BO), Heating oil (HO), Natural gas (NG), and London gasoline (LG). The data presented herein spans from January 1993 to December 2023 and is denominated in U.S. Dollars. By tracking the price movement of a single energy futures contract, this research intended an in-depth exploration of the state of the energy futures markets.

Fig. 1 briefly depicts the monetary conditions and energy market conditions. Fig. 1 exhibits interest rates dictated by central banks as a blue line and inflation as a green line. Inflation and interest rates are less volatile. Interest rates were higher compared to inflation until November 2008, while the reversal occurred thereafter. Variations in the price of energy globally are shown as black lines. The fluctuations exhibit a significant magnitude and occur with considerable frequency. The orange line denotes energy price variants, and the money stock tracks an analogous trajectory. A relatively stable trend was observed in the industrial production index. This occurrence could be attributed to evolving economic conditions, significant happenings, or economic policy. For instance, geopolitical determinations, worldwide economic downturns and special episodes like wars or diplomatic conflicts on an international scale. Geopolitical disputes frequently heighten the unpredictability and intricacy of traditional energy markets. Furthermore, the economic recession and the fast-paced development of energy innovations have jeopardized the short-term equilibrium between supply and demand, triggering a spike in energy prices. Recently, typical energy costs have been volatile owing

to the repercussions of unique incidents like the COVID-19 epidemic and the crisis between Russia and Ukraine. Fig. 2 illustrates the price tendencies of four energy futures. Their fluctuation frequency and amplitude follow analogous tendencies. Particularly, the highest-frequency and largest-magnitude can be observed in natural gas.

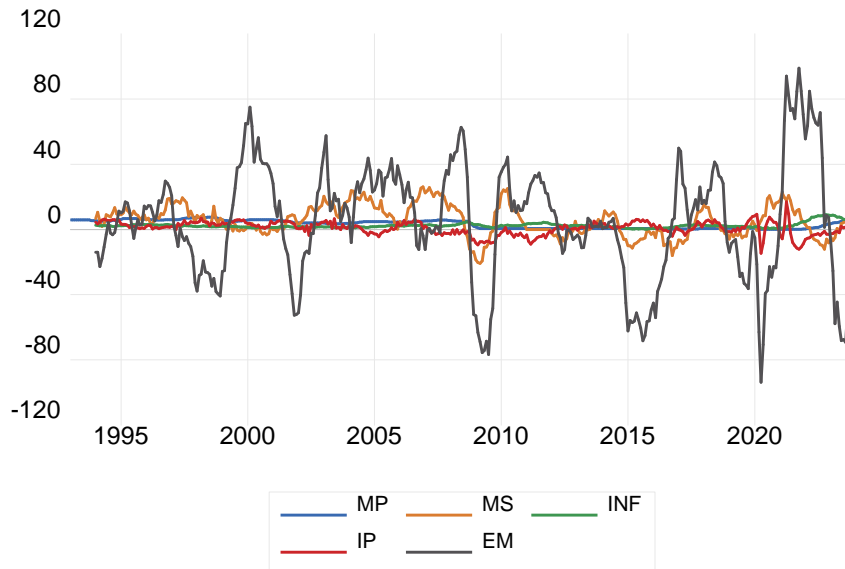


Fig. 1 Graphing of the MP, MS, INF, IP and EM

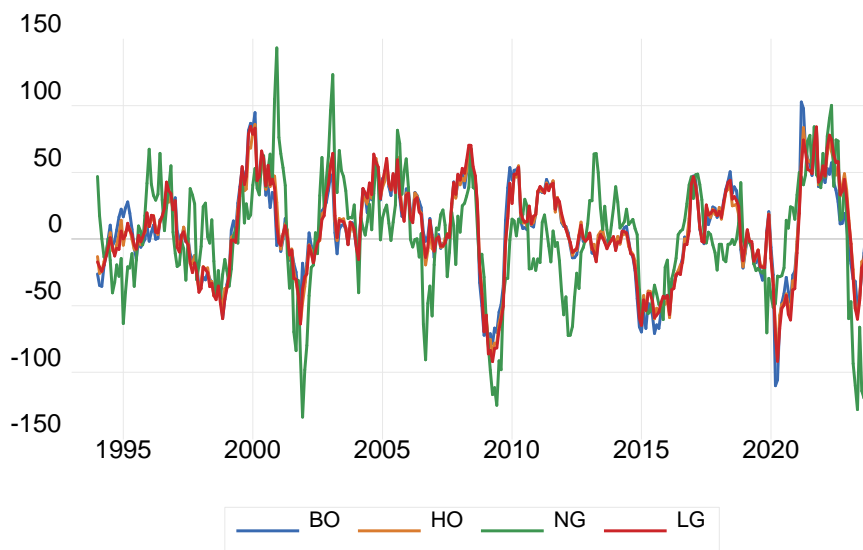


Fig. 2 Graphing of individual energy futures prices

3. Methodology

Since Sims introduced the Vector Autoregression (VAR) framework in economics, numerous researchers have applied it to gauge the repercussions of monetary policy [10]. The VAR model has been widely employed and highly esteemed by scholars. Primarily due to its simplicity and ability to depict intricate dynamic interactions among several variables. More precisely, it can understand the dynamic changes of multivariable data more comprehensively, in addition to identifying the relationship between variables depending on the data itself. Furthermore, it has a smaller error and a superior overall data-fitting effect when analyzing the dynamic features of time series data. In finality, it has utility in practice and tends to adequately convey information concerning variables when forecasting future values.

This article builds four six-variable VAR models to observe the response of individual energy futures prices to monetary policy shocks by applying historical UK economic data from January 1993 to December 2023. The first five variables are applied to determine shocks to monetary policy, following successively policy rates (MP), money stocks (MS), inflation level (INF), industrial production index (IP) and energy market prices (EM). All other variables are allowed to affect it simultaneously when the energy futures price is ordered as the last element in the equation. To denote the state of the energy market, the sixth variable deploys four distinct types of energy futures CFD prices. It encompasses futures CFDs on Brent crude oil, Heating oil, Natural gas and London gasoline. The implications of monetary policy on the energy futures market are revealed through a scrutiny of the responses of various categories of energy futures in price fluctuations to monetary policy actions. At every iteration, each equation is re-estimated separately.

The 6-factor VAR model vectorization endogenous variables are the following:

$$Y_t = [mp_t, ms_t, inf_t, ip_t, em_t, ep_t] \tag{1}$$

Where Y_t is a 6-dimensional variable vector including $\{mp_t, ms_t, inf_t, ip_t, em_t, ep_t\}$, denotes the policy rate, the amount of money in circulation, inflationary, industrial utility, and international energy price indexes respectively. ep_t represents futures price of specific energy futures. It is expressed in four independent VAR models as follows: Brent crude oil (bo_t), Heating oil (ho_t), Natural gas (ng_t), and London gasoline (lg_t).

Under the assumption that no external variables are present, the procedure that follows is the unrestricted VAR model for recognizing a shock of the UK's monetary policy.

The equation of the classical VAR model is written:

$$Y_t = A_0 + A_1 Y_{t-1} + \dots + A_q Y_{t-q} + \phi_t \tag{2}$$

Where A_0 is the constant vector, A_1 to A_q are matrices of estimated coefficients, ϕ_t is a 6-dimensional perturbation vector, q is the lag length and $Var(\phi_t) = \Sigma$.

The residuals satisfy the conventional hypotheses.

$$E(\phi_t) = 0 \tag{3}$$

$$E(\phi_t \phi_s') = \begin{cases} \Sigma & \text{when } t = s \\ 0 & \text{when } t \neq s \end{cases} \tag{4}$$

Criteria (4) hints that simultaneous correlation is allowed instead serial autocorrelation between perturbations is not supported.

4. Empirical Results

4.1. Unit Root Test

It is essential to check the time series for stationarity before the model estimate to avoid erroneous regression. This paper adopts the Augmented Dickey-Fuller (ADF) approach for evaluating the variables. In each of the results of the ADF test exhibited in Table 1, the series of interest rates is the only one that is non-stationary and not significant. By conducting the test on the first difference (FD) of the series in interest rates, the consequence shows a T-statistic of -5.777 and a p-value of 0. This means that the null hypothesis is refuted at a confidence level of 5%, indicating that the BoE interest rate following the second-order difference is regarded as a stationary sequence. The significant test outcomes for the other variables at the p-value of 0.05 also leads to the null hypothesis being rejected. It indicates that the absence of a unit root and confirms that the time series are stable.

Table 1. ADF test for unit roots

Variables	ADF T-test	Prob.	Has a Unit Root
mp_t	-1.8791	0.3421	Yes
dmp_t	-5.7770	0.0000	No
ms_t	-2.9910	0.0367	No
inf_t	-3.2395	0.0186	No
ip_t	-3.0142	0.0346	No
em_t	-4.2017	0.0008	No
bo_t	-3.7301	0.0041	No
ho_t	-3.9661	0.0018	No
ng_t	-4.5755	0.0002	No
lg_t	-3.7972	0.0032	No

4.2. Lag Length Selection

Ascertaining the VAR model's optimal lag order based on the information criterion is a prerequisite for its establishment. This paper determines the appropriate lag order by picking the lag length that contains the most amount of significance among the five criteria. The test outcomes for each of the four VAR models are displayed in Table 2. VAR models with a lag of 2 orders typically exhibit more statistical significance, leading to the maximum lag period being fixed at 2.

Table 2. Lag order selection criteria

Brent Oil					
Lag	LR	FPE	AIC	SC	HQ
0	NA	2.31e+09	38.5866	38.6521	38.6127
1	5355.956	584.9596	23.3988	23.8569	23.5810
2	217.2892	379.6225*	22.9662*	23.8170	23.3048*
3	57.8444*	391.6059	22.9969	24.2403	23.4916
Heating Oil					
Lag	LR	FPE	AIC	SC	HQ
0	NA	1.77e+09	38.3201	38.3855	38.3461
1	5573.769	594.1460	23.4144	23.8725*	23.5966
2	193.2902*	413.6135*	23.0520*	23.9028	23.3905*
3	44.9129	448.1598	23.1212	24.3646	23.6158
Nature Gas					
Lag	LR	FPE	AIC	SC	HQ
0	NA	1.25e+10	40.2788	40.3443	40.3049
1	5314.234	3581.852	25.2109	25.6690*	25.3931
2	191.2515	2508.407*	24.8545*	25.7052	25.1929*
3	55.6734*	2604.362	24.8916	26.1350	25.3863
London Gasoline					
Lag	LR	FPE	AIC	SC	HQ
0	NA	2.05e+09	38.4688	38.5442	38.4948
1	5294.875	619.6809	23.4564	23.9146*	23.6387
2	196.2042*	427.7295*	23.0856*	23.9363	23.4240*
3	48.2009	454.0787	23.1449	24.3883	23.6396

Note: *indicates lag order selected by the criterion. LR: sequential modified LR test statistic (each test at 5% level), FPE: Final prediction error, AIC: Akaike information criterion, SC: Schwarz information criterion, HQ: Hannan-Quinn information criterion

4.3. AR Unit Root Test

Following the establishment of four 6-element VAR models in conformity with the chosen lag order, a robust test is required performed on the model. Fig. 3 exhibits that all the unit-roots of the characteristic root equations of the VAR model created are located inside the unit circle. Thus, the model expresses robustness against 2-lag.

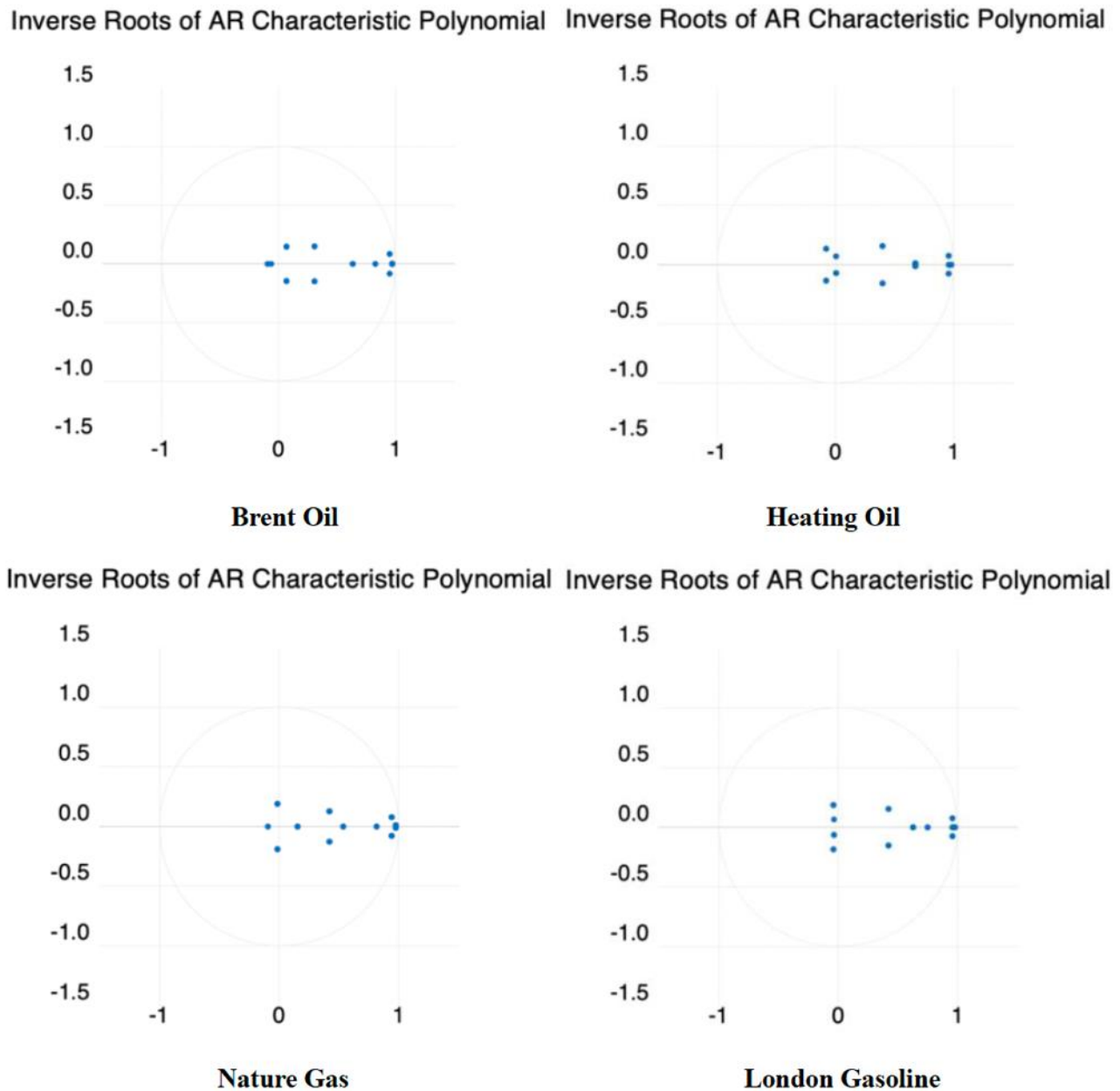


Fig. 3 AR root diagram

4.4. Johanson Cointegration Test

Considering there might exist numerous types of long-run cointegration ties among variables, the Johanson cointegration test is essential to spot the cointegration relationships. The elements contained in each VAR model equation that are utilized in the empirical evaluation are inspected for cointegration in this piece. There is a cointegration relationship among the factors stated in this piece, as all the inspection results refute the null assumption at the 5% significant level. As shown in Table 3, the findings of the Trace Statistics display that each of the VAR models conveying the monetary policy shocks to the energy futures market comprises four cointegration connections.

Table 3. Cointegration Rank Test (Trace)

Brent Oil				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5% Critical Value	Prob.**
None*	0.2146	215.7608	95.7537	0.0000
At most 1*	0.1517	130.0085	69.8189	0.0000
At most 2*	0.0991	71.6163	47.8561	0.0001
At most 3*	0.0546	34.5829	29.7971	0.0130
At most 4	0.0320	14.6450	15.4947	0.0669
At most 5	0.0087	3.1168	3.8415	0.0775
Heating Oil				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5% Critical Value	Prob.**
None*	0.1787	206.8753	95.7537	0.0000
At most 1*	0.1530	137.0082	69.8189	0.0000
At most 2*	0.0969	77.9718	47.8561	0.0000
At most 3*	0.0733	41.7713	29.7971	0.0013
At most 4	0.0326	14.7570	15.4947	0.0644
At most 5	0.0084	3.0061	3.8415	0.0829
Nature Gas				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5% Critical Value	Prob.**
None*	0.1656	188.9512	95.7536	0.0000
At most 1*	0.1549	124.6942	69.8189	0.0000
At most 2*	0.0810	64.9327	47.8561	0.0006
At most 3*	0.0595	34.9334	29.7971	0.0117
At most 4	0.0277	13.1639	15.4947	0.1089
At most 5	0.0089	3.1894	3.8415	0.0741
London Gasoline				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5% Critical Value	Prob.**
None*	0.1616	193.6161	95.7537	0.0000
At most 1*	0.1502	131.0533	69.8189	0.0000
At most 2*	0.0850	73.2770	47.8561	0.0000
At most 3*	0.0725	41.7231	29.7971	0.0014
At most 4	0.0332	14.9869	15.4947	0.0595
At most 5	0.0084	3.0091	3.8415	0.0828

Note: *denotes rejection of the hypothesis at the 0.05 level, **MacKinnon-Haug-Michelis (1990) p-values, Trace test indicates 4 cointegrating eqs(s) at the 0.05 level

4.5. Granger Causality Test

A VAR model could be constructed for sequences that exhibit stationarity. The Granger causality method is applied in this paper to figure out the objectivity and pervasiveness of the causal links across variables before building a VAR model. Each of the four selected sorts of energy futures is examined to reflect the energy futures market. The status of the energy futures market is reported here in general, given that different types of energy futures respond to macroeconomic variables such as monetary policy in a similar way. It is clear from Table 4 that policy rate shocks and inflationary shocks are not Granger causes of energy futures markets. Money stock shock and energy price shocks are Granger causes of energy futures prices. It indicates that changes in monetary supply and energy price volatility tend to more precisely and comprehensively account for past variations in the market of energy futures. Oscillations in the money supply and energy prices may exert an immediate impact on the energy futures markets. Nevertheless, the effect of industrial production is solely seen in the movements of Brent crude oil futures and heating oil futures.

Table 4. Granger causality test

Hypothesized No. of CE(s)	F-Statistic	Prob.
mp_t does not Granger cause bo_t	0.2947	0.7450
ms_t does not Granger cause bo_t	3.5471	0.0298
inf_t does not Granger cause bo_t	1.4807	0.2289
ip_t does not Granger cause bo_t	3.8648	0.0219
em_t does not Granger cause bo_t	0.7674	0.4650
mp_t does not Granger cause ho_t	1.3404	0.2631
ms_t does not Granger cause ho_t	2.9621	0.0530
inf_t does not Granger cause ho_t	1.6352	0.1964
ip_t does not Granger cause ho_t	3.0480	0.0487
em_t does not Granger cause ho_t	5.5365	0.0043
mp_t does not Granger cause ng_t	0.5512	0.5768
ms_t does not Granger cause ng_t	5.2799	0.0055
inf_t does not Granger cause ng_t	13.5466	2.E-06
ip_t does not Granger cause ng_t	1.2663	0.2832
em_t does not Granger cause ng_t	7.2589	0.0008
mp_t does not Granger cause lg_t	1.2370	0.2915
ms_t does not Granger cause lg_t	3.3922	0.0347
inf_t does not Granger cause lg_t	1.5987	0.2036
ip_t does not Granger cause lg_t	3.6134	0.0514
em_t does not Granger cause lg_t	3.3911	0.0348

4.6. Parameter Estimations

The estimations of four six-variable VAR models provide overwhelming proof that the energy futures market effectively reflects market information. An improved grasp of a nation’s currency condition and a more comprehensive supply of information to investors could be achieved through the tracking of fluctuations in energy futures prices. Additionally, it possesses the ability to forecast the spot market by observing the energy futures market’s trend, which is in line with the findings of Chinn, LeBlanc and Coibion [1]. Consequently, while the energy futures market has over time soared in the degree of efficacy with which monetary policy is transmitted, the gravity of the policy is limited. At the same time, the energy futures market has expanded investment market prospects and diversified investment portfolios for investors’ decision-making to some degree, therefore stimulating the inflow of capital to the energy field. In essence, it is beneficial to fostering progression and originality within the energy sector. For the detailed estimations, please contact the author.

4.7. Impulse Responses

Impulse responses facilitate the comprehension of transient dynamics relationships within a system. This research seeks to gain insight into the implications of monetary policy shocks on the energy futures market by observing how energy futures prices behave to these shocks. Fig. 4 portrays the estimated impulse response functions of the individual energy futures prices. Each column presents the impulse response (60 months) to one standard deviation of a monetary policy shock. The leftmost side of each row lists the name of each kind of energy futures, which is the response variable. Shock variables are designated at the top of each column. Unit standard error bars are represented by the upper and lower dashed lines in each figure.

Policy interest rate shocks typically exert a positive impact on energy futures prices, which gradually diminishes and approaches zero by the 18th period. The repercussions typically reach its zenith in the third month following the shocks on the prices of energy futures. Secondly, the impact of the money supply shock on the energy futures prices is positive at the outset but negative afterwards; this impact tends to zero after 60 periods. Nevertheless, the prices of natural gas futures are going to

experience a swift decline during the initial two periods following the shocks. Generally, inflationary disruptions have a negligible effect on the prices of energy futures, the effect turns into adverse after the 4th period. Among these, the price of natural gas futures is going to climb sharply in the short-term following the shocks. Subsequently, energy futures prices normally respond to industrial output disturbances optimistically initially, then inversely, and finally turn back optimistic. It demonstrates a transiently helpful effect followed by a detrimental impact starting from the third period. Then, the impact becomes predominantly positive, commencing with the 22nd period, which grows to trend toward zero after the 53rd period. Conversely, natural gas futures prices exhibit an initial adverse trend and thereafter demonstrate a beneficial trend after the 17th period. Ultimately, energy futures prices are the most significantly impacted by global energy price disruptions. Energy price shocks initially exert an advantageous impact on energy futures prices, afterwards experiencing a detrimental impact. This influence gradually declines to close to zero after the 53rd period. Typically, a negative trend kicks off to emerge during the 14th to 16th periods. Out of all the influences, the effect of this shock on Brent crude oil futures was particularly fleeting, specifically fading away progressively after the 49th period. Comparably, the duration of the effect of the shock on heating oil and London gasoline futures is prolonged, subsiding after the 56th period.

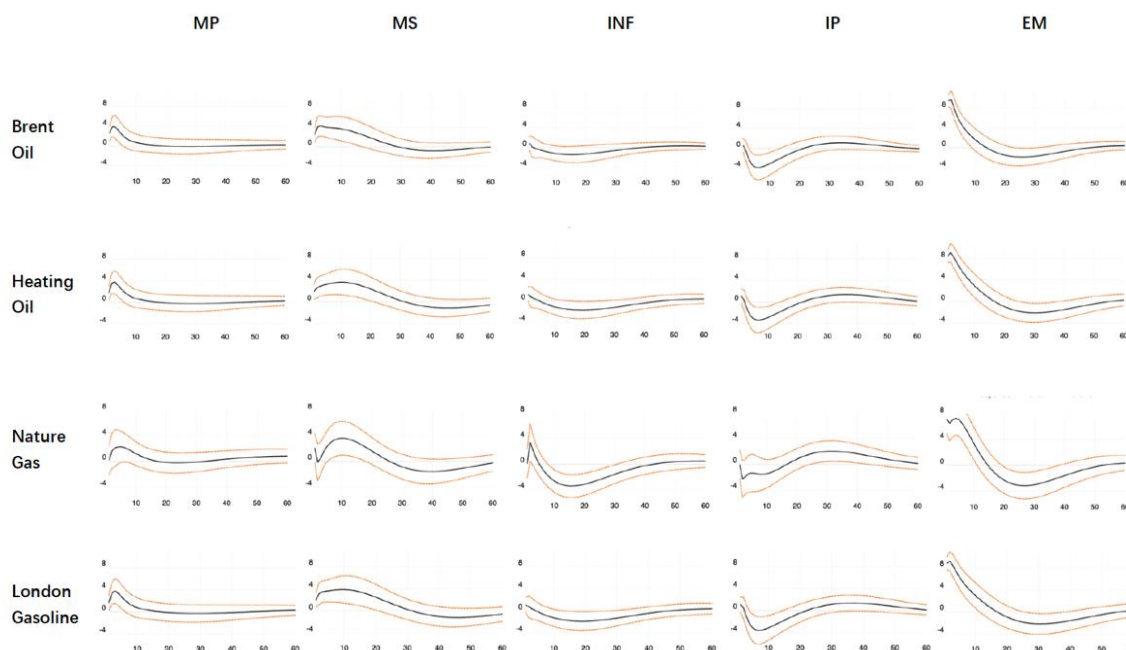


Fig. 4 Impulse Response to UK's Monetary Policy Shock

4.8. Variance Decompositions

Observe the contribution of each variable as variance decomposition assesses the influence of various system variables to alter in the data. In Fig. 5, this paper reports the variation decomposition of four energy futures into shocks to monetary policy. A percentage deviation is the scale of all variables.

According to the findings, energy price shocks account for the largest proportion, while inflation shocks account for the lowest proportion of the contributions. Specifically, interest rates account for around 5% of the explanation for energy futures prices. The volatility of natural gas futures prices in response to interest rate modifications is unident, as their variance contribution stands at a mere 2.3%. Secondly, approximately 20% of the variance in energy futures prices could be attributed to money supply changes. However, its impact on the variability of futures prices for natural gas is a mere 8.9%. Next, inflation shocks contribute to approximately 5% of the explanation for energy futures price fluctuations. Natural gas futures display an elevated degree of sensitivity to inflationary

shocks compared to other sorts of energy futures, contributing up to 10.8% to the variation. The Brent crude oil futures have the lowest spectrum of responsiveness to inflationary shocks, contributing barely 3% to the overall variance. Industrial production shocks typically constitute around 10% of the variability in energy futures prices. In contrast, with a mere 5.9% variance contribution, natural gas futures show the least sensitivity to industrial production variations. Finally, energy prices are responsible for more than 30% of the explanation for energy futures price alternations. Among them, London gasoline futures suffer the most impact by energy price variance (40%) while natural gas futures receive the lowest (28.4%).

While monetary policy shocks do help shed light on energy futures price variances, it's plausible to conclude that it is not the major driver of such volatility.

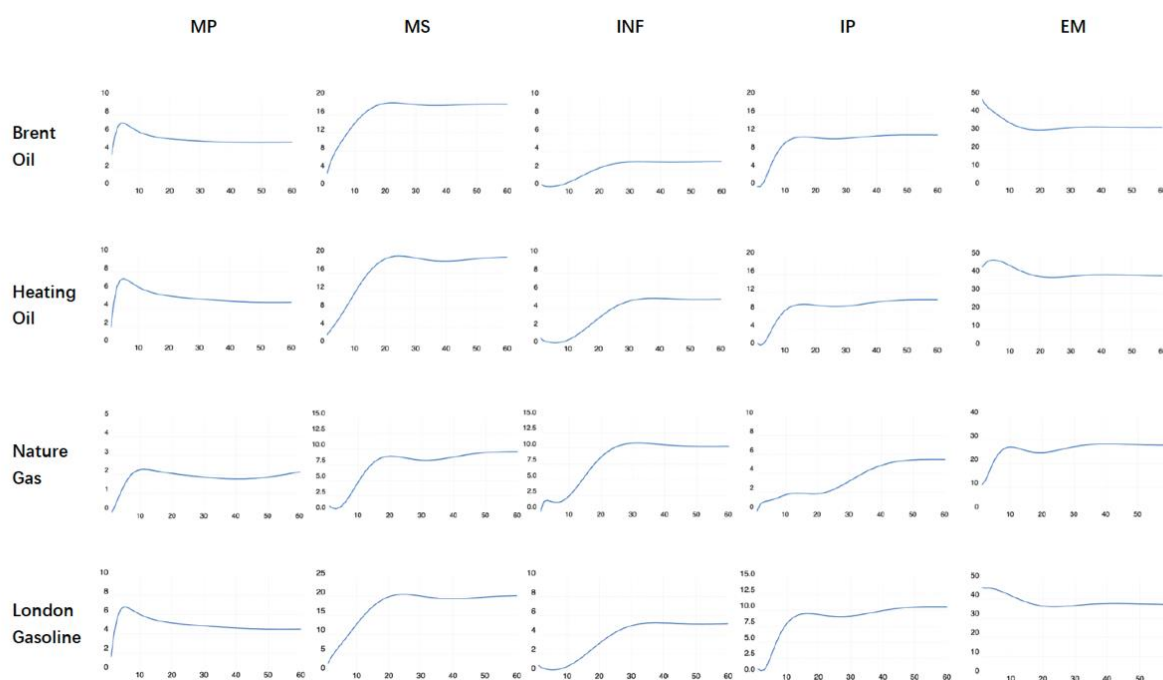


Fig. 5 Variance decomposition of individual energy futures

5. Conclusion

The energy futures market is very sensitive to monetary policy, which is a core tool for controlling the economy at the national level. From January 1993 through December 2023, this research examines the reactions of the UK energy futures market to shocks in monetary policy incorporating four six-variable VAR models. According to the findings, monetary policy does have a far-reaching positive effect on the energy market and is a crucial instrument for fostering industrialization as well as financialization. The real energy prices and money supply provide a largely precise and insightful description of the energy futures markets. Concurrently, the energy futures market's reaction to monetary policy shocks is demonstrated clearly by the findings for individual energy futures prices from impulse response functions and variance decomposition. To be more precise, energy futures prices are susceptible to shifts in UK monetary policy, but this transmission of policy adjustments to the market takes time. It means that the influence of the UK's monetary policy on the energy sector is gradual and durable but limited. The central bank utilizes monetary policy tools to directly adjust short-term policy interest rates, which in turn indirectly shape the market price of energy futures.

Considering this, the monetary policy shocks in the UK do not dominate the volatility of the energy futures market. There are certain limitations of this article that propose a desire for additional research. Firstly, the ignorance of contemporaneous effects in this paper ignores the possibility that more

significant effects occurred during the same period. Further investigation might be performed by generating a Structural Vector Autoregressive (SVAR) model and imposing certain constraints on it to represent the genuine economic circumstances of a nation more accurately. Second, the article may have overlooked other exogenous shocks, involving changes in exchange rates, that are more impactful on the energy futures market. Additional shocks could be introduced to the system in subsequent studies to obtain fresh insights.

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