THE RESPONSE OF ELECTRICITY AND GAS IN THE EU TO THE RUSSIA-UKRAINE CONFLICT DURING THE FIRST YEAR OF WAR

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Abstract
This article aims to analyse the effect of stressful events and uncertainty, specifically the war in Ukraine on electricity and gas prices in the EU relative to the evolution of Brent Oil Futures (BRENT). The results obtained from the impulse response function provide proof of high volatility being present for Electricity_EU and Gas_EU due to the evolution of BRENT, and as well proof of a delayed reaction to the war, more precisely in the next month since the war started. The Granger causality test under VAR provides proof that an increase in BRENT leads to an increase in Electricity_EU with a 4,95% probability level and an adverse relationship between BRENT and Gas_EU for a 52,38% probability level. This article could support policy makers in taking timely measures regarding pricing, and stocking-up a certain commodity and might even help to analyze the political implications given that crude oil, electricity and natural gas are important commodities that shape consumer consumption and corporations and governments budgets.

Keywords
VAR, impulse response, variance decomposition, electricity, gas, war.

JEL Classification
G01, C19, C01, O13

Introduction

Electricity and natural gas are one of the main drivers of the economy, from private to public consumption, it influences product and service production it is tightly connected to inflation and also it is known that prices of electricity and natural gas are sensible to times of uncertainty.

The problem of electricity prices and inflation was addressed in the Joint Declaration of the European Parliament, the Council of the European Union and the European Commission (2022), when it was stated that "*At the moment when we have just begun to recover from the pandemic and are going through the radical transformation to combat*

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other serious challenges such as the climate and nature crises, our citizens are confronted with ***spiralling electricity prices and rising inflation***."

Crude oil is thought of as being one of the most relevant and important natural resources that have an impact on consumer consumption, corporations and governments budgets and has political implications as well. Also, natural gas is often a byproduct result of crude oil drilling and it is expected for them to be correlated and as well a substitute for oil. Given the latest studies and interest in the evolution of electricity and natural gas prices during crisis periods, I chose to analyze in my article the dependency between these variables against Brent Oil Futures, during the first year of the war in Ukraine.

The novelty aspect of this article is that it analyzes the evolution of both electricity and natural gas at the European Union level, relative to crude oil during the most recent energy crisis generated by the war in Ukraine and covers a gap in the current literature, as to studies of crude oil connectedness relative to the evolution of stock market indexes, including energy, as well as natural gas, however I didn't identify any studies that cover the relationship among electricity and natural gas relative to crude oil during an energy crisis.

1. Review of the scientific literature

Oil price shocks were analyzed from its perspective of connectedness' to the financial market and authors Demirer et al. (2020) find proof that the oil price shocks extend to both bond and stock markets by analyzing several financial markets from Europe, Emerging countries and G7 countries, similar to the findings of Umar et al. (2021) whom find proof of connection in terms of returns and volatility between the oil shocks and equity markets from the empirical analysis of GCC and BRICS countries, characterized by unpreceded levels during the COVID-19 pandemic, while Escribano et al. (2023) find proof that during the GFC, COVID-19 and war in Ukraine due to dependence on oil and economic structure, importing countries present a negative dependence with BRENT oil more frequently than exporting countries. Also, Behera and Rath (2024) find proof of volatility transmission between crude oil prices and stock returns.

Magazzino et al. (2023) also find strong proof of time-varying causality from the supply and demand side perspective between the oil and European stock market, similar to the findings of Jia et al. (2020) and Boubaker and Raza (2017) whom by examining the dependence between stocks returns in BRICS countries and oil shocks find proof of a significant spillover risk in all BRICS countries from shock to shock of oil specific demand and as well Chang et al. (2023) who conclude that during the Global Financial Crisis and the COVID-19 pandemic an average connectedness is found present between BRENT and BRICS countries stocks.

From the analysis of GCC stock markets return Abuzayed and Al-Fayoumi (2021) find substantial systemic oil risk spillover, greater during the COVID-19 pandemic compared to the period before the pandemic while shock and volatility spillover from West Texas Intermediate (WTI) crude oil to Karachi Stock Exchange is found present by Lei et al. (2023) after the outbreak of the COVID-19 virus and Russia's aggression on Ukraine, while Ali et al. (2022) find proof of oil prices having an influence on the

Russian market on a small scale previous to the outbreak of the COVID-19 virus, but not after.

After the war began evidence of herding in energy markets is found present in emerging countries close to the conflict borders and in Italy a developed market that is dependent on the oil and gas imported from Russia from the analysis of MSCI Emerging and MSCI World indexes by Blasco et al. (2024). Also, Nerlinger and Utz (2022) find that during catastrophic events such as wars, capital markets have a fast reaction and in turn lead to changes in the supply chain.

A high correlation of price variance for crude oil and gas is found present by Pindyck (2004) and Lin and Li (2015). On the other hand, Szafranek and Rubaszek (2024) analyze the relationship between oil and natural gas between January 1993 and October 2022 and find natural gas markets, whether European or American have limited impact on oil price fluctuations, while for the period specifically covering the OCVID-19 and war period a notable but short-term reaction of American gas market is found relative to the European gas market.

Mübariz (2024) finds proof that after 2011 the effects of oil on gas prices became less significant and volatility, a dependency based on regimes for price variation for the short-run relationships, and that the relationships shifted notably over time and are highly nonlinear in the short-run and long-run, from the analysis of oil and gas US market between January 1997 and June 2022. Similar results were found by Rizvi et al. (2022) whom identify a weak correlation between oil and gas prices.

2. Data and Research methodology

The period analyzed is January – December 2022, representing the first year of the war in Ukraine and the data consists of daily values (5-day week) of electricity and natural gas prices in the European Union and BRENT index. A detailed description of the data series analyzed can be found in Table no. 2 below.

Table no. 2: Variable description

Variables	Description
Electricity_EU	The average SPOT price of LPXBHRBS Index (DE), PWNXFRAV Index (FR) and AELCTDAY Index (NL) expressed in EUR/MWh.
Gas_EU	Dutch TTF Natural Gas Futures price expressed in EUR/MWh.
BRENT	Brent Oil Futures (BRENT) are expressed in EUR.

Source: Author's own work.

The Electricity_EU data is retrieved from Blomberg, while Gas_EU and BRENT data is retrieved from the Investing website. For BRENT the European Central Bank exchange rate was used for the USD/EUR conversion. To have data uniformity, for the week day where data was not published, the price from the previous day was taken into consideration.

Based on the raw data analysis, as presented in Figure 1 below, it can be noticed that Electricity_EU and Gas_EU have a similar evolution, with exception of February 2022 when a decrease is recorded for electricity while natural gas remains rather constant and months October-December 2020 when the variables have a different evolution.

When it comes to the evolution of BRENT about electricity and natural gas, there isn't a consistent correlation, being periods when BRENT increased and as well electricity and gas, or when BRENT decreased and the price of electricity and gas increased, thus the relation between variables needs to be further analysis.

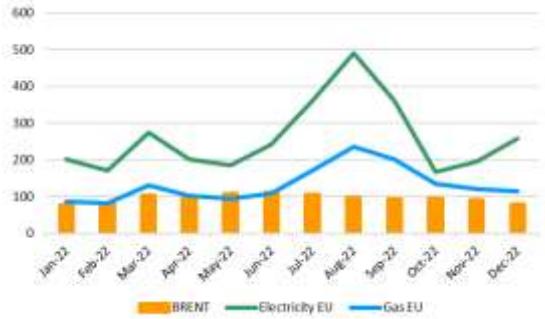

Figure no. 1: Variable evolution

Source: Author's own work based on the information available on Investing and Bloomberg.

For the empirical analysis, EViews 10 program was used to deploy the VAR model, a model often used in literature Blanchard et al. (1990), Friedman et al. (1997), Stock and Watson (2001) and Blanchard and Galí (2010) and Kilian (2011), to observe the correlation and connectedness among variables.

To get a better view of the correlation and causal relation between electricity, gas and BRENT, the impulse response function will be deployed to analyze the response of the variables to the impulse generated by BRENT and afterwards, the variance decomposition to capture how much of the variance of the electricity and natural gas can be explained by the evolution of BRENT.

The two hypotheses established for the Granger causality test under the VAR model are as follows:

(H1) - An increase in BRENT price leads to an increase in Electricity_EU and Gas_EU price for a level of significance greater than 5% and

(H2) - The BRENT price evolution adversely influences Electricity_EU and gas_EU price for a level of significance below 5%.

3. Results and discussions

Before deploying the VAR model, I applied the logarithmical transformation for all the variables analyzed for data normalization.

Upon this to establish if the series has unit roots, I deployed the Augmented Dickey-Fuller (ADF) test for which the null hypothesis is: Series has a unit root for a probability level of significance greater than 5%. Based on the results obtained for the ADF test (Table no. 3) I decided to apply the second difference on the logarithmical form, to also have data comparability even though based on the ADF test there was no unit root for Gas_EU and BRENT series for the first difference of the logarithmical form.

Table no. 3: ADF test results

ADF / Variable	Logarithmical form of data series	First difference of logarithmical form	Second difference of logarithmical form
Electricity_EU	57,81%	59,66%	0%
Gas_EU	37,55%	0%	0%
BRENT	12,28%	0%	0%

Source: Authors' own work using EViews 10 software.

The lag order selection (Table no. 4) for the VAR model is 10 and it was selected based on the AIC, LR and FPE criterion and also due to the fact that a greater number of lags could lead to better estimation results.

Proof of the model's stability is reinforced by the AR unit root graph (Figure no. 2) given that all unit roots are within the circle.

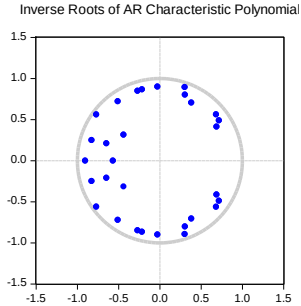

Figure no. 2: AR unit root graph to BRENT

Source: Authors' own work using EViews 10 software.

Table no. 4: Lag order selection criteria for the VAR model

VAR Lag Order Selection Criteria
Endogenous variables: D2LOG_ELECTRICITY_EU D2LOG_GAS_EU D2LOG_BRENT
Exogenous variables: C
Date: 12/21/24 Time: 20:59
Sample: 1/03/2022 12/30/2022
Included observations: 246

Lag	LogL	LR	FPE	AIC	SC	HQ
0	500.9170	NA	3.50e-06	-4.048106	-4.005358	-4.030893
1	612.9621	220.4465	1.52e-06	-4.885871	-4.714879	-4.817020
2	673.4499	117.5332	9.97e-07	-5.304471	-5.005235	-5.183983
3	728.5868	105.7911	6.86e-07	-5.679568	-5.252088	-5.507442
4	763.3875	65.92324	5.56e-07	-5.889329	**-5.333606***	**-5.665565***
5	776.7676	25.01962	5.37e-07	-5.924939	-5.240972	-5.649538
6	789.9302	24.29209	5.19e-07	-5.958782	-5.146571	-5.631743
7	796.4972	11.95942	5.30e-07	-5.939002	-4.998547	-5.560324
8	807.6041	19.95621	5.21e-07	-5.956131	-4.887432	-5.525815
9	834.4020	47.49556	4.51e-07	-6.100830	-4.903887	-5.618876
10	851.2543	**29.45720***	**4.24e-07***	**-6.164669***	-4.839483	-5.631078
11	856.9746	9.859404	4.36e-07	-6.138005	-4.684575	-5.552776
12	863.5395	11.15491	4.45e-07	-6.118207	-4.536533	-5.481340

* 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

Source: Authors' own work using EViews 10 software.

The impulse response function to BRENT provides proof of high volatility with similar evolution for Electricity_EU and Gas_EU till mid of the 11th period representing November after which in December Electricity_EU displays a significant increase, while Gas_EU a rather modest one as to the evolution of BRENT. The presence of such volatility was also found present by Umar et al. (2021), Boubaker and Raza (2017) and Behera and Rath (2024).

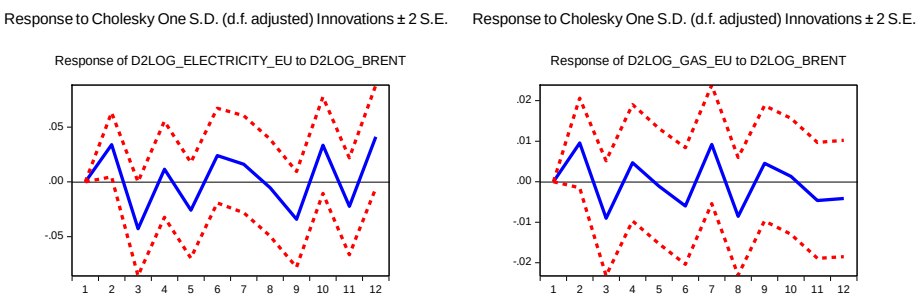

Figure no. 3: Impulse response graph to BRENT

Source: Authors' own work using EViews 10 software.

Both variables, electricity and gas display a delayed response to the war in Ukraine, recording a first decrease in March more significant for electricity, an evolution which is expected to be found in the time of catastrophic events such as wars, especially since Europe was at that time predominantly importing energy from other countries, finding similar to Escribano et al. (2023).

Similar behaviour of a delayed response of stock market indexes is found present following the announcement of a catastrophic event by Razmi and Razmi (2023) during the COVID-19 pandemic and as well Chang et al. (2023) whom found a connectedness between BRENT and stock exchanges during times of crisis such as GFC and COVID-19 pandemic.

From the variance decomposition of the variables analyzed due to BRENT, it can be noticed that the variance of Electricity_EU and Gas_EU explained by BRENT is at most 10% and it has a greater value by the end of the analyzed period.

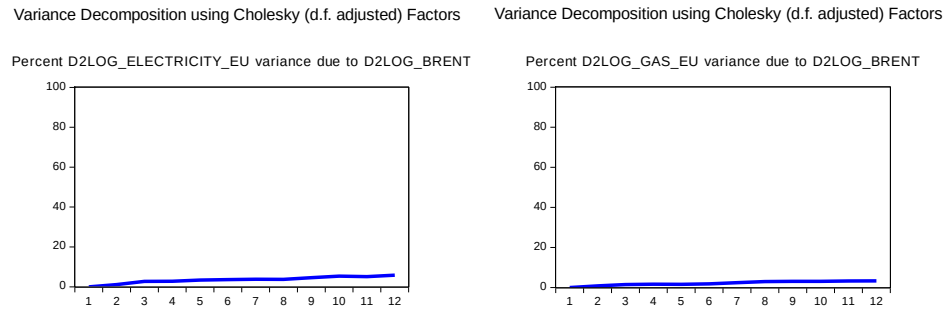

Figure no. 4: Variance decomposition graph to BRENT

Source: Authors' own work using EViews 10 software.

In March, the month following the start of the war in Ukraine 2.7058% of the variance of Electricity_EU can be explained by BRENT, while by December it reached a level of 5.8072% which represents more than double the value in only eight months, similar to the findings of Lei et al. (2023) during the COVID-19 and war period for the Pakistani stock exchange and Magazzino et al. (2023) for the European stock market between May 2007 and April 2022.

Given the variance percentage of GAS_EU explained by BRENT in March is 1.4439% it can be said that the correlation among them is not as significant as compared to Electricity EU, similar to the aspects identified by Rizvi et al. (2022), Mübariz (2024) and Szafranek and Rubaszek (2024), whom identified a weak correlation between gas and oil prices. However, given that by December 2022 the variance is more than doubled, with a value of 3.3150% the relationship among these variables cannot be ignored especially during stressful economic events, especially since a correlation of price variance for the inverse relationship is found present by Pindyck (2004) and Lin and Li (2015).

Although the variance of the variables explained by BRENT has a similar evolution when it comes to trend, both recording an increase over the time frame analyzed and ending at more than double in December compared to March, Electricity_EU price evolution is more dependable and correlated to BRENTs evolution than Gas_EU.

Based on the hypotheses set up in the methodology section, it can be noticed from the results obtained below in Table no. 5 for the Granger causality test under VAR, BRENT has a different influence relation to the variables analyzed.

Table no. 5: Granger causality

VAR Granger Causality/Block Exogeneity Wald Tests
Date: 12/21/24 Time: 21:00
Sample: 1/03/2022 12/30/2022
Included observations: 248

Dependent variable: D2LOG_ELECTRICITY_EU

Excluded	Chi-sq	df	Prob.
D2LOG_GAS_EU	26.04031	10	0.0037
D2LOG_BRENT	18.34084	10	0.0495
All	43.92568	20	0.0015

Dependent variable: D2LOG_GAS_EU

Excluded	Chi-sq	df	Prob.
D2LOG_ELECTRICI...	17.74298	10	0.0595
D2LOG_BRENT	9.088075	10	0.5238
All	27.86155	20	0.1127

Source: *Authors' own work using EViews 10 software.*

Based on H1 an increase in BRENT leads to an increase in Electricity_EU with a 4,95% probability level. On the other hand, based on H2 BRENTs price evolution adversely

influences the Gas_EU for a 52,38% probability level, meaning that an increase in BRENT price will lead to a decrease in Gas_EU and viceversa, similar to the findings of Magazzino et al. (2023) and Jia et al. (2020).

Conclusions

It is expected to notice a correlation between Electricity_EU, and Gas_EU with BRENT, especially in times of uncertainty such as the crisis generated by the COVID-19 pandemic and war. From the analysis of these variable in time of war, the results of the impulse response function provide proof of high volatility being present, similar to the findings of Umar et al. (2021), Boubaker and Raza (2017), Lei et al. (2023) and Behera and Rath (2024).

Another behavior that is found present in the impulse response function is a delayed reaction to the war, more precisely in the next month since the war started, finding similar to Escribano et al. (2023). Similar behaviour of a delayed response of stock market indexes is found present following the announcement of a catastrophic event by Razmi and Razmi (2023) during the COVID-19 pandemic and as well Chang et al. (2023) whom found a connectedness between BRENT and stock exchanges during times of crisis such as GFC and COVID-19 pandemic.

The variance decomposition results which provide insight on how much of the variance of the variables can be explained by BRENT evolution that show a greater impact on Electricity_EU and also corroborated with the Granger causality results that an increase in BRENT leads to an increase in Electricity_EU which emphasizes the concern expressed in the Joint Declaration of the European Parliament, the Council of the European Union and the European Commission (2022) regarding spiraling electricity prices and rising inflation.

The Granger causality test under VAR also provides proof of an adversely relation between BRENT and gas prices and the same relation between BRENT, similar to the findings of Jia et al. (2020) and Magazzino et al. (2023).

The limitations of the article is related to the differentiation among countries from the EU related to their dependance on oil, economic structure and if they are predominantly importing or exporting energy, this kind of differentiation among countries could lead to different results regarding the correlation with BRENT, similar to the ones obtained by Escribano et al. (2023).

Although, the results obtained show that both electricity and gas in the EU are sensitive to shocks that happen even outside the region, such as wars, especially since there are countries in the EU that were a significant importer of Russian gas, further analysis of other variables is needed to determine the extent and effect of the war on the economy.

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