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THE IMPACT OF THE RUSSIAN INVASION OF UKRAINE ON THE ENERGY SECTOR IN THE EUROPEAN UNION.

Prepared by:
Mr. NSUBUGA EMMANUEL REAGAN

Supervised by:
Mr. KHELIFA MAZOUZ

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President Mr. MOHAMED ACHOUCHE…………

Examiner ……………………………………………

Rapporteur ……………………………………………

DEDICATION

I dedicate this research paper to the unwavering pillars of my life: my loving mother, my supportive father, and my incredible sisters. Their boundless encouragement and unwavering belief in my abilities have been the driving force behind my journey.

To my dear mother, your unconditional love and endless sacrifices have shaped me into the person I am today. Your support, guidance, and belief in my dreams have instilled in me the courage to pursue this research with passion and dedication. Your constant presence has been a source of inspiration, and I am forever grateful for your nurturing spirit.

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With all my love and appreciation,

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ABSTRACT

While limited by its scarcity of natural resources, the impacts of energy price changes due to the war in Ukraine on the European Union's economic activities have been an important issue for social public and government authorities. This study applies the multivariate Error Correction model and the VAR analysis to investigate the effects of various international energy price shocks on the European Union's macroeconomic activity caused by the on-going war in Ukraine. The results highlight the significance of the industrial production index and imports in explaining forecast error variance. Share prices and short-term interest rates have a relatively greater impact on Brent crude oil, while changes in the industrial production index and imports have a relatively greater impact on the variability of the Henry Hub natural gas index. Coal price shocks initially affect the industrial price index and exports negatively but diminish over time. Share prices recover gradually, and import levels switch from positive to negative impact. Short-term interest rates show a moderate positive effect, and unemployment initially decreases before stabilizing. Brent crude oil price shocks have positive effects on exports initially but subsequently have negative impacts that gradually diminish. Henry Hub natural gas price shocks have mixed effects on exports and imports, dissipating gradually. Share prices recover after being negatively impacted, and short-term interest rates exhibit a slow decay of positive effects. Unemployment initially decreases and then stabilizes.

FRENCH AND ARABIC VERSIONS OF THE ABSTRACT

Bien que limitée par sa rareté en ressources naturelles, les impacts des variations des prix de l'énergie sur les activités économiques de l'Union européenne ont été un enjeu important pour le public et les autorités gouvernementales. Cette étude applique le modèle de correction d'erreur multivarié et l'analyse VAR pour étudier les effets des différents chocs internationaux des prix de l'énergie sur l'activité macroéconomique de l'Union européenne. Les résultats mettent en évidence l'importance de l'indice de production industrielle et des importations pour expliquer la variance des erreurs de prévision. Les prix des actions et les taux d'intérêt à court terme ont un impact relativement plus important sur le pétrole Brent, tandis que les variations de l'indice de production industrielle et des importations ont un impact relativement plus important sur la variabilité de l'indice du gaz naturel Henry Hub. Les chocs des prix du charbon affectent initialement négativement l'indice des prix industriels et les exportations, mais diminuent avec le temps. Les prix des actions se rétablissent progressivement et les niveaux d'importation passent d'un impact positif à négatif. Les taux d'intérêt à court terme montrent un effet positif modéré, et le chômage diminue initialement avant de se stabiliser. Les chocs des prix du pétrole Brent ont des effets positifs sur les exportations initialement, mais ont ensuite des impacts négatifs qui diminuent progressivement. Les chocs des prix du gaz naturel Henry Hub ont des effets mixtes sur les exportations et les importations, dissipant progressivement. Les prix des actions se rétablissent après avoir été impactés négativement, et les taux d'intérêt à court terme présentent une décroissance lente des effets positifs. Le chômage diminue initialement puis se stabilise.

النشاط على أوكرانيا في للحرب نتيجة الطاقة أسعار تغيرات آثار فإن، الطبيعية مواردها ندرة بسبب قدرتها تقتصر حين في
نموذج الدراسة هذه تطبق. الحكومية والسلطات الاجتماعي للجمهور مهمة قضية تكون قد الأوروبي للاتحاد الاقتصادي
النشاط على المختلفة الدولية الطاقة أسعار صدمات تأثيرات لاستقصاء VAR وتحليل المتغيرات المتعدد التصحيحي الانحدار
الصناعي الإنتاج مؤشر أهمية النتائج تبرز. أوكرانيا في المستمرة الحرب عن الناتج الأوروبي للاتحاد الماكرواقتصادي
على نسبيًا أكبر تأثير وجود إلى القصير المدى على الفائدة وأسعار الأسهم أسعار تشير. التنبؤ خطأ تباين تفسير في والواردات
في الطبيعي الغاز مؤشر تباين على نسبيًا أكبر تأثير والواردات الصناعي الإنتاج مؤشر في للتغيرات يكون حين في، برنت نفط
مع تتلاشى لكنها سلبي بشكل والصادرات الصناعية الأسعار مؤشر على أولي بشكل الفحم أسعار صدمات تؤثر. هاب هنري
الفائدة أسعار تظهر. سلبي تأثير إلى إيجابي تأثير من الواردات مستويات وتتحول، تدريجيًا الأسهم أسعار تتعافى. الوقت مرور
إيجابي بشكل برنت نفط أسعار صدمات تؤثر. تستقر أن قبل البداية في البطالة وتقل، معتدلاً إيجابيًا تأثيرًا القصير المدى على
ص تأثيرات تتراوح. تدريجيًا يتلاشى سلبيًا تأثيرًا تكتسب لكنها البداية في الصادرات على

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LIST OF ABBREVIATIONS

EU………. European Union
NATO…… North Atlantic Treaty Organisation
OPEC ……. Organisation of Petroleum Exporting Countries
TAR………. Threshold Autoregressive Regression
MVECM…… Multivariate Error Correction Model
VAR……… Vector Auto Regression
LNG……… Liquefied Natural Gas
ECB ……… European Central Bank
NACE …… National Association of Colleges and Employers
OECD …… Organisation for Economic Co-operation and Development
TIVA ……. Trade In Value
ISIC ………. International Standard Industrial Classification
UK ………. United Kingdom
IEA ……… Internal Energy Agency
US ………. United States
ICE ……… Inter-Continental Exchange
TTF ……… Title Transfer Facility
EC ………… European Commission
LFS ………. Labour Force Surveys
Pwc ………. Pricewaterhousecoopers
IMF ……….. International Monetary Fund
VD………… Variance Decomposition
IRF …………Impulse Response Function
TAR…………Threshold Autoregression
EGARCH…… Exponential General Autoregressive Conditional Heteroskedastic
NACE…. 'Nomenclature statistique des Activites economiques dans la Communaute Europeenne'-Statistical classification of economic activities in the European Community

THE IMPACTS OF THE RUSSIAN INVASION OF UKRAINE ON THE ENERGY SECTOR IN EUROPE.

1. INTRODUCTION

The Russia-Ukraine war has been actively raging since February 2014, when a dispute over the official status of Crimea and Donbas erupted between the two countries. According to Johannesson and Clowes (2022), Ukraine tends to represent a potentially direct competitive threat to Russia's energy exports, and that is one of the key reasons for the dispute and Russian annexation of Crimea. Hence, following a full-scale invasion by Russia on February 24, 2022, tensions between the two countries have skyrocketed to a great extent. The Russian government is subject to severe economic sanctions that have been imposed by a number of countries and corporations around the world (Funakoshi et al., 2022). In the energy markets in particular, Russia is one of the top exporters of oil, gas, and coal to Europe. As a result of the war that has ensued, there has been a significantly adverse impact on the energy sector in Europe.

The influence of the Russia-Ukraine war on the energy sector has been critically examined in this study.

1.1 BACKGROUND OF THE RUSSIA-UKRAINE WAR

Russia maintains its ability to be the dominant military power in nuclear weapons by controlling the Eurasian region with its geopolitical structure and territorial integrity (Karabayram, 2007). Geopolitically, Russia has the largest surface area in the world. It is an important raw material and energy exporter with its petroleum, natural gas, copper, iron, and many other minerals and rich forest resources (Ağır 2016). In the 1990’s Russia entered into an economic transformation with the effect of the economic crisis, lost its former imperialist power and super power in the international arena with the narrowing of its borders, entered into a hot conflict with Chechnya and on the other hand, it faced more independence demands from other autonomous regions included in the federation (Yılmaz, 2006). Countries of the Former Soviet Socialist Republics Union have always held close relations with international organizations such as European Union (EU) and NATO an issue that made Russia uncomfortable. However, Ukraine is of special importance to Russia due to both its geopolitical position and its role in Russian history. Ukraine which joined the Soviet Union in 1922 and left the Union in 1991 to became one of the founding members of the Commonwealth of Independent States in the following period. Although Ukraine declared its independence after the Soviet Union, it could not achieve a stable political structure in the last period and went back and forth between Western countries and Russia. Ukraine, which followed a distant policy with Russia during the Orange Revolution and Yushchenko period, experienced various crises with Russia due to the sharing of the Black Sea fleet, the energy problem and its rapprochement with Western countries (Bolgün, 2022).

The announcement by the Ukrainian Government that the Association Agreement, which was expected to be signed in November 2013 between Ukraine and EU was suspended, came to the agenda of other countries and turned into a major crisis. This crisis, which continued with the annexation of Crimea by Russia, turned into an international problem (Semercioğlu, 2016). Ukraine's location between Europe and Russia, its dominance over the Black Sea, and the fact they come from the same race has made Ukraine to come into prominence in the immediate surroundings. For this reason, Russia has been making moves to prevent Western countries from advancing towards to the Ukraine. Consequently, the rapprochement of NATO and EU with Ukraine disturbed Russia and it caused Russia to intervene Ukraine (Keskin, 2015).

After weeks of protests as part of Euromaidan movement (2013-2014), pro-Russian Ukrainian President Viktor Yanukovych and Ukrainian parliamentary leaders signed a compromise agreement calling for early elections on February 21, 2014. The leaders of the Russian speaking eastern regions of Ukraine declared their continuing loyalty to Yanukovych, leading to pro-Russian unrest. The turmoil was followed by the Donbass war which began with the annexation of Crimea by Russia in March 2014 and the formation of the two Russia-backed separatist quasi states of the Donetsk People's Republic and the Luhansk People's Republic. On September 14 2020, Ukrainian President Volodymyr Zelenskyy approved Ukraine's new National Security Strategy which ensures the development of distinctive partnership with NATO for the purpose of NATO membership. On March 2021, Zelenskyy signed a decree approving "the strategy for the de-occupation and the reintegration of the temporarily occupied territory of the Autonomous Republic of Crimea and the city of Sevastopol. On February 24 2022 Putin announced that he had made a decision to launch a military operation in Ukraine. He remarked that there were no plans to occupy Ukrainian territory and he supported the right of the Ukrainian people to self-determination. He stated that the purpose of the operation was to protect the people in the predominantly Russian-speaking region of Donbas who had been facing humiliation and genocide perpetrated by the Kyiv regime for eight years now. Within the minutes of Putin’s announcement explosions were begun in Kyiv, Kharkiv, Odessa, and the Donbas region. Immediately following the attack, Zelenskyy announced the introduction of martial law in Ukraine (Wikipedia, 2022).

1.2 MOTIVATION AND RESEARCH QUESTIONS OF THE STUDY

Russia’s invasion of Ukraine on February 24 has thrown into question the recovery of growth from pandemic Covid 19 and unleashed catastrophe across the region that has destroyed lives, homes, and infrastructure. The impact has been felt around the world. Russia and Ukraine are major commodity producers. The disruptions have caused global prices to skyrocket, especially in the area of natural gas and oil in the European countries. As energy prices play a critical role in influencing economic growth and economic activities, we want to analyse the linkage of energy prices and macroeconomic variables in the Eurozone with linear and asymmetric frameworks.

This study is motivated by three reasons. First, several studies have indicated that oil price shocks have a significantly negative impact on industrial production (e.g., Mork, 1989; Hooker, 1996; Hamilton, 1996; Bernanke et al., 1997; Hamilton, 2003; Hamilton and Herrera, 2004), yet little is known about the relationship between other energy prices and economic activities. Second, some studies already consider the asymmetric relation in terms of the impact of an oil price change or its volatility on industrial production and stock returns (e.g., Mork, 1989; Mork et al., 1994; Sadorsky, 1999; Papapetrou, 2001). However, these studies use zero as a cut-off point for distinguishing oil price changes into up (increase) and down (decrease) segments. In other words, any change in oil prices that is greater than zero is considered an upward change, and any change that is less than zero is considered a downward change. This approach has limitations because it does not distinguish between the impact of small versus large price changes. Moreover, the effect of an oil price increase may not be symmetric with the effect of an oil price decrease. Using a predetermined value as a trigger point lacks any statistical verification because it is an arbitrary decision that’s not based on any statistical or empirical evidence. In statistical analysis, it is generally preferrable to use an approach that is based on data and empirical evidence rather than relying on arbitrary cut-offs or predetermined values. The use of a predetermined value as a trigger can lead to biased results and can also lead to erroneous conclusions about the relationship between oil prices and stock returns. Using a Multivariate Error Correction Model, on the other hand, provides a more robust statistical approach because it is based on modelling the dynamic relationships between different variables, and it allows you to estimate the impact of changes in oil prices on stock returns while taking into account other relevant factors that may be affecting stock returns.

Thirdly, the studies mentioned above neglect the asymmetric association to accurately gage varying degrees of the macroeconomic impacts of energy price. The two-regime model based on the value of a variable (greater than zero or less than zero) is somewhat arbitrary. Is it true that a very small increase in energy prices changes would have a significant negative effect on economic activities? Although oil price changes certainly affect economic activities, they will also affect the production sector when the oil price increase exceeds a certain economical threshold level. To cautiously respond to these arguments, we need more rigorous econometric models other than the Threshold Autoregressive Models (TAR) and Exponential Generalized Autoregressive Conditional Heteroscedasticity (EGARCH) because of the reasons cited above.

In this study, I employ the Multivariate Threshold Error Correction Model (MVECM) by Tsay (1998) to analyse the impacts of different energy price changes on the Eurozone macroeconomic activities. The MVTECM is different from the TAR and EGARCH because it incorporates both the threshold effects and the error correction mechanism to model the dynamic relationship between variables. It allows you to capture the asymmetric effects of oil price changes on stock returns and industrial production, while also taking into account the long-run equilibrium relationship between these variables. The MVECM allows you to identify the threshold level at which the impact of energy price changes on macro-economic variable changes. This is an improvement over the TAR model, which assumes that the threshold value is fixed and known. Moreover, the MVECM allows you to incorporate the error correction mechanism, which captures the long-run equilibrium relationship between variables. This means that the MVECM model can identify both the short-term and long-term effect of oil price changes on stock returns and industrial production, while also taking into account the interdependence between these variables. The energy price changes are treated as the threshold variable to test whether there is an asymmetric association in the multivariate VAR model.

This study aims to address how the Russian invasion of Ukraine may have impacted the energy security of Europe and what measures can be taken to mitigate the potential consequences. In order to answer this question, we have to know the current state of the energy sector in Europe, to what extent it depends on Russian gas exports, how the Russian invasion of Ukraine may have affected the Eurozone's energy sector, particularly in terms of energy prices and supply chain dynamics. We have to further analyse the policy measures the EU can implement to improve its energy security and mitigate the consequences of the war and the long-term implications of the invasion on the EU's energy security and how it can adapt to these changing geopolitical dynamics.

1.3 SIGNIFICANCE AND CONTRIBUTIONS OF THE STUDY

This research topic is significant for several reasons. Firstly, it addresses a critical issue that could potentially affect the economic stability and security of the European Union. Secondly, it sheds light on the geopolitical implications of the Russian invasion of Ukraine, highlighting the interconnectedness of global energy markets. The interconnectedness of global energy markets refers to the fact that energy commodities, such as crude oil and natural gas, are traded and consumed on a global scale, with supply and demand in one region affecting prices and availability in other regions. This interconnectedness is driven by a range of factors including geopolitical dynamics. One way to highlight this interconnectedness is to consider the impact of the war on energy prices around the world. Changes in demand for natural gas in Europe can impact the availability of and pricing of liquefied natural gas (LNG) exports from other countries such as North America. Lastly, it provides insights into the challenges facing the Eurozone's energy sector, and how these challenges can be addressed to improve the region's energy security. Energy security is a major policy priority for the European Union (EU), given the importance of energy to the EU's economy, security and sustainability. The EU's energy policy aims to ensure the uninterrupted supply of energy resources, such as oil, natural gas and electricity, at affordable prices, while promoting transition to a low-carbon economy. This study, therefore, adds to the literature by investigating the impact of the Russian-Ukraine war on the energy sector in the Eurozone.

This research will contribute to the understanding of the impact of the Russian invasion of Ukraine in 2022 on the energy sector in the Europe. By answering the research questions, the study will provide insights into the current state of the Europe's energy sector and the region's dependence on Russian gas exports. Moreover, the study will shed light on the potential consequences of a disruption in the supply chain, including changes in energy prices and supply chain dynamics.

Furthermore, the research will offer recommendations on policy measures that can be implemented to mitigate the potential consequences of a disruption in Russian gas exports and improve the Eurozone's energy security. The study will also provide insights into the long-term implications of the Russian invasion of Ukraine on the Eurozone's energy security and the region's adaptation to changing geopolitical dynamics. Overall, the research will be valuable to policymakers, energy analysts, and academics interested in understanding the interconnectedness of global energy markets and the challenges facing the Eurozone's energy sector.

1.4 SUMMARY OF METHODS AND FINDINGS

In this research paper, we aimed to investigate the impacts of price shocks in the energy sector on the European economy. To achieve this objective, we employed both the Multivariate Threshold Error Correction and Vector Autoregressive (VAR) models.

Firstly, we estimated the error correction model to investigate the long-term relationship between energy prices and the European economy. The results showed that a long-term equilibrium exists between the Brent crude oil price, the Newcastle coal futures price, and the European economy. Moreover, the Newcastle coal futures price has a stronger impact on the European economy compared to the Brent crude oil price.

Secondly, we employed the VAR model to analyze the short-term dynamics of energy price shocks. Our findings revealed that a one-unit price shock in Brent crude oil has a negative effect on industrial production and exports. In contrast, a price shock in Henry Hub natural gas has a short-lived negative effect on exports and a positive effect on short-term interest rates. The Newcastle coal futures price shock has a significant negative impact on the industrial production index and short-term interest rates. Furthermore, our variance decomposition results showed that changes in industrial production account for a relatively large portion of the overall variability in the energy prices compared to exports, share price, unemployment, and short-term interest rates.

Overall, our results suggest that the European economy is vulnerable to energy price shocks. Therefore, policymakers should implement policies aimed at diversifying the energy sources, reducing dependence on energy imports, and promoting stability in share prices and short-term interest rates to mitigate the negative impact of energy price shocks on the economy.

1.5. THESIS STRUCTURE

The rest of this paper is as follows: Section 2 gives an overview of the Europe’s energy sector. Section 3 gives an overview of previous research on the impacts of geopolitical events on global energy markets. Section 4 covers the data sources, methodology and analyis while section 5 covers policy implications and discussions. Section 6 addresses some concluding remarks and scope and limitation of the study.

2. OVERVIEW OF EUROPE'S ENERGY SECTOR.

Europe's energy sector is diverse and complex, consisting of various sources of energy generation, transmission, and consumption. The sector includes traditional sources such as oil, coal, and gas, as well as newer sources such as renewable energy, nuclear power, and hydrogen.

In terms of electricity generation, Europe's energy mix is shifting towards cleaner sources, with renewable energy sources such as wind, solar, and hydropower contributing to an increasing share of electricity generation. According to the European Environment Agency, renewable energy accounted for 34.6% of the EU's electricity consumption in 2019, with wind and solar power contributing to most of this share. Meanwhile, fossil fuels remain a significant source of electricity, with gas being the most commonly used fossil fuel for electricity generation.

The transmission of energy in Europe is primarily managed through a network of power grids that connect different countries and regions. The European Union's internal energy market ensures that energy can flow freely across borders and that prices are determined by market forces. The EU has also established interconnections between member states to promote energy security and diversify energy supplies.

The consumption of energy in Europe is driven by a variety of sectors, including transportation, industry, households, and services. The transport sector is the largest consumer of energy in the EU, with oil being the primary fuel used for road transportation. The industrial sector is the second-largest consumer of energy, with energy-intensive industries such as steel, chemicals, and cement being major users. The residential sector consumes energy for heating, cooling, and lighting, while the service sector includes energy consumption in commercial buildings such as offices and shops.

Europe's energy sector faces several challenges, including energy security, reducing greenhouse gas emissions, and transitioning to a more sustainable and low-carbon energy system. The region's dependence on imported energy, particularly from Russia, makes energy security a top priority. Additionally, the EU has set ambitious targets to reduce greenhouse gas emissions and transition to a low-carbon energy system, with the aim of achieving net-zero emissions by 2050.

2.1 EUROPE’S ENERGY DEPENDENCE ON RUSSIA

The majority of natural gas supplied to the European Union comes from just three countries outside the EU, namely Russia, Norway, and Algeria. In 2005, Russia alone accounted for 37.7% of the total gas imports of the EU 27, making it the largest gas provider to the continent by a significant margin. In Europe, the level of dependence on Russian gas imports tends to increase as one moves towards the east. This is particularly evident in the case of seven former Warsaw Pact and Soviet Union states, which rely on Russia for over 99% of their natural gas needs. Additionally, most Central and Eastern European countries heavily rely on Russia to meet the majority of their natural gas consumption requirements.

According to Marshall Centre’s estimates, in 25 years' time, up to 80% of the natural gas consumed by the EU will be sourced from imports, with Russia being a potential supplier of as much as 60%. Approximately 20% of the EU's total energy mix is sourced from Russia through pipeline natural gas, not accounting for the additional energy in the form of oil which could constitute up to 10% of the overall energy mix. Being the primary determinant of natural gas prices worldwide, Russia will have the ability to exert control through the use of its energy resources by setting terms, considering it will supply approximately one-third of the EU's energy by 2030. The negotiations held with Ukraine at the start of 2006 and with Belarus towards the end of the same year serve as evidence of Russia's significant economic and political influence over countries reliant on its energy. (Marshall Centre, 2022)

“The EU and Russia depend on each other as energy buyer and supplier" is a phrase commonly used in European political discussions. However, this oversimplifies the complex situation, possibly to make it more acceptable to EU constituents. The relationship between the EU states and Russia is likely to be dominated by Russia unless the EU states make serious concerted efforts. This is because energy demand in highly developed economies, such as Europe, is not affected by changes in price. As a result, demand for energy will remain constant even if prices are high. Europeans will choose to pay exorbitant prices rather than endure a cold, dark home. Additionally, the mutual dependence theory promoted by European politicians does not consider how Russia is using its hydrocarbon revenues. Russia has been accumulating a significant portion of these revenues in an oil stabilization fund.

The fact that this revenue is not being allocated towards non-discretionary funding suggests that Russia may have a higher tolerance for interruptions in these revenue streams compared to their European customers' ability to withstand disruptions in energy supply.

2.2 NATURAL GAS DEPENDENCE AND RISKS TO EURO AREA ACTIVITY

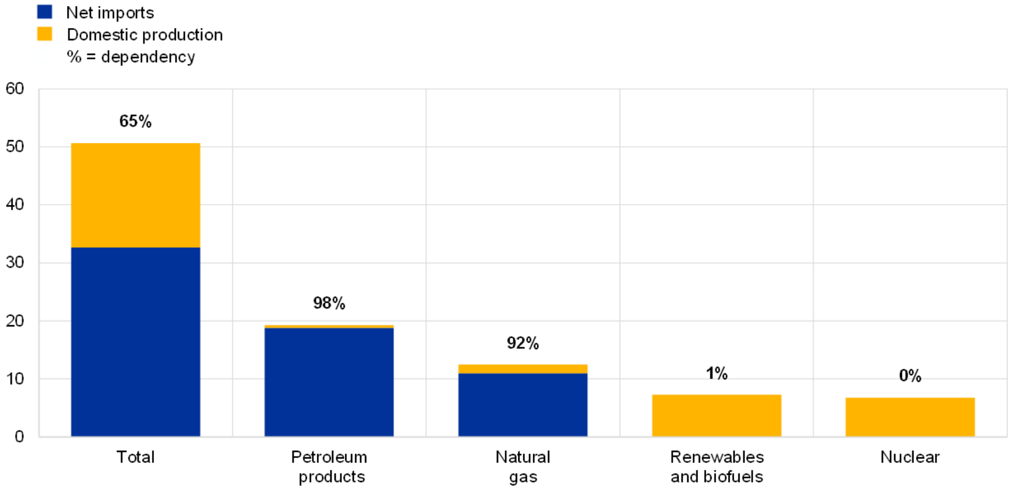
After petroleum-based products, natural gas is the euro area's second most significant primary energy resource. It holds the top spot in the manufacturing sector and accounts for over 90% of the gas consumption in the region. The euro area relies heavily on imports for both natural gas and petroleum-based energy products. However, renewable energy and nuclear energy are primarily produced domestically. (Chart A, panel a)

Petroleum-based energy is the most widely used source of energy when considering the entire economy, primarily due to its use in transportation. On the other hand, in the industrial sector, as well as in households and services that are not related to transportation, gas is the primary energy source that is consumed the most (Chart A, panel b). Due to the flexibility of gas-fired power plants and the overall gas infrastructure, which includes network interconnections, storage capacity, and liquified natural gas terminals, gas has become the primary marginal energy resource in electricity generation. This is particularly important in responding to fluctuations in electricity demand. As the transition towards renewables continues, which depend on variable weather patterns, the reliance on gas has increased.

Chart A

Energy dependency and energy use by primary fuel type in the euro area

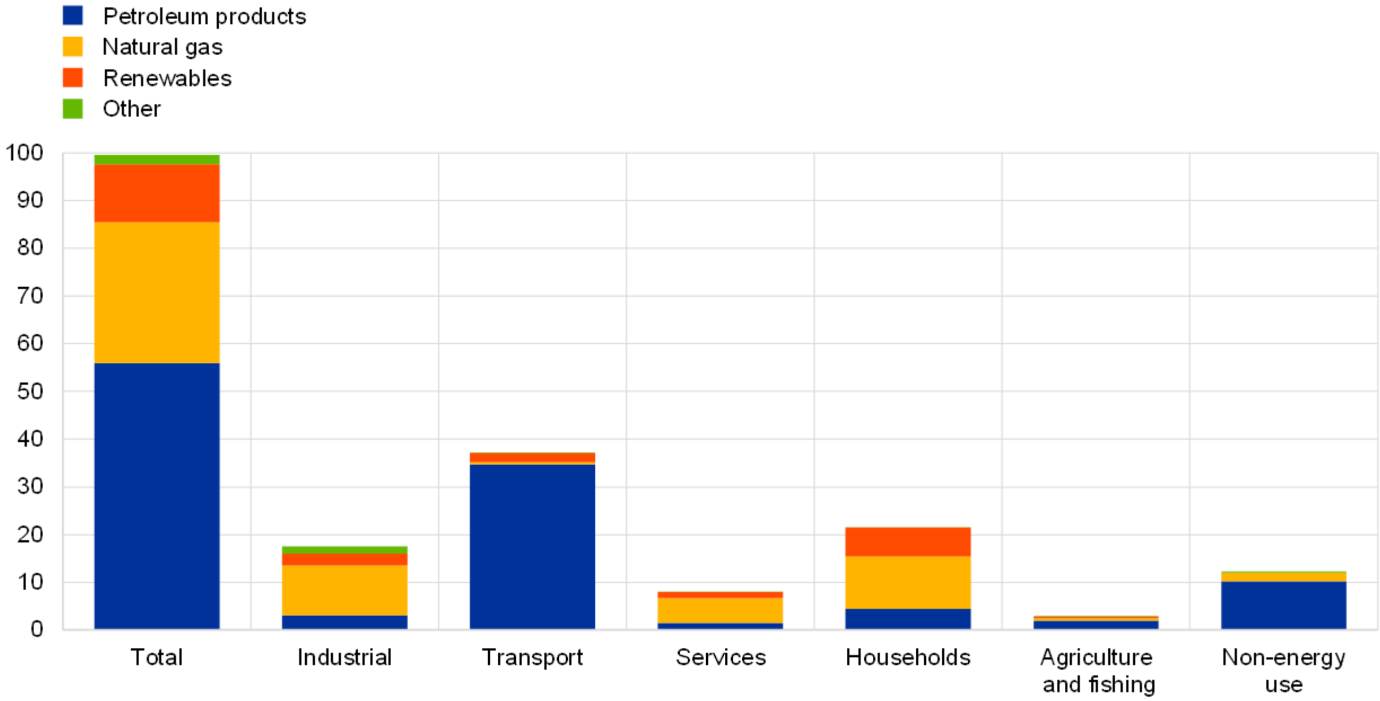
a) Euro area energy dependency



Source: Eurostat (energy balances).

b) Use by primary fuel type in 2019

(energy use as a percentage of total use)



Source: Eurostat (energy balances).

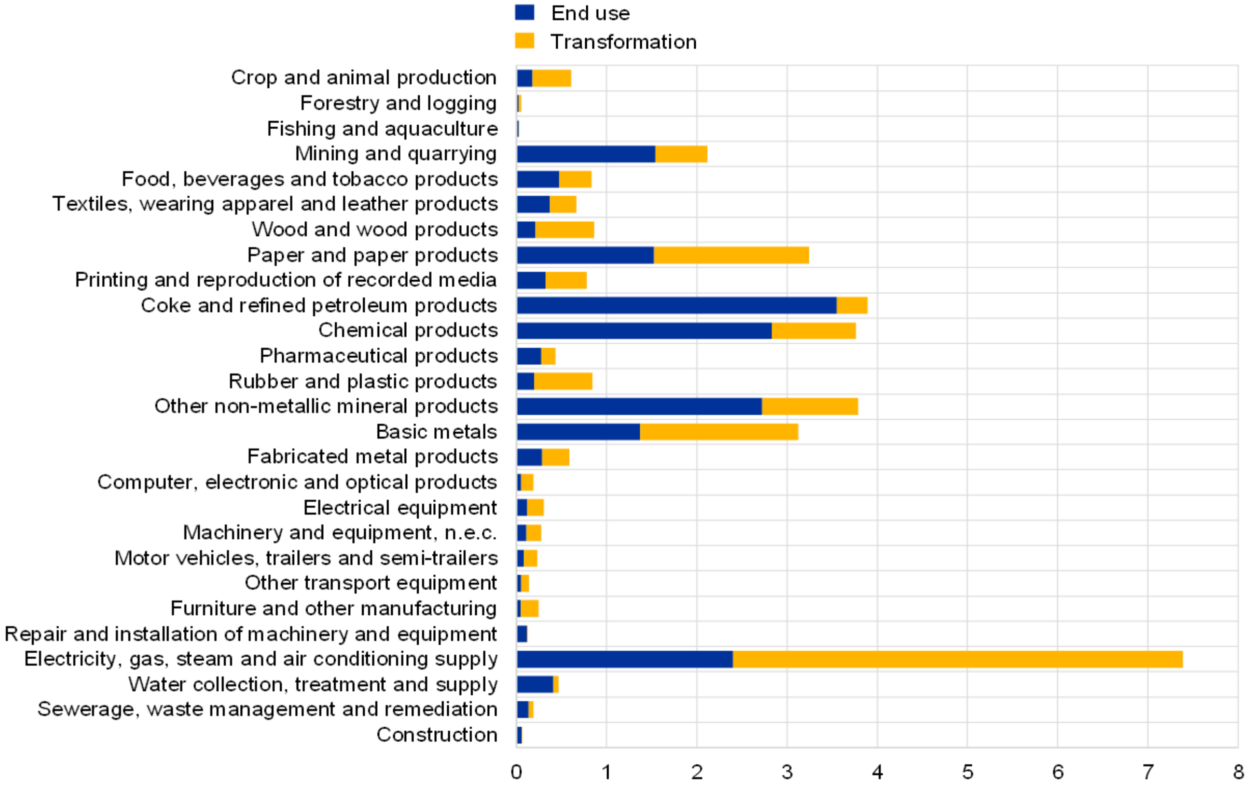
Notes: Dependency refers to the ratio of net imports to gross available energy. Intra-euro area trade is not included

Economic activity can be restrained by notable rises in natural gas prices via two channels: consumption and intermediate goods. Through the consumption channel, increased gas and electricity costs diminish households' real disposable income and purchasing power, resulting in a decrease in private consumption, as imported energy's increased cost leads to a deterioration in terms of trade.

Gas is a crucial input in the production processes of various firms, particularly those in the industrial sector. Chart B provides data on the usage of natural gas by industrial sectors, classified based on the Statistical classification of economic activities in the European Community (NACE2). The classification distinguishes between two types of usage, namely transformation use and end use. The energy sector mainly transforms natural gas into other energy forms, while other significant consumers of gas include producers of chemicals, basic metals, non-metallic minerals such as glass, cement, ceramics, and food and beverages.

Chart B

Gas use by industrial sector in 2019

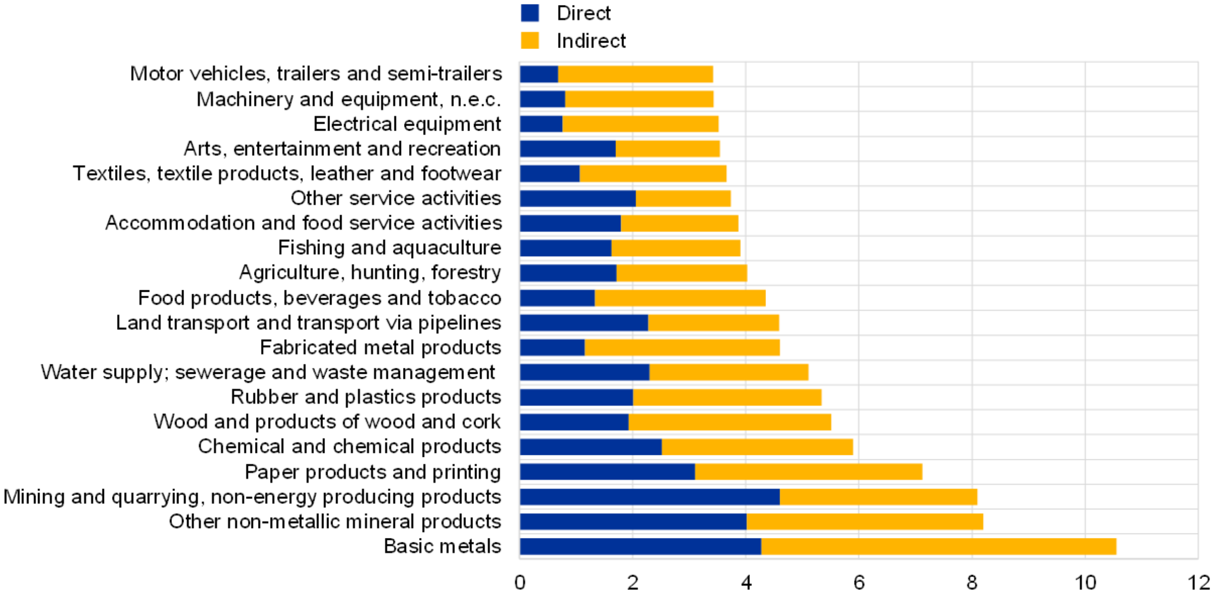


Source: Eurostat (energy supply and use tables) and ECB staff calculations. The sectors are classified according to the Statistical classification of economic activities in the European Community (NACE Rev. 2).

Due to the significant amount of energy consumption that is indirectly embedded in earlier stages of production, supply chain linkages can greatly amplify the response of producers and service providers to increase gas prices. Chart C provides a breakdown of the 25 most energy-intensive sectors in the euro area, taking into account both direct sourcing and indirect use via other sectors' inputs, with some industrial sectors having a significant direct use of energy (such as mining and metal and minerals sectors), while others mainly use electricity and gas indirectly. Downstream industrial sectors, including those related to fabricated metals, food, textiles, electrical equipment, machinery and equipment, and motor vehicles, as well as services sectors such as transport-related, water supply, and accommodation and food, are particularly reliant on indirect use of energy. The input from the electricity, gas, steam and air conditioning supply industries is especially relevant for the basic metals, mining and quarrying, paper and printing, and chemical sectors.

Chart C

Direct and indirect gas and electricity use by sector



Sources: OECD Trade in Value Added (TiVA) database 2021 and ECB staff calculations.

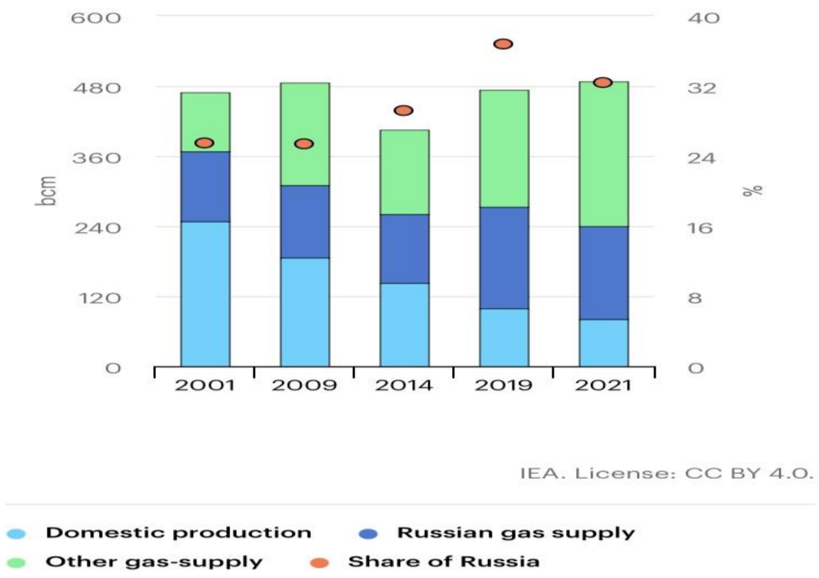
Note: The chart shows the 25 most energy-intensive sectors measured by the share of input from the electricity, gas, steam and air conditioning industries, classified according to the United Nations International Standard Industrial Classification for All Economic Activities (ISIC).

2.2.1 The role of Russia and Ukraine's transit in Europe's gas supply

Over the last decade, there has been an increase in the dependence of the European Union and indirectly the United Kingdom on Russian gas supplies. Although the aggregate natural gas consumption in the EU and UK has remained stable during this period, the production has decreased by one-third, resulting in increased imports to fill the gap. This has led to a rise in the proportion of Russian gas supplies, which now make up 32% of the region's total gas demand, up from 25% in 2009.

The significance of Ukraine as a transit country has decreased due to the establishment of supplementary transit routes that transport Russian gas via pipelines to the EU and UK, such as Nord Stream. In 2021, transit volumes through Ukraine constituted slightly over 25% of Russia's pipeline exports to the EU and UK, down significantly from over 60% in 2009. Despite this, Ukraine continues to be a crucial channel for transporting Russian gas to Europe, accounting for about 8% of the combined gas demand of the EU and UK, and heavily depending on imported gas for its domestic consumption.

Share of Russia in European Union and United Kingdom gas demand, 2001-20



Source: IEA global energy markets report

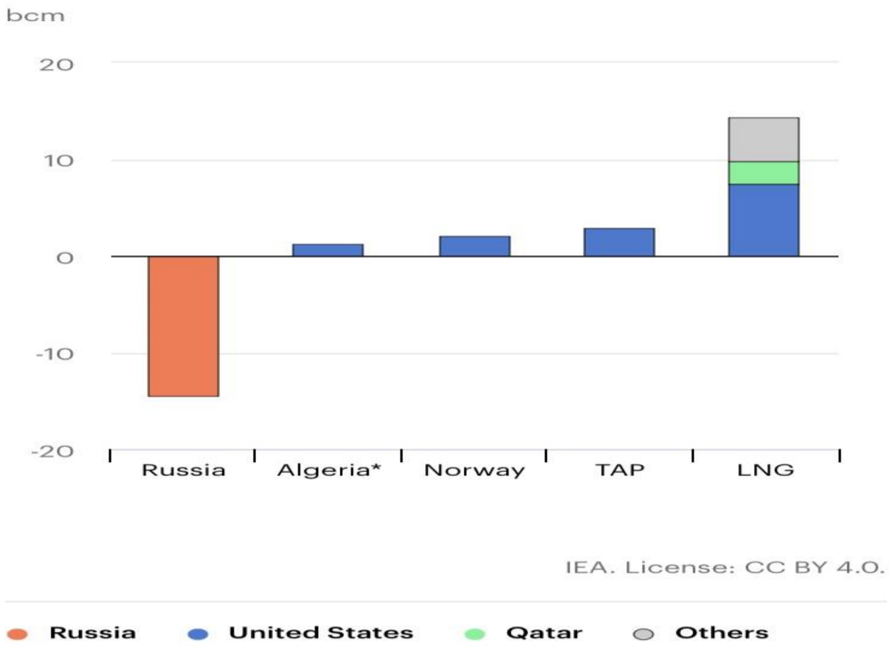
Russia reduced gas supplies to the EU and UK markets during the heating season

As highlighted by the International Energy Agency in September 2021, Russia has been reducing its piped gas supplies to the EU market, while it did not fill its storage sites in the EU to adequate levels. In Q4 2021, there was a 25% year-on-year decline in pipeline deliveries from Russia. The reduction in Russian pipeline supply to the EU intensified during the initial seven weeks of 2022, dropping by 37% year-on-year. The YAMAL pipeline (which passes through Belarus) delivered its final gas supplies to Germany on December 20, 2021. Furthermore, gas flows to Slovakia via Ukraine have dwindled from an average of more than 80 mcm/d in December to merely 36 mcm/d in the first seven weeks of 2022

During this period, the average gas flows via Ukraine from Russia amounted to 55 mcm/d, which is significantly lower than the available capacity of around 109 mcm/d as per the contract. However, other pipeline suppliers such as Algeria, Azerbaijan, and Norway utilized commercially available supply routes to increase their deliveries to the European market compared to the previous year's heating season.

To make up for reduced pipeline flows from Russia, there has been a partial increase in the inflow of liquefied natural gas (LNG), which rose by 63% year-on-year through October year-to-date. In January, LNG inflows to the UK and the EU reached an unprecedented level of 13 bcm, which is nearly three times their levels from last year and around 70% higher compared to Russian pipeline flows for that month. The redirection of cargoes from Northeast Asia to Europe was facilitated by strong supply and milder-than-anticipated temperatures, mitigating the impact of strong European demand on the LNG markets. Since the start of the heating season, more than half of the additional LNG imported by the European Union and United Kingdom was provided by the United States, comprising 37% of the total LNG supplies. This emphasizes the significance of the US LNG export sector and the essential role of robust transatlantic connections in securing energy for Europe.

Year-on-year change in the European Union and United Kingdom natural gas imports by source, Oct 2021- Jan 2022

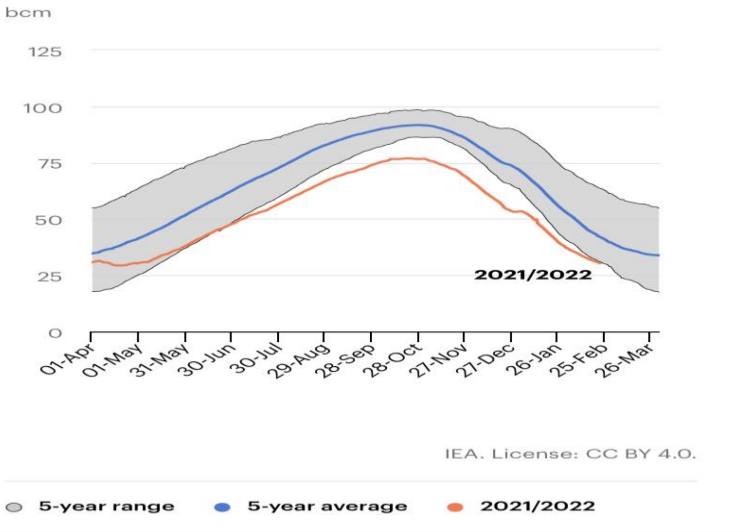


Source: IEA global energy markets report

European storages are 30% below their 5-year average and are less than a third full

Due to low inventory levels at the start of the heating season and a significant drop in Russian piped flows to the EU, gas storage levels decreased to 30% below their maximum storage capacity, which is also 28% lower than their average levels for this time of the year over the past five years. At the beginning of the heating season, the storage facilities belonging to Gazprom or under its authority had extremely low storage levels, only containing 25% of their working storage capacity. Although Gazprom's storage sites represent only 10% of the EU's overall working storage capacity, they were responsible for 50% of the EU's storage shortfall over the past five years. The current storage levels in Europe are at 31%, which would have been below 15% full by now if there hadn't been a significant rise in LNG imports since October. This indicates the importance of both underground gas storage and LNG regasification capacity in ensuring a secure supply of natural gas, especially during periods of late cold spells or supply disruptions. The security value of gas storage should be more strongly recognised in this context. As the IEA previously stated, enforcing minimal storage requirements for commercial operators alongside effective market-driven allocation systems are crucial measures that can guarantee the optimal utilization of all storage capacity that is accessible.

Inventory levels in EU underground storage sites, 2016-2022



Grey 5-year range blue 5-year average orange 2021/2022

Source: IEA Global energy markets Report

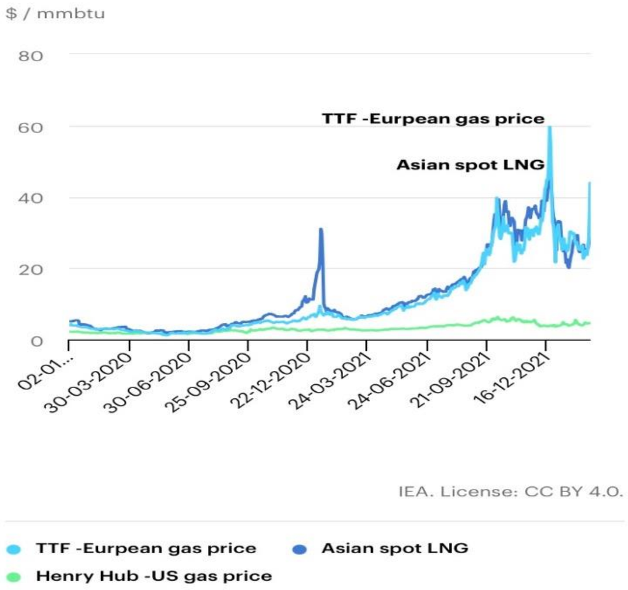
European natural gas prices rose to all-time highs and remains extremely volatile

In Q4 2021, the average hub prices in Europe rose significantly, exceeding USD 30/MMBtu, due to a combination of factors including decreased pipeline flows from Russia, depleted storage levels, and unfavourable weather conditions.

In the initial seven weeks of 2022, the average price of natural gas was USD 27/MMBtu, which was tempered due to unseasonably mild weather conditions, leading to a reduction of 14% year-on-year in distribution-network related demand as per preliminary evaluations. Furthermore, despite lower availability of nuclear and hydro sources, the strong wind output increased by 20% year-on-year, resulting in decreased gas burn in the power sector.

On February 24th, 2022, European gas prices rose sharply by 50% to reach USD 44/MMBtu, as a result of Russia's invasion of Ukraine. This surge in prices had a positive impact on Asian LNG spot prices, which also rose significantly by 30% to USD 37/MMBtu. As of the same date, natural gas flows through Ukraine to Slovakia remained unaffected, with nominations for February 25th, 2022 increasing to 75 mcm/d. Given the current market uncertainty, natural gas prices are expected to remain highly volatile.

Natural gas prices in Europe, Asia and the United States, Jan 2020-February 2022



Source: IEA Russian supplies to global energy markets report

2.3 THE ROLE OF THE EUROPEAN UNION IN MITIGATING THE IMPACTS OF THE INVASION.

2.3.1 Energy prices and security of supply.

The continent of Europe is presently facing an energy crisis of an exceptional nature, prompting collaboration among EU nations to tackle the issue of soaring costs and ensure a reliable energy source for the people of Europe.

2.3.2 What are EU countries doing to address the energy crisis?

EU leaders and the Council are highly concerned about the increase in energy prices and the disruptions to energy supply, which have become major priorities. The EU countries are working together and closely collaborating to devise effective strategies to address the energy market's imbalances and surging prices. To confront the energy crisis, it is crucial for the EU member states to unite. Collaborating is the most effective approach for EU nations to minimize the crisis's effects and lower risks. An illustration of this is when energy is jointly procured, which lowers import expenses. Furthermore, in the present context, where there is high uncertainty regarding energy supply and Russia's delivery interruptions, solidarity among EU nations is necessary to offer aid to the nations that rely more heavily on Russian energy, making them more vulnerable to supply reductions.

According to the council of the European Union, the main goals of the EU's response to the energy crisis are to; ensure affordable and competitive energy for EU consumers, increase the EU's energy security and preparedness in the event of emergencies, strengthen the energy resilience and autonomy of EU countries. To this end, EU countries are working together on limiting excessively high gas prices, improving solidarity and sharing supply, cutting energy costs for households and businesses, reducing the EU's energy dependencies, securing gas supplies and accelerating the green transition.

2.3.3 Limiting excessively high gas prices

A mechanism to correct the market has been agreed upon by EU member states, aimed at curbing instances of abnormally high gas prices within the EU. This will lessen the adverse effects of price surges on both citizens and the economy by enforcing a maximum limit on gas transactions during times of exceptional price increases.

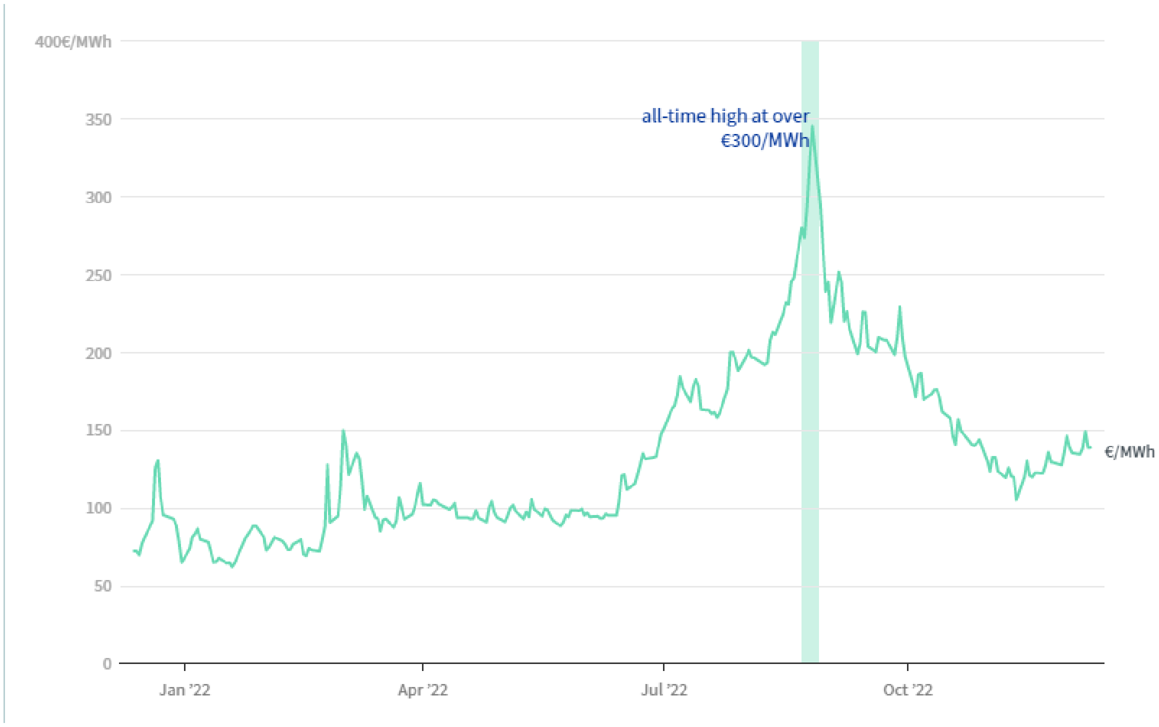
If both parameters are met simultaneously, namely the month-ahead price on the TTF exceeds 180€/MWh for three working days, and the month-ahead TTF price is 35€ higher than a reference price for LNG on global markets for the same three working days, the mechanism will be automatically activated. To address the issue of gas prices that are significantly higher than world market rates and to ensure energy security and financial stability, a temporary emergency measure has been introduced through regulation. The measure will be applicable to derivative contracts for the upcoming month, three months, and one year, and will come into effect from February 15th, 2023. It can be revoked or halted according to predetermined regulations.

2.3.3.1 A market mechanism to limit excessive gas price spikes

The EU member states have reached a consensus on a corrective mechanism for the market, aimed at mitigating the effects of extremely high gas prices on the economy and citizens. This mechanism involves the implementation of a price limit for gas transactions in cases of exceptionally high gas prices. The new regulations have been established in response to the

European Council's October 2022 conclusions, which called for the implementation of a pricing mechanism to curb excessive gas price spikes while safeguarding the EU's supply security and market stability.

Gas prices in the EU

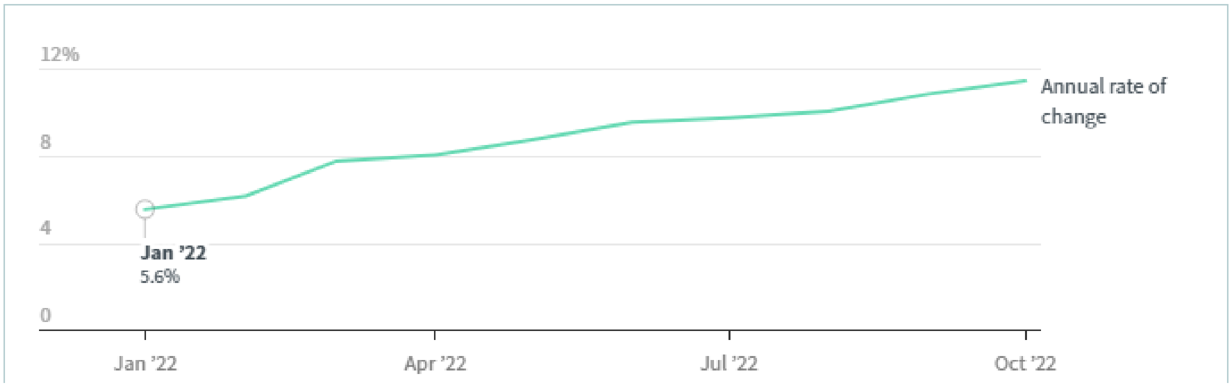


Source: [ICE index]
Chart showing the evolution of gas prices in the EU. Data from ICE Endex on Dutch TTF Natural Gas Futures.

The EU economy has been severely affected by the prolonged surge in gas prices in August, which has resulted in increased financial strain for energy customers and posed significant challenges to the EU market's supply security. Additionally, Russia's military aggression against Ukraine and use of gas supplies as a weapon have continued to impact the markets, making supply security a persistent issue in the EU. Consequently, the exorbitant gas prices have played a role in driving up inflation, which rose to 11.5% in the EU in October 2022.

2.3.3.2 EU inflation rates in 2022

Data from 17 November 2022



Source: Eurostat

Chart showing annual rate of change of inflation in the EU. Data shows a growing trend from 5.6% in January 2022 to 11.5% in October 2022.

As Russia's incursion into Ukraine persists, the market is anticipated to remain volatile and uncertain even after the winter of 2022/2023. To mitigate the impact, EU member states will continue to enhance their efforts to diversify their energy sources and build new infrastructure, including liquefied natural gas terminals. Furthermore, through the market correction mechanism, EU countries aim to avert future occurrences of exorbitant gas prices, safeguarding European citizens and businesses from adverse economic shocks.

2.3.4 Improving solidarity and sharing supply

Given the continued volatility of energy prices on the markets, EU nations have come to an agreement on implementing measures to strengthen solidarity across the EU and enhance coordination for joint gas procurement. The newly adopted measures will enable member states and energy firms to collectively purchase gas from global markets. By pooling their demand at the EU level, member states will be able to negotiate better terms for buying gas and avoid outbidding each other in the process.

The recently approved regulations will promote the formation of solidarity agreements between EU nations. Countries that do not currently have an agreement with another EU member state will be able to request assistance in times of need.
Moreover, the new rules establish a new pricing benchmark for liquefied natural gas transactions that will ensure stable and predictable pricing, which complements the existing Title Transfer

Facility (TTF). The measures were officially endorsed during the Energy Council meeting held on December 19th, 2022.

2.3.4.1 Gas market measures to secure and share supply in the EU

EU nations are collaborating closely to counteract the effects of Russia's energy market conflict and decrease their reliance on external sources for energy. In September 2022, the percentage of pipeline gas imports from Russia, out of the total gas imports in the EU, dropped significantly from 41% in 2021 to 9%. To meet the EU's gas demand, the imports of liquefied natural gas (LNG) have risen and now account for 32% of all gas imports. EU gas storage facilities are filled to 94.8% (EU Council, November 2022)

Despite ongoing price fluctuations, EU nations have reached a consensus on the specifics of new measures that will bring them closer to achieving a more integrated energy market for gas within the EU.

i) Buying gas together

The unreliability of Russia as a gas supplier has compelled EU nations to seek alternative sources of gas supply for the future. By engaging in joint procurement at the EU level, member states can leverage their collective demand to secure gas at more favourable prices and avoid bidding against each other. **In practice:**

1. Gas companies in EU nations, as well as Energy Community partners such as Albania, Bosnia and Herzegovina, Kosovo, North Macedonia, Georgia, Moldova, Montenegro, Serbia, and Ukraine, produce projections for their gas import requirements.
2. The EU determines its total demand by consolidating individual demands, identifies the overall requirements, and procures supplies from suitable sources.
3. Companies have the option to opt-in to the joint EU purchasing platform for gas procurement. However, demand aggregation must cover a minimum of 15% of gas storage for each EU country as a mandatory requirement. Additionally, the joint purchasing of Russian gas is not permitted.

ii) Sharing supplies and facilities

Ensuring solidarity between EU nations is the most effective way to safeguard against supply shortages. The newly implemented regulations strengthen solidarity agreements between member states and guarantee that gas can be distributed to where it is required.

Currently, there are only six existing bilateral solidarity agreements between member states, which are Germany with Denmark, Finland with Estonia, Estonia with Latvia, Latvia with Lithuania, Germany with Austria, and Italy with Slovenia. However, as per the Security of Supply Regulation of 2017, up to 40 agreements are anticipated to be established.

In practice: the newly established regulations will become the default for countries that have no pre-existing solidarity agreement. These rules will include the provision that in the event of an EU country facing a supply emergency, another country will provide gas and receive just compensation. These regulations will also be extended to countries possessing LNG facilities that are not directly linked to the European gas grid. Furthermore, countries will be permitted to request solidarity from other nations if they lack the necessary supply to sustain their electricity systems. Additionally, under exceptional circumstances, countries may restrict non-essential gas consumption to guarantee the supply of essential services, with a particular emphasis on shielding vulnerable households.

2.3.5 Limiting price volatility

Gas prices remain too volatile on the markets. New measures limit price fluctuations and help keep prices down.

2.3.5.1 New benchmark for liquified natural gas

The TTF was designed for pipeline gas and therefore, is not suitable for serving as a benchmark for LNG prices. To address this issue, a new benchmark will be introduced that will not be reliant on the TTF and will more accurately reflect market realities.

Imports of LNG account for a substantial and increasing proportion of the EU's gas imports. In fact, imports from the United States have risen from 0.65 billion cubic meters in January 2021 to 4.63 bcm in August 2022

What is the TTF? – The title transfer facility is a virtual gas trading platform widely used for gas transactions in the EU, which serves as the main benchmark to define the price of gas. Groundwork will be done in the next months so that the new index will be available to the market by 31 March 2023. In addition, a new mechanism is introduced to limit intra-day volatility of gas prices in the TTF.

2.3.6 Cutting energy costs for households and businesses

In 2022, energy prices have reached unprecedented heights, largely due to Russia's unwarranted invasion of Ukraine and its manipulation of gas supplies as a tool of war.
The cost of gas, which is primarily imported, has a direct correlation with the wholesale price of electricity in the EU's domestic market. Russia's intentional curtailment of gas supplies has been the principal catalyst behind the recent surge in gas prices throughout the EU, impacting electricity prices as a result of the heightened cost of gas-fired power plant operations.

The price of energy is expected to continue to remain high in the EU in the coming months, as it takes time to replace Russian gas supplies with supplies from EU sources. EU countries have therefore adopted an emergency regulation to address high energy prices and help citizens and businesses that are most affected by the energy crisis.

Compared to the previous year, electricity rates for consumers in the EU have increased by 35%. Given the ongoing energy crisis, there is a pressing need for a united and immediate response from EU countries. To tackle high energy prices and supply insecurity, effective coordination and solidarity between countries will be crucial. In this vein, the introduction of new emergency measures will permit member states to alleviate the financial strain on the most vulnerable households and companies by reducing energy expenses.

2.2.6 Securing a solidarity contribution from fossil fuel businesses

The surge in energy prices has led to increased profits for companies in the fossil fuel industry. The proposed measure seeks to ensure that these firms assume their fair share of the responsibility to assist individuals and businesses who are grappling with the cost of their energy bills. This contribution is expected to be derived from the profits earned by these companies, specifically those that have risen by more than 20% in comparison to their average profits over the previous four years. The new measure will be applicable to businesses operating within the petroleum, gas, coal, and refinery sectors. This measure will supplement the revenue ceiling for select electricity producers. EU member states will be responsible for collecting revenue, which will then be disbursed to families and companies - particularly those experiencing the most significant financial burden from high energy expenses. They also have the option to show solidarity by contributing a portion of the generated revenue to finance EU measures aimed at alleviating the energy crisis. (European Union Council, 2023)

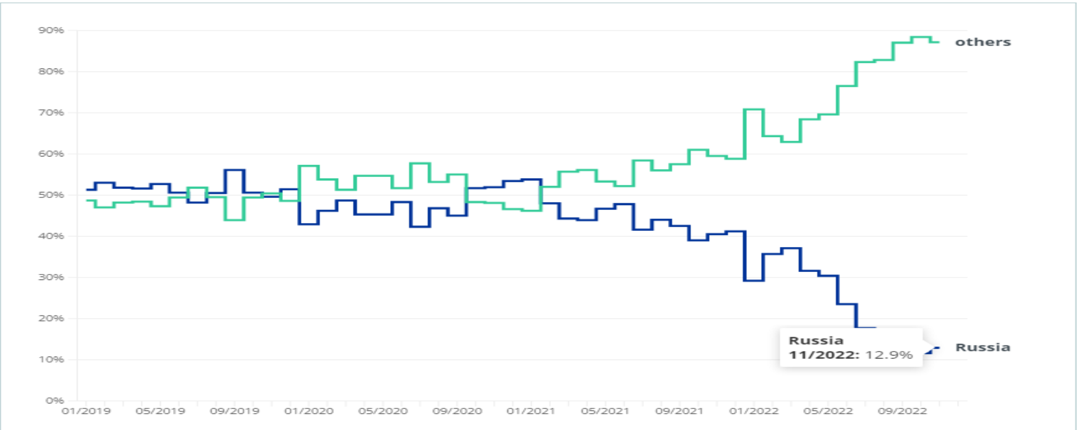
2.4 WHERE DOES THE EU’S GAS COME FROM?

Although the EU continues to rely on the importation of fossil fuels, it has been actively seeking to diversify its gas suppliers. The unprovoked and unwarranted invasion of Ukraine by Russia, and their use of energy as a weapon, has increased the EU's prioritization of supply diversification. Despite being a time-consuming and expensive undertaking that necessitates the development of new infrastructure such as pipelines and LNG terminals, the fruits of these efforts are already apparent.

2.4.1 The EU's gas supply

During 2021, the EU sourced 83% of its natural gas through imports. Following Russia's incursion into Ukraine, gas imports from Russia to the EU have experienced a notable decline. To compensate for this reduction, the EU has primarily relied on a substantial increase in liquified natural gas (LNG) imports, with a particular emphasis on supplies from the US.

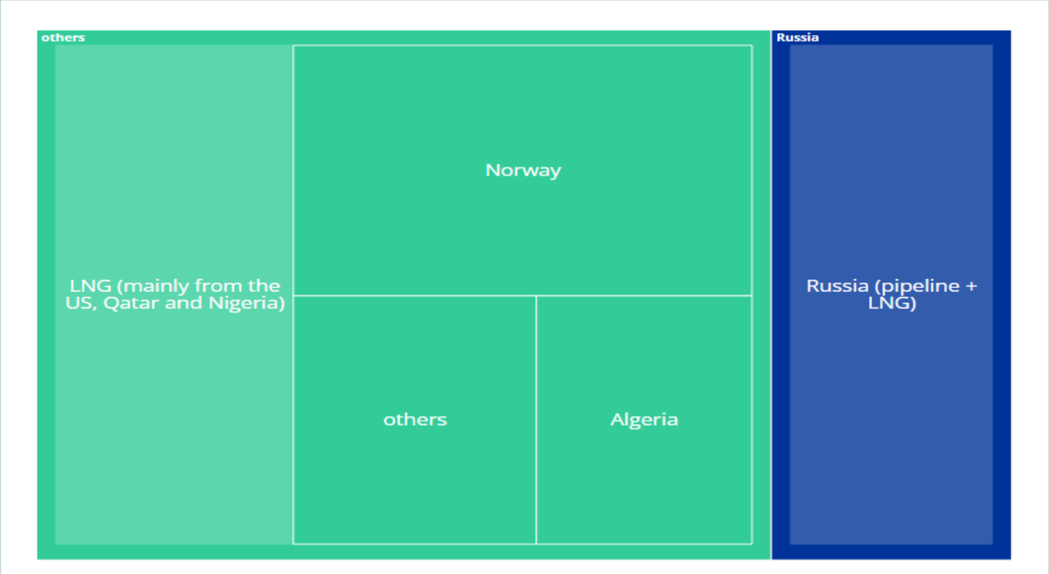
2.4.2 The EU's diversification away from Russian gas



Source: European Commission
Chart showing the monthly share of gas delivered to the EU by Russia compared with other countries between January 2019 and November 2022.

Until the latter half of 2021, Russia accounted for approximately 50% of the market share. However, since then, the proportion of Russian gas has sharply declined, resulting in the growth of other suppliers' market shares. This process accelerated significantly in 2022, particularly since June, when Russia's share of EU gas imports dropped to under 20%. As of November, their share stood at 12.9%. From January to November 2022, less than a quarter of the EU's gas imports (combining pipeline gas and LNG imports) were sourced from Russia. In contrast, a quarter of the EU's gas imports came from Norway, and 11.6% originated from Algeria. LNG imports, excluding those from Russia (primarily from the US, Qatar, and Nigeria), accounted for 25.7% of the EU's gas imports.

2.4.3 Gas import sources (January-November 2022)



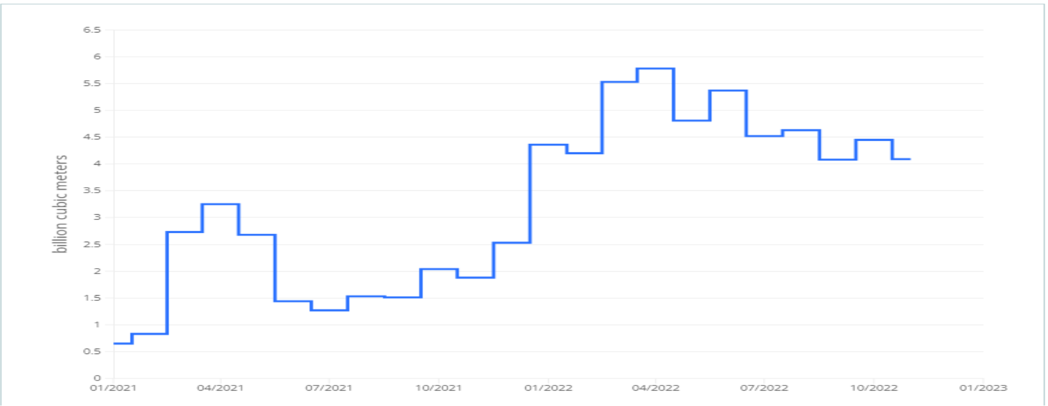
Source: European Commission
Area chart showing market shares and values for various suppliers of gas to the EU between January and November 2022.

- Russia (pipeline + LNG): 24.65%, 803.8 TWh
- LNG (mainly from the US, Qatar and Nigeria): 25.7%, 838.8 TWh
- Norway: 24.9%, 812.9 TWh

- Algeria: 11.6%, 378.8 TWh
- others: 13%, 426.9 TWh

Between January and November 2022, LNG imports from the US accounted for over 50 bcm (billion cubic meters). This is more than twice as much as in the whole of 2021 (over 22 bcm).

2.4.4 Monthly volumes of LNG imports from the US to the EU



Source: European Commission

Step line chart showing monthly imports of LNG from the US to the EU between January 2021 and November 2022. In 2021, imports varied from less than 1 billion cubic meters (bcm) per month in January and February to a peak of over 3 bcm in April. Between July and December 2021, imports grew from 1.27 bcm to 2.53 bcm. Imports significantly increased in 2022, starting at around 4 bcm in January and February and reaching 5.87 bcm in April and 5.37 in June. Between July and November, monthly imports varied at around 4 bcm.

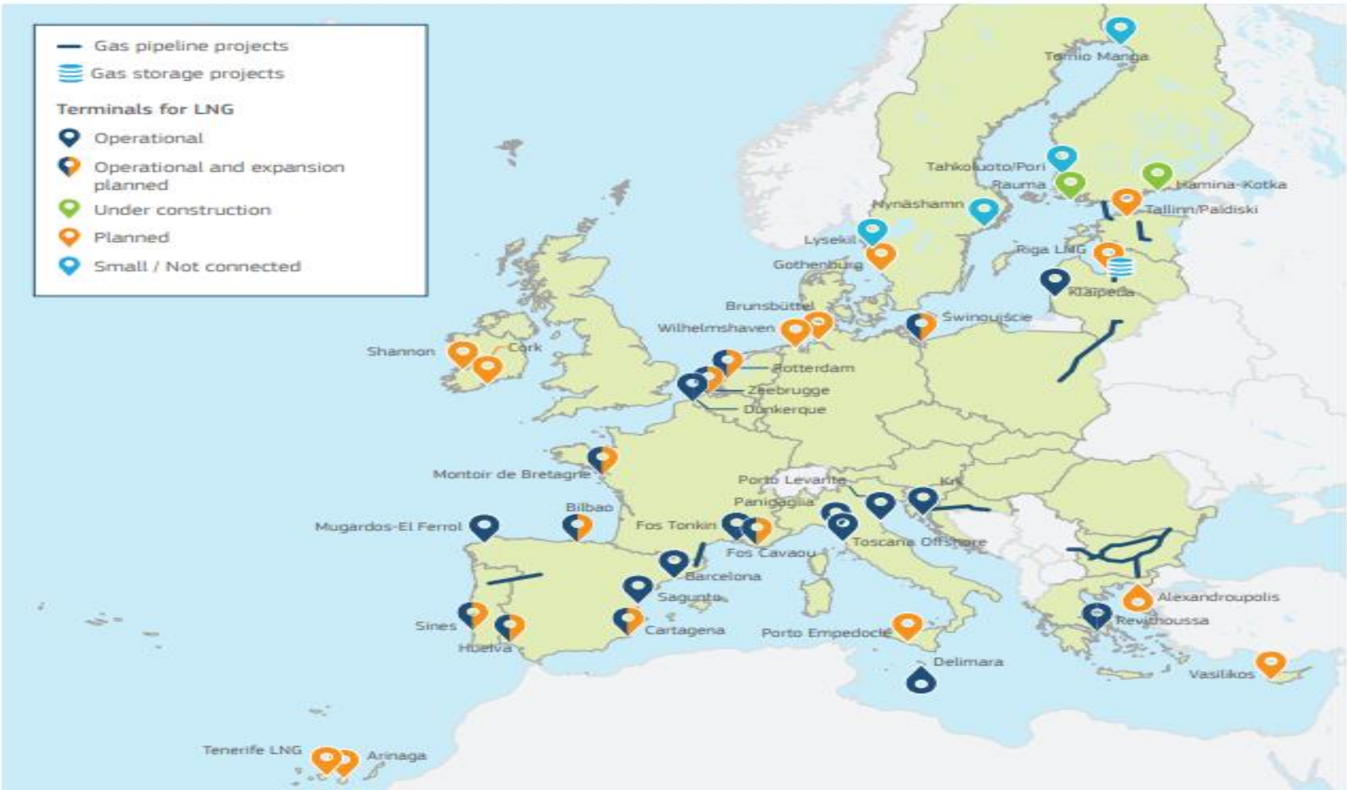
2.4.6 Liquefied natural gas infrastructure in the EU

Importation of liquefied natural gas (LNG) provides a means for the EU to broaden its natural gas suppliers and transportation pathways, with its significance becoming more pronounced in light of Russia's invasion of Ukraine and the EU's commitment to lessening its reliance on Russian gas imports. As the world's biggest LNG importer, the EU procured more than 65 billion cubic meters (bcm) of LNG, valued at over €60 billion, in the first half of 2022. Among EU nations, France ranked as the biggest importer of LNG, followed by Spain and Belgium.

During the first half of 2022, the US was the most extensive supplier of LNG to the EU, constituting nearly 50% of the total imports. When compared to the previous year, the imports of

LNG from the US more than doubled. The EU has a considerable capacity for importing LNG (approximately 157 bcm in regasified form per year), which is sufficient to fulfill approximately 40% of the total gas demand. However, the availability of LNG infrastructure varies across EU nations. In light of Russia's military intervention in Ukraine and the weaponization of gas supplies, member states of the EU have been incentivized to expand their LNG infrastructure further. Some planned investments have been categorized as EU Projects of Common Interest, which allow for simplified procedures and, in some cases, co-financing through the Connecting Europe Facility.

LNG infrastructure in the EU



The map shows LNG terminals in the EU member states that are currently operational, due for further expansion, under construction or at the planning stage. Spain, France, Italy, Portugal, Belgium, the Netherlands, Croatia, Poland, Greece and Lithuania all have operational LNG terminals. There are over a dozen planned LNG terminals across the EU and a few are currently under construction.

This data comes from the European Commission and Gas Infrastructure Europe.

Enhancing the EU's energy resilience and independence, especially in the face of potential energy scarcities, can be achieved by decreasing reliance on Russian fuel sources. Additionally, this reduction presents an opportunity to accelerate the transition towards renewable energy sources. As a response to the leaders' request for a plan to enforce their decision on Russian imports, the Commission unveiled the REPowerEU strategy in May 2022. Under this plan, the EU has created the voluntary EU Energy Platform, which aids in the collective procurement of energy for all EU nations and some European partners. The EU has reached fresh energy supply arrangements with several international partners, including:

- Increased LNG deliveries to the EU from the United States and Canada.
- Greater gas provision from Norway.
- Increased collaboration with Azerbaijan.
- Future gas deliveries are expected from Israel and Egypt.

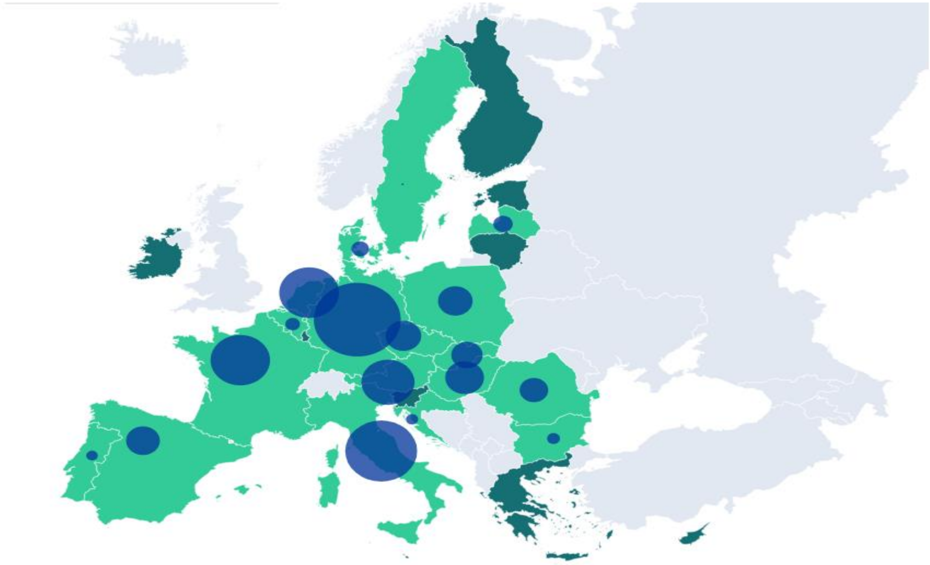
2.4.7 SECURING GAS SUPPLY

2.4.7.1 How much gas have the EU countries stored?

Russia's military intervention in Ukraine has led to a surge in energy prices and has had a significant impact on the EU's energy supply. Protecting citizens from the increased energy costs and ensuring a stable energy supply are top priorities for EU leaders. To address these issues, EU countries have agreed to increase gas reserves in the near term to guarantee an adequate supply for Europeans. In June 2022, the Council adopted a regulation to ensure that storage capacities in the Union are consistently filled prior to the colder months and can be collectively shared across the Union in the spirit of solidarity.

The newly established regulation stipulates that countries without storage facilities must store 15% of their annual domestic gas consumption in stocks situated in other member states, providing them with access to the gas reserves stored in those countries. This approach enhances the security of the EU's gas supply while also distributing the cost of filling the EU's storage capacity among member states. To guarantee their reserves, member states with limited storage capabilities will cooperate with those that possess larger facilities.

2.4.7.2 Gas storage capacity and filling level in the EU member states



Green: having storage capacity
Blue: no storage capacity but solidarity arrangements with other member states.

Source: [Gas Infrastructure Europe]

The chart shows the gas storage capacity, amount of gas in storage and filling level for each EU member state as of 18 January 2023. Germany, France, Italy and the Netherlands are the countries with the largest storage capacity. Cyprus, Estonia, Finland, Greece, Ireland, Lithuania, Luxembourg, Malta and Slovenia do not have gas storage facilities. However, under the new EU regulation they will need to make solidarity arrangements with other member states in order to secure their gas reserves. With the delivery of gas supplies becoming increasingly unpredictable due to Russia suspending delivery to several EU nations, the Council has taken urgent action to:

- Guarantee a secure gas supply for the winter season.
- Decrease the demand for gas within the EU.

In June 2022, the Council passed a new regulation concerning gas storage, which intends to ensure that storage facilities are filled prior to the colder months. Underground gas storage facilities on member states' territories must be filled to at least 80% of their capacity by November 1, 2022, and to 90% in the following winters.

The new rules will also establish solidarity agreements between member states to provide assistance to countries without gas storage facilities on their territory. Such nations will be required to store 15% of their annual domestic gas consumption in stocks located within another member state. Additionally, the regulation mandates that all underground gas storage site operators must possess compulsory certification to mitigate the risk of external interference.

3 PREVIOUS RESEARCH ON THE IMPACT OF GEOPOLITICAL EVENTS ON GLOBAL ENERGY MARKETS

The impact of geopolitical events on global energy markets has been a topic of significant interest and research in recent years. In this chapter, we will examine the various theories and models that have been proposed to understand this complex relationship. We will also provide a comprehensive review of existing research on the subject, including the key findings and limitations of each study. By delving into the existing literature, this chapter aims to provide a thorough understanding of the impact of geopolitical events on global energy markets, as well as the state of current research in this field.

3.1 Theories and models relating to geopolitical events

Geopolitical events, such as the Russian invasion of Ukraine, can have significant impacts on energy markets. There are several theories and models that relate geopolitical events to energy markets. Some of the main theories and models are:

1. The Resource Curse Theory: This theory suggests that countries that are rich in natural resources, including energy resources, are more likely to experience political instability and conflict. The idea is that the abundance of natural resources can create economic distortions, fuel corruption, and concentrate power in the hands of a few, leading to social unrest and conflict. For instance, in the context of the Russian invasion of Ukraine, this theory could help explain the historical dependence of some EU countries on Russian gas supplies and the potential vulnerability of these countries to geopolitical shocks that affect energy trade. (Auty, R. M. 1993)

2. Political Business Cycle Model: This model suggests that politicians may manipulate energy prices in order to gain political support and win elections, which could have implications for energy markets. The idea is that politicians may delay energy price hikes before elections or reduce them to bolster their popularity, leading to imbalances in supply and demand that can affect prices and market stability. In the context of the Russian invasion of Ukraine, this theory could help explain why some European countries were reluctant to impose sanctions on Russia or reduce their gas imports from Russia, despite political pressure to do so. (Nordhaus, W. D. 1975)

3. The Transit State Theory: This theory focuses on the role of transit states, which are countries that serve as transit routes for energy exports from one country to another, and how they can exert significant political influence over energy markets. The idea is that transit states can use their strategic location to extract rent from energy trade or to leverage their influence over energy flows to advance their political goals. This theory could help explain why some transit countries, such as Ukraine and Belarus, have been subject to frequent energy disputes with Russia and how these disputes have affected the wider energy markets in Europe. (Behrens, A., & Masten, S. 2018)

4. Geopolitical Risk Model: This model focuses on the impact of geopolitical events, such as wars, sanctions, and political instability, on energy markets, including potential supply disruptions, price volatility, and changes in trade patterns. The idea is that geopolitical risks can create uncertainty and affect energy trade and investment decisions, leading to market imbalances and higher risk premiums. This theory could help explain why some energy companies and investors are more cautious about investing in Russia or Ukraine, and how this affects the overall energy security of the EU. (Caldara, 2018)

3.2 Review of Existing Research

Fen Li et al (2021) conducted a study utilizing a fixed-effect model and regression discontinuity model to examine the negative impact of geopolitics on energy trade. They also analysed the mechanism and heterogeneity of this impact. Their findings demonstrate that geopolitics has a significant negative effect on both import and export of energy trade, with a greater inhibition observed in the export sector. Moreover, the study shows that the negative impact of geopolitics on energy trade persists even after ten months, and its impact mechanism is reflected in the lagging effect and mediating effect on the imports and exports. The study also identified that coal and crude oil prices, as mediating variables, decreased to reduce the imports and exports, while natural gas prices showed an increase. Finally, the research reveals that the impact of geopolitics on energy trade is heterogeneous in terms of national attribute characteristics and geo-event types.

By conducting a study that demonstrated the negative impact of economic policy uncertainty on aggregate demand, specifically in response to an oil price shock, Antonakakis et al. (2017) found high risks associated with the energy supply could cause a stagnation of national energy production and supply, which may lead to insufficient energy supply to meet domestic demand and foreign exports, as seen in instances like the Iran-Iraq War and the Ukraine crisis. However, the global oil production's supply side shock did not have a significant influence on the United States' economic policy uncertainty.

By employing a gravity model to investigate the impact of political stability on liquefied natural gas (LNG) imports, Zhang et al. (2021) indicated that countries tend to import LNG from regions with a more stable political environment. This could be due to their desire to ensure a secure energy supply. The importance of energy security is also highlighted in the context of oil imports, as many oil exporting countries are known for their high levels of political instability. Furthermore, political risks can have a far-reaching impact on global energy trade by affecting energy transport, investment, and pricing, among other related factors.

Simonia and Torkunov conducted research on frontier and emerging countries and observed that the impact of geopolitical risks on energy trade varied among countries based on their level of interest correlation. They highlighted geopolitics as the primary factor affecting global energy industry pricing, with the United States serving as the main source of turbulence. Meanwhile, the members of the Three Seas Initiative aim to decrease their reliance on natural gas from Russia and Ukraine. Oral and Ozdemir (2015) stated that Turkey, given its location near 70% of the world's oil and gas reserves, should strive to become the hub of global energy trade in the context of energy geopolitics.

3.3 SHOCKS IN ENERGY PRODUCTS

The world's economies have faced significant supply shocks, particularly the sudden and sharp rise in the prices of oil and other energy products. Oil price shocks are given considerable attention due to their potential impact on macroeconomic factors. Several studies (e.g., Carruth et al., 1998; Davis and Haltiwanger, 2001) have linked these shocks to a rise in the natural rate of unemployment, a decrease in irreversible investment due to increased uncertainty (Ferderer, 1996), and a reduction in the impact of technology shocks on the real business cycle (Davis, 1986). From a theoretical perspective, there are various explanations as to how an energy shock could impact macroeconomic factors. Some of these explanations consider a non-linear correlation between energy prices and the macroeconomy. For instance, an increase in oil prices may result in a decrease in overall demand as income is redistributed between countries that import and export oil. Additionally, the increase in energy prices may lead to a reduction in aggregate supply as firms buy less energy. This decline in productivity of labor and capital can lead to a decrease in economic output. If workers voluntarily withdraw their labor, then the potential output may further decrease, compounding the direct effect of lower productivity.

Several studies have demonstrated that oil price shocks have an impact on both output and inflation, as noted by various researchers including Hamilton (1983, 1996), Hooker (1996), and Mork (1989) among others. Over the past thirty years, these energy price fluctuations have played a significant role in economic fluctuations, as noted by Kim and Loungani (1992). These studies have also investigated whether there is a link between oil price shocks and their effect on the US economy. These studies suggest that increases in oil prices are a contributing factor in causing US economic downturns. However, the impact of an increase in oil prices on the economy appears to have diminished since 1973, with a smaller macroeconomic effect than the same magnitude of increase would have had before that year.

A rise in oil prices can lead to an increase in production cost, which is offset by a decrease in resource allocation cost. On the other hand, when oil prices fall, the cost of production reduces. These two forces have a significant impact on the GDP. Mory (1993) employs the same measures used by Mork (1989) and finds that positive oil price shocks are a cause of macroeconomic variables. Additionally, Mork et al. (1994) confirm that inflation caused by an oil price shock reduces real balances. One of the areas that have attracted resaerchers is the correlation between oil price shocks and stock returns. Sadorsky (1999) examines this correlation using a four-variable VAR model. The findings reveal that oil price fluctuations can account for a larger portion of the forecast error variance of stock returns than interest rates.

Davis (1986) presents distinct time trends before and after 1974 in his unemployment equations. The findings suggest that the estimated time trend coefficients are minor and frequently statistically insignificant, with most of the upward trends in unemployment over the analyzed period. Carruth et al. (1998) demonstrate an asymmetric correlation between unemployment, real interest rates, and oil prices, stating that a rise in oil prices causes a more significant decline in employment growth than a decrease in oil prices causes an increase in employment growth. Davis and Haltiwanger (2001) examine how oil price movements influence the unemployment rate over time using structural VAR models, where oil prices are measured by a weighted average of real oil prices. Their findings reveal that an oil price shock can explain 25% of the cyclical variability in employment growth from 1972 to 1988. Additionally, Lardic and Mignon (2008) demonstrate that a long-lasting increase in oil prices can alter production structures and have an impact on unemployment.

The above studies provided reference experience and ideas for this research. The use of the Error Correction Model (ECM) and Vector Autoregression (VAR) models in this research on the impact of the war in Ukraine on European energy markets is justified for several reasons. First, both models are widely used in the existing literature on this topic and have been shown to be effective in modeling the complex relationships between various economic and geopolitical variables. The ECM, in particular, is well-suited for analyzing long-term relationships and adjustments in response to shocks, which is relevant for studying the impact of geopolitical events on global energy markets. Second, the VAR model is useful for capturing the dynamic interactions between multiple variables, which is necessary for understanding the complex relationships between geopolitical events and energy markets. By using the VAR model, I can analyze the impact of multiple variables simultaneously and capture the feedback loops and spillover effects between different energy markets and geopolitical events. Overall, the ECM and VAR models are well-established and effective tools for analyzing the impact of geopolitical events on global energy markets.

The previous research reviewed in this chapter highlights the significant impact that geopolitical shocks can have on the energy sector. The next chapter details the data and methodology of this research.

4. METHODOLOGY AND DATA

The research sample here contains time series datasets for three energy prices and six macroeconomic variables. The price of oil is proxied by the **Brent crude oil spot price index.** The price of natural gas (gas) is proxied by the **Henry Hub Natural Gas Spot Price** The price of coal (coal) is proxied by the **Newcastle Coal Futures** spot price index. Following Sadorsky (1999), our macroeconomic variables include the industrial production index, stock prices, short term interest rate, unemployment rate, exports, and imports. The industrial production index represents the level of output produced within an economy in a given year. The short-term interest rate is the rate at which short-term borrowings are affected between financial institutions or the rate at which short-term government paper is issued or traded in the market. Short-term interest rates are generally averages of daily rates, measured as a percentage. To test the impacts of energy price changes on the labour market, the unemployment rate is treated as a desirable proxy. The unemployed are people of working age who are without work, are available for work, and have taken specific steps to find work. The uniform application of this definition results in estimates of unemployment rates that are more internationally comparable than estimates based on national definitions of unemployment. This indicator is measured in numbers of unemployed people as a percentage of the labour force and it is seasonally adjusted. The labour force is defined as the total number of unemployed people plus those in employment. Data are based on labour force surveys (LFS). For European Union countries where monthly LFS information is not available, the monthly unemployed figures are estimated by Eurostat. All monthly variables incur a seasonal adjustment before the analysis.

All data used in this study are monthly frequencies. The raw data are available with the same time period: January 2021 to February 2023. The natural gas price data are obtained from the Federal Reserve Bank of St. Louis; Economic data. The data on the price of coal (Newcastle Coal Futures) is got from investing.com while the data on the macroeconomic variables is obtained from The Organization for Economic Cooperation and Development database.

Definitions of variables

Variables	*Definition of variables*	*Sources*
oil	Logarithmic transformation of the monthly real West Texas Intermediate crude oil spot price index in US dollars (in 2006 prices)	Federal Reserve Bank of St. Louis
gas	Logarithmic transformation of the monthly real Russian Federation natural gas spot price index in US dollars (in 2006 prices)	Federal Reserve Bank of St. Louis
coal	Logarithmic transformation of the monthly real Australia coal spot price index in US dollars (in 2006 prices)	Investing.com
y	Logarithmic transformation of the monthly real industrial production index in NT dollars (in 2006 prices)	OECD (Organisation for Economic Cooperation and Development) database
sp	Logarithmic transformation of monthly real stock prices in NT dollars (in 2006 prices)	OECD (Organisation for Economic Cooperation and Development) database
un	Monthly unemployment rate	OECD (Organisation for Economic Cooperation and Development) database
r	Monthly interest rate	OECD (Organisation for Economic Cooperation and Development) database
ex	Logarithmic transformation of monthly real exports in NT dollars (in 2006 prices)	OECD (Organisation for Economic Cooperation and Development) database
im	Logarithmic transformation of monthly real imports in millions of NT dollars (in 2006 prices)	OECD (Organisation for Economic Cooperation and Development) database

4.1 Theoretical Model

Choosing Henry Hub Natural gas as my dependent variable from the three energy variables so as to demonstrate the theory underlying the model, the identified model is a three variable model which hypothesizes the Henry Hub natural gas as a function of all the six macroeconomic variables.

$LogHenryHub_t$ = F ($LogExp_t$, $LogImp_t$, $LogIndpi_t \ldots\ldots$)   (1)

4.1.1 Stationary Test:

Stationary Test: Stationarity of a series is an important phenomenon because it can influence its behaviour. If x and y series are non-stationary random processes(integrated), then modelling the x and y relationship as in equation 2 will only generate a spurious regression.

$Y_t = \alpha + \beta X_t + \varepsilon_t$ (2)

Time series stationarity is the statistical characteristics of a series such as its mean and variance over time. If both are constant over time, then the series is said to be a stationary process (i.e., Is not a random walk/has no unit root). Differencing a series using differencing operations produces other sets of observations such as the first-differenced values, the second-differenced values and so on.

x level x_t
x level x_t-x_{t-1}
x 1^{st}-differenced value x_t-x_{t-2} (3)

If a series is stationary without any differencing, it is designated as I (0), or integrated of order 0. On the other hand, series that have stationary first differences are designated I (1) or integrated of order one. Augmented Dickey Fuller test suggested by Phillips-Peron has been used to test the stationarity of the variables.

4.1.2 Engel and Granger Cointegration test: The procedure uses two tests to determine the number of cointegration vectors: the Maximum Eigenvalue test and the Trace test. The Maximum Eigen value statistic tests the null hypothesis of r cointegrating relations against the alternative r+ 1 cointegrating relations for r+0, 1, 2…n-1. This test statistics are computed as;

$$LR_{\max}(r/n+1) = -T * \log(1-\hat{\lambda}) \qquad (4)$$

Where λ is the Maximum Eigenvalue and T is the sample size. Trace statistics investigate the null hypothesis of r cointegrating relations against the alternative of n cointegrating relations, where n is the number of variables in the system for r = 0, 1, 2.n-1. Its equation is computed according to the following formula:

$$LR_{tr}(r/n) = -T * \sum_{i=r+1}^{n} \log(1-\hat{\lambda}_i) \qquad (5)$$

In some cases, Trace and Maximum Eigenvalue statistics yield different results.

4.1.3 Vector Error Correction Model (VECM): If cointegration has been detected between series, we know there exists a long-term equilibrium relationship between them so we apply VECM in order to evaluate the short run properties of the cointegrated series. In case of no cointegration, VECM is no longer required and we proceed with a VAR model estimation. The regression form for VECM is as follows:

$$\Delta Y_t = \alpha_1 + p_1 e_1 + \sum_{i=0}^{n} \beta_i \, \Delta Y_{t-i} + \sum_{i=0}^{n} \delta_i \, \Delta X_{t-i} + \sum_{i=0}^{n} \gamma_i \, Z_{t-i}$$

$$\Delta Y_t = \alpha_2 + p_2 e_2 + \sum_{i=0}^{n} \beta_i \, Y_{t-i} + \sum_{i=0}^{n} \delta_i \, \Delta X_{t-i} + \sum_{i=0}^{n} \gamma_i \, Z_{t-i} \qquad (6)$$

In VECM, the cointegration rank shows the number of cointegrating vectors. For instance, a rank of two indicates two linearly independent combinations of the non-stationary variables will be stationary. A negative and significant coefficient of the ECM (i.e., e_{t-1} in the above equation) indicates that any short-term fluctuations between the independent variables and the dependent variable will give rise to a stable long run relationship between the variables.

4.1.4 Granger-Causality: A general specification of the Granger causality test in a bivariate (X, Y) context can be expressed as:

$$Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \ldots\ldots\ldots + \alpha_i Y_{t-i} + \beta_1 X_{t-1} + \beta_i X_{t-i} + \mu$$

$$X_t = \alpha_0 + \alpha_1 X_{t-1} + \ldots\ldots\ldots + \alpha_i X_{t-i} + \beta_1 Y_{t-1} + \beta_i Y_{t-i} + \mu$$

In the model, the subscripts denote time periods and µ is a white noise error. The constant parameter "0 represents the constant growth rate of Y in the equation 7 and X in the equation 8 and thus the trend in these variables can be interpreted as general movements of cointegration between X and Y that follows the unit root process. We can obtain two tests from this analysis: the first examines the null hypothesis that the X does not Granger-cause Y and the second test examines the null hypothesis that the Y does not Granger-cause X. If we fail to reject the former null hypothesis and reject the latter, then we conclude that X changes are Granger-caused by a change in Y. Unidirectional causality will occur between two variables if either null hypothesis of equation (7) or (8) is rejected. Bidirectional causality exists if both null hypotheses are rejected and no causality exists if neither null hypothesis of equation (7) nor (8) is rejected.

VECM estimation is used when there is cointegration among the variables in the system. This technique enables the estimation of both short-term and long-term coefficients. Through VECM, we can examine the long-term equilibrium relationships among the variables as well as the short-term deviations from that equilibrium. Furthermore, the adjustment coefficients provide insights into the correction of short-term deviations or disequilibrium.

4.2 RESULTS

The correlations between the energy prices and the macroeconomic variables are shown in correlation matrix in table 1(b). Brent crude oil has a strong negative correlation with unemployment rate (-0.83), a weak positive correlation with short term interest rates (0.2), a weak negative correlation with share price (-0.3), a moderate positive correlation with the industrial production index (0.63), and strong positive correlations with exports (0.77) and imports (0.82). This suggests that an increase in Brent crude oil prices is associated with a decrease in unemployment rates, but an increase in short term interest rates. The increase in Brent crude oil prices is also associated with a decrease in share prices, but an increase in industrial production and trade through exports and imports.

Newcastle coal futures have a negative strong correlation with unemployment rate (r = -0.89). This suggests that as Newcastle coal futures prices increase, the unemployment rate tends to decrease in the eurozone countries, a positive moderate correlation with short-term interest rates (r = 0.6) which suggests that as Newcastle coal futures prices increase, short-term interest rates also tend to increase. There is a negative moderate correlation with share prices (r = -0.5). This suggests that as Newcastle coal futures prices increase, share prices tend to decrease. A strong positive correlation with the industrial production index (r = 0.74) suggests that as Newcastle coal futures prices increase, the industrial production index tends to increase in these countries. Newcastle coal futures also have a strong positive correlation with the value of exports (r = 0.83). This suggests that as Newcastle coal futures prices increase, the value of exports tends to increase in the eurozone countries. They have a very strong positive correlation with the value of imports (r = 0.92). This suggests that as Newcastle coal futures prices increase, the value of imports tends to increase in the eurozone countries.

Similarly, the correlation between Henry Hub natural gas and the macroeconomic variables are: Henry Hub natural gas has a negative strong correlation with unemployment rate (r = -0.7). This suggests that as Henry Hub natural gas prices increase, the unemployment rate tends to decrease in the eurozone countries. A positive moderate correlation with short-term interest rates (r = 0.3) suggests that as Henry Hub natural gas prices increase, short-term interest rates also tend to increase in the eurozone countries. Henry Hub natural gas has a negative moderate correlation with share prices (r = -0.5). This suggests that as Henry Hub natural gas prices increase, share prices tend to decrease in the eurozone countries, has a moderate positive correlation with the industrial production index (r = 0.5). This means that as Henry Hub natural gas prices increase, the industrial production index tends to increase in the eurozone countries. Henry Hub natural gas has a strong positive correlation with the value of exports (r = 0.7). This suggests that as Henry Hub natural gas prices increase, the value of exports tends to increase in the eurozone countries. Henry Hub natural gas has a strong positive correlation with the value of imports (r = 0.7). This suggests that as Henry Hub natural gas prices increase, the value of imports tends to increase in the eurozone countries.

4.2.1 Newcastle coal futures

Using the Akaike and Schwarz Information Criteria, the optimum lag is found to be one. From the estimation output of the Granger Causality tests in table 2, we reject the null hypotheses if the probability is less than the 5% level of significance. The output suggests that the Newcastle Coal Futures granger cause industrial production index, exportations and short-term interest rates. This means that the past values of Newcastle Coal future have an effect on these variables according to the Granger causality tests. The Granger causality test is widely used in econometrics and other fields to study causal relationships between variables. However, it is important to note that the Granger causality test can only establish correlation, and not necessarily causation, between two time series. It is also sensitive to model specification and may produce spurious results if not used appropriately. In order to determine the effect of different energy shocks, it’s important to include all the variables in the model irrespective the results of the Granger causality tests.

After estimating the long run equilibrium model, the short-term interest rates are not found to be significant. Table 3 shows the cointegration test. Using the Engel and Granger Cointegration tests, the probabilities are found to be greater than 5% suggesting we accept the null hypothesis; The series are not cointegrated i.e. There is no stable long-term equilibrium relationship between the series. In other words, the series do not move together in the long run. The lack of cointegration does not necessarily mean that the series are not related or that one does not cause the other, but rather that they do not have a stable long-term relationship.

Since there is no evidence of cointegration between the series, we cannot continue with the Vector Error Correction model. (Khalid et al., 2020) We therefore employ a VAR model. In the VAR model, I’ve included all the variables in my research much as the granger causality tests only verified the use of three variables. The aim in doing this is to capture the shocks in these variables due to the Newcastle coal futures and not to necessarily determine causality. The VAR results show that the past values of Newcastle Coal futures have a causal effect on their own current values and exports using a lag of 1 according to Akaike and Schwarz.

MODEL DIAGNOSTICS:

The Var model is diagnosed for stability and all the roots are found to lie within the circle. (Figure 10) This indicates that the model is stable and that the shocks of the Newcastle coal futures to these variables will eventually die out. (Sims, 1980). This is desirable because it means that the variables in the model are not experiencing explosive or erratic behaviour, and the model can be used to make reliable forecasts of the variables' future values.

Autocorrelation tests: The model is found to have serial correlation after performing residual tests. (Figure 11) To solve for this, the logarithm of Newcastle Coal futures lagged by 1 is added to the independent variables and the mode is re-estimated. The resulting output shows absence of autocorrelation:

4.2.2 BRENT CRUDE OIL.

Following the Granger Pairwise causality tests, Brent crude oil granger causes exports, industrial price index, share price and short-term interest rates using a lag of 1 according to Akaike and Schwarz. (Table 5) As mentioned earlier, the variables will still be included in the VAR model for the reasons mentioned earlier. A long run model is estimated using Ordinary least squares method and the variables are found to be significant apart from the industrial price index. A second model is re-estimated excluding this variable and the residues are generated.

On testing for cointegration, the null Hypothesis is rejected as the probabilities are found to be less than 5% hence there is evidence of cointegration. (Table 8) The generated residues from the long run model are used to estimate the short run model. (Table 6) The error correction term is found to be negative and significant. (Table 9) On performing the normality tests, the probability of the Jaque Bera Statistic is found to be greater than the 5% level of significance indicating the residues are normally distributed. (Table 13) The model is also corrected for serial correlation. (Figure 14) The roots of the polynomial are all found to lie within the circle suggesting the mode is stable.

The error correction term is found to be negative and significant. The error correction term (ECT) represents the short-run dynamics that adjust the variables in the model back to their long-run equilibrium relationship. The ECT captures the speed of adjustment of the variables in response to deviations from the long-run equilibrium. The significant negative error correction term of -1.94 suggests that the variables in the model will adjust downwards by 1.94 units in response to a one-unit positive deviation from the long-run equilibrium. Similarly, a one-unit negative deviation from the long-run equilibrium will result in an upward adjustment of 1.94 units. This adjustment occurs in the short run, indicating that the system will converge to its long-run equilibrium relationship over time.

4.2.3 HENRY HUB

Pairwise Granger Causality tests suggest that the logarithm of Henry hub natural gas index granger causes the logarithm of exports, industrial price index and share price. (Table 14) This means that the natural gas index has predictive power over these three variables. Because the goal of the research is to determine how energy affects macroeconomic variables, all the other variables will be included so as to determine the shocks induced by natural gas.

On performing the Cointegration tests, the series are found to be cointegrated but the error term is found to be non-significant. This means we cannot apply the Vector Error correction model. A VAR model is estimated and all the roots are found to lie within the circle. (Table 15) The model diagnostics show absence of autocorrelation and the residues are found to certify the normality condition. (Figures 17 and 18)

4.3 IMPULSE RESPONSE FUNCTIONS (IRF):

The impulse response function (IRF) shows the response of one or more variables in a statistical model to a shock in another variable. The IRF can be used to interpret the dynamic effects of an innovation or unexpected change in one variable on the other variables in the model. (Baumeister and Kilian, 2015)

4.3.1 IRF OF NEWCASTLE COAL FUTURES

Figure 12 shows the impulse response functions from one-standard deviation shocks to industrial production, share prices, real interest rates, unemployment rates, exports, and imports. It can be seen that a coal price shock has an initial negative effect on industrial Price index but the shock dies out after four months, a negative impact on exportations that increased within the first three months but dies out after six months. The effect on share price is negative but dies out moderately. The coal price shock had an initial positive impact on imports that disappeared immediately and the effect became negative within the next three months but the impact decreased gradually and died out in the sixth month. The effect on short term interest rates is positive but moderately low and continues to die slowly but never reaches zero. The impact on unemployment is initially negative but becomes positive after three and half months after which it begins to die out and approaches zero.

4.3.2 IRF OF BRENT CRUDE OIL:

A one-unit price shock of Brent crude oil had a positive effect on exports within the first month but the effect became negative within a month and by the sixth month, the effect had begun to die out. The shock produced a weak positive effect that died out quickly on imports. The negative effect on the industrial price index was not felt in the first two months but after this, it increased rapidly to more than two standard deviations but died out within two months. The price shock of Brent crude oil had a negative impact on the share price but it started to die out after two months. The shock also had a negative effect on short term interest rates but the effect continues to die out slowly. The shock had a negative effect on unemployment within the first month but continued to decrease after which it remained stable for a while. As the war wages on, the shock is continuing to produce a negative effect on unemployment but moderately. (Figure 15)

4.3.3 IRF OF HENRY HUB NATURAL GAS INDEX

A one-unit price shock of henry hub natural gas has an initial negative impact on exports but the negative effect dies out quickly. The shock initially has no effect on imports but after two months, the shock produces a negative effect that dies out after four months. The shock produces a weak negative effect on industrial production index that continues to die out slowly. The initial shock on share price is negative and continues to worsen within the first two months but then dies out quickly. The effect on short term interest rates is positive. Its magnitude decays slowly but remains positive with time. The initial impact on unemployment rate is negative but die out immediately into positive and remains stable for a while. (Figure 19)

4.4 VARIANCE DECOMPOSITION (VD):

4.4.1 VD OF NEWCASTLE COAL FUTURES

The variance decomposition is useful for understanding the relative importance of the different shocks to the variability of the variables in the model. (Lutz Kilian and Jeremy Piger, 2014) It can help to identify which variables are driving the fluctuations in the system, and to assess the impact of different shocks on the economy.

The percentage of the logarithm of Newcastle Coal futures and industrial price index is between 0 and 9%. This means that the forecast error variance of the Henry Hub natural gas model is influenced by up to 9% from the logarithm of Newcastle Coal futures and industrial price index variables, between 0 and 6% for the logarithm of exports, between 0 and 1.6% for share price, between 0 8.9% for imports,0 and 3.2% for short term interest rates,0 and 1.19% for unemployment. (Table 4)

The higher the percentage, the more important the variable is in explaining the forecast error variance. Therefore, the industrial production index and imports are the most important in explaining the forecast error variance.

4.4.2 VD OF BRENT CRUDE OIL

According to the variance decomposition results in table 14, between 0 and 2% of the variance in Brent crude oil can be attributed to changes in exports. This means that changes in exports explain a very small portion of the overall variability in Brent crude oil, between 0 and 7.3% of the variance in Brent crude oil can be attributed to changes in imports. Changes in imports account for a slightly larger portion of the variability in Brent crude oil compared to exports, between 0 and 1.2% of the variance in Brent crude oil can be attributed to changes in the industrial price index indicating that changes in the industrial price index account for a very small portion of the overall variability in Brent crude oil, between 0 and 4.7% of the variance in Brent crude oil can be attributed to changes in share prices showing that changes in share prices explain a larger portion of the variability in Brent crude oil compared to exports, imports, and the industrial price index, between 0 and 3.9% of the variance in Brent crude oil can be attributed to changes in short-term interest rates. This means that changes in short-term interest rates account for a moderate portion of the overall variability in Brent crude oil. The variance decomposition results suggest that changes in unemployment explain only up to 0.07% of the variability in Brent crude oil suggesting that changes in unemployment account for a very small portion of the overall variability in Brent crude oil. The results suggest that changes in share prices and short-term interest rates may have a relatively greater impact on Brent crude oil compared to other variables in the model.

4.4.3 VD OF HENRY HUB NATURAL GAS.

According to the variance decomposition results in table 16, between 0 and 3.26% of the variance in the Henry Hub natural gas index can be attributed to changes in exports. This indicates that changes in exports explain a small portion of the overall variability in the Henry Hub natural gas index, between 0 and 9.4% of the variance in the Henry Hub natural gas index can be attributed to changes in imports indicating that changes in imports account for a relatively larger portion of the variability in the Henry Hub natural gas index compared to exports, between 0 and 10.13% of the variance in the Henry Hub natural gas index can be attributed to changes in the industrial production index. Changes in the industrial production index account for a relatively large portion of the overall variability in the Henry Hub natural gas index, between 0 and 1.95% of the variance in the Henry Hub natural gas index can be attributed to changes in share price. This means that changes in share price account for a relatively small portion of the overall variability in the Henry Hub natural gas index, between 0 and 4.2% of the variance in the Henry Hub natural gas index can be attributed to changes in short-term interest rates. Changes in short-term interest rates account for a moderate portion of the overall variability in the Henry Hub natural gas index. The variance decomposition results suggest that changes in unemployment explain only up to 0.28% of the variability in the Henry Hub natural gas index. This shows that changes in unemployment account for a very small portion of the overall variability in the Henry Hub natural gas index. The results suggest that changes in the industrial production index and imports may have a relatively greater impact on the variability in the Henry Hub natural gas index compared to other variables in the model.

In conclusion, this chapter examined the correlations between three major energy variables, namely Brent crude oil, Henry Hub natural gas, and Newcastle coal futures, and six macroeconomic variables, including unemployment, short-term interest rates, share price, industrial price index, imports, and exports. The analysis was carried out using Vector Error Correction Models (VECM) and Vector Autoregression (VAR) estimations, along with variance decompositions and impulse response functions.

The results of the study revealed significant correlations between the energy variables and the macroeconomic variables, highlighting the impact of changes in energy prices on the overall economy. Specifically, the study found that Brent crude oil, Henry Hub natural gas, and Newcastle coal futures were positively correlated with share price and industrial price index, while they were negatively correlated with unemployment, imports, and exports. Short-term interest rates showed mixed results with energy variables. The VECM and VAR estimations allowed for a better understanding of the dynamic relationships between the energy and macroeconomic variables. The variance decompositions and impulse response functions indicated that changes in energy prices have significant short-term and long-term effects on the macroeconomic variables, with varying magnitudes and durations. Overall, this chapter provides important insights into the complex interactions between energy prices and macroeconomic variables.

5. POLICY IMPLICATIONS AND DISCUSSION

The preceding chapters have examined the impact of various external shocks on the EU economy, with a particular focus on the effects of oil, natural gas, and coal price shocks. This chapter seeks to provide policy implications and discussion based on the findings presented in the previous sections. The aim is to identify potential policy measures that can be implemented to mitigate the negative effects of external shocks and promote economic stability and resilience. The chapter first provides a brief overview of the policy implications that arise from the analysis of each external shock before discussing the broader implications of the study's findings. The section concludes with recommendations for policymakers based on the analysis presented in this study.

5.1 NEWCASTLE COAL FUTURES

Policy implications derived from this study need to be clarified. In order to design an applicable energy price policy, we need to consider the asymmetric relationships between energy prices and the macroeconomy. As the impulse response function shows, a coal price shock has a negative impact on the industrial price index, exports, share price, imports, and employment. Hence, policies aimed at stabilizing coal prices can help reduce the negative impact on these variables.

The ongoing war in Europe has led to an increase in coal prices due to supply chain disruptions, and this has resulted in negative impacts on industrial price index, exports, share price, imports, and employment. In order to stabilize coal prices in Europe, policymakers can implement various policies, including:

1. Diversification of energy sources: One way to stabilize coal prices is by diversifying energy sources. This can be achieved by promoting the use of renewable energy sources such as wind and solar power, which are not affected by the war in Europe. The use of other fossil fuels such as natural gas can also be encouraged as a substitute for coal. A study by the National Renewable Energy Laboratory (NREL) found that "Wind and solar power can help reduce the need for conventional power sources such as coal, reducing price volatility and increasing energy security" (NREL, 2019)
2. Promoting energy efficiency: Another policy that can help stabilize coal prices is to promote energy efficiency. This can be achieved by implementing energy-saving policies such as building codes and standards that require buildings to be constructed in a way that

reduces energy consumption. This can help to reduce the demand for coal and hence the price. According to the International Energy Agency (IEA), energy efficiency measures can significantly reduce the demand for coal and other fossil fuels. IEA (2020) estimates that energy efficiency can contribute to about 40% of the cumulative CO2 emissions reductions needed by 2040 to meet global climate goals.

3. Increasing imports from non-conflict regions: Europe can also stabilize coal prices by increasing imports from non-conflict regions such as the United States, Canada, and Australia. This can help to diversify the sources of coal and reduce dependence on regions affected by the war.

The variance decomposition results suggest that the industrial production index has the highest influence on the forecast error variance of the model. Hence, policies aimed at promoting industrial production can help stabilize the energy market and reduce the impact of shocks on other variables. The results also suggest that imports have a significant influence on the forecast error variance of the model. Therefore, policies aimed at reducing dependence on imports and promoting domestic production can help reduce the impact of external shocks on the energy market.

According to the International Energy Agency (IEA), reducing dependence on energy imports and promoting domestic production can be achieved through several policies (IEA, 2022). One such policy is to provide subsidies or tax incentives to domestic producers to encourage them to increase production. This can be coupled with investment in research and development to improve the efficiency of domestic production processes and reduce costs (IEA, 2022).

The impulse response function shows that a coal price shock has a negative impact on short-term interest rates, albeit moderately low. Hence, policies aimed at stabilizing short-term interest rates can help reduce the negative impact of coal price shocks on the economy.

There are several policies that can be implemented to stabilize short-term interest rates and reduce the negative impact of coal price shocks on the economy:

1. Monetary Policy: Central banks have a variety of tools at their disposal to stabilize short-term interest rates. These tools include adjusting interest rates, open market operations, and reserve requirements. Through these measures, central banks can influence the supply of money and credit in the economy. By lowering interest rates, the central bank can encourage borrowing and spending, which can help stimulate economic growth and reduce the negative impact of coal price shocks on the economy (Bernanke and Gertler, 1995). However, the effectiveness of monetary policy may be limited in situations where interest rates are already low or where there are other structural impediments to borrowing and spending (Krugman, 2012).
2. Fiscal Policy: According to PwC, governments can use fiscal policy tools such as tax cuts, infrastructure spending, and direct investment to stimulate economic growth and reduce the negative impact of coal price shocks on the economy (PwC, 2021). For example, by increasing government spending, the government can create jobs and boost economic activity, which can help offset the negative impact of coal price shocks. Tax cuts can also encourage consumer spending and business investment, further boosting economic growth (PwC, 2021).
3. Strategic Stockpiling: Governments can use strategic stockpiling as a policy tool to stabilize coal prices and reduce their negative impact on the economy (Kwak et al., 2018). Strategic stockpiling involves maintaining reserves of energy resources such as coal that can be released into the market during periods of supply disruption or price volatility (Sioshansi, 2015). By doing so, governments can help stabilize short-term interest rates and reduce the impact of coal price shocks on the economy (Sioshansi, 2015).

5.2 BRENT CRUDE OIL

According to a study by Kavtaradze and Metreveli (2018), policies that promote stability in share prices and short-term interest rates can help mitigate the negative impact of Brent crude oil price shocks on the EU economy as a result of the war in Ukraine. Policies that promote stability in short-term interest rates can include maintaining a stable inflation rate, implementing effective monetary policies, and improving the regulatory environment. Central banks can use monetary policies such as open market operations and changes in reserve requirements to stabilize short-term interest rates (Eser et al., 2019). Additionally, policies that promote financial stability, such as regulations that ensure banks maintain adequate capital buffers and liquidity, can help reduce the impact of Brent crude oil price shocks on short-term interest rates (Makarova, 2020).

Regarding exports, the results indicate that changes in exports explain a very small portion of the overall variability in Brent crude oil. However, policies aimed at diversifying the export base and reducing dependence on a single commodity can help reduce the impact of price shocks on exports. The EU can strengthen its relationships with other energy suppliers such as the United States and Middle Eastern countries. This can help diversify the EU's energy sources and reduce the dependence on Russian energy.

Another policy is to increase the production of domestic energy resources. The EU can promote the exploration and development of its own oil and gas reserves, as well as the adoption of technologies such as hydraulic fracturing to extract unconventional sources of energy. This can help reduce the dependence on imports from Russia and other countries.

Although changes in imports account for a slightly larger portion of the variability in Brent crude oil compared to exports, the effect of price shocks on imports was weak and short-lived. According to a study by the European Central Bank, changes in imports were also found to account for a slightly larger portion of the variability in Brent crude oil compared to exports (Mursula & Viren, 2018). Nonetheless, policies aimed at reducing dependence on imports and promoting domestic production can help reduce the impact of external shocks on the economy. The industrial price index had a very small impact on the variability of Brent crude oil, suggesting that policies aimed at stabilizing industrial prices may not be effective in mitigating the impact of Brent crude oil price shocks.

According to the results, changes in unemployment have a minimal effect on the overall variability in Brent crude oil prices. However, policies aimed at promoting job creation and reducing unemployment can enhance economic growth and improve resilience, which can help offset the impact of external shocks on the economy. (Mehrara & Musai, 2017).

5.3 HENRY HUB NATURAL GAS

According to a study by the International Monetary Fund (IMF) on the impact of energy price shocks on exports and imports, diversifying the export base and reducing dependence on natural gas imports can help mitigate the negative impact of price shocks on exports and imports (IMF, 2016). This can be achieved through initiatives to promote the development and export of alternative energy sources, as well as policies to encourage greater energy efficiency and conservation. The study also suggests that reducing trade barriers and promoting economic diversification can help reduce the negative impact of energy price shocks on exports and imports (IMF, 2016). In addition, policies aimed at promoting stability in the industrial production index could also help to reduce the impact of price shocks on the economy. This could include initiatives to support innovation and investment in new technologies, as well as efforts to promote greater efficiency and productivity in key industries.

The EU should set up measures to reduce its dependence on natural gas from Russia. Reducing dependence on natural gas imports from Russia can be achieved through various policy measures, including:

1. Reducing dependence on imports and promoting domestic production can be achieved through several policies. One such policy is to provide subsidies or tax incentives to domestic producers to encourage them to increase production. This can be coupled with investment in research and development to improve the efficiency of domestic production processes and reduce costs. Another policy option is to promote energy conservation and efficiency measures to reduce overall demand for energy, thereby reducing the need for imports. This can include programs such as public transportation subsidies, energy-efficient building codes, and consumer education campaigns. (IMF, 2017)
2. Central banks can use monetary policy tools such as adjusting interest rates, open market operations, and reserve requirements to stabilize short-term interest rates. By lowering interest rates, the central bank can encourage borrowing and spending, which can help stimulate economic growth and reduce the negative impact of coal price shocks on the economy. (Federal Reserve Bank of St. Louis, n.d.)
3. Governments can use fiscal policy tools such as tax cuts, infrastructure spending, and direct investment to stimulate economic growth and reduce the negative impact of coal price shocks on the economy. By increasing government spending, the government can

create jobs and boost economic activity, which can help offset the negative impact of coal price shocks. (OECD, 2018)

4. Governments can maintain strategic reserves of energy resources such as coal to help stabilize prices during periods of price volatility. By maintaining stockpiles, the government can provide a buffer against sudden price increases, which can help stabilize short-term interest rates and reduce the negative impact of coal price shocks on the economy. (EIA, 2020)
5. Based on the results, policies that promote stability in share prices and short-term interest rates can help mitigate the negative impact of Brent crude oil price shocks on the EU economy as a result of the war in Ukraine. Policies that promote stability in short-term interest rates can include maintaining a stable inflation rate, implementing effective monetary policies, and improving the regulatory environment. (European Central Bank, 2021)
6. Although changes in imports account for a slightly larger portion of the variability in Brent crude oil compared to exports, the effect of price shocks on imports was weak and short-lived. Nonetheless, policies aimed at reducing dependence on imports and promoting domestic production can help reduce the impact of external shocks on the economy. The industrial price index had a very small impact on the variability of Brent crude oil, suggesting that policies aimed at stabilizing industrial prices may not be effective in mitigating the impact of Brent crude oil price shocks. (European Commission, 2014)
7. Regarding unemployment, the results suggest that changes in unemployment account for a very small portion of the overall variability in Brent crude oil. Nonetheless, policies aimed at promoting job creation and reducing unemployment can help boost economic growth and resilience, which can reduce the impact of external shocks on the economy. (IMF, 2018)
8. The results suggest that policies aimed at diversifying the export base and reducing dependence on natural gas imports could help mitigate the negative impact of price shocks on exports and imports. This could include initiatives to promote the development and export of alternative energy sources, as well as policies to encourage greater energy efficiency and conservation. (European Parliament, 2021)

6.0 CONCLUSION, SCOPE AND LIMITATIONS

The war in Ukraine, has had significant consequences on various aspects of the European Union and its neighboring regions. Stemming from complex political, historical, and ethnic factors, the conflict originated in the aftermath of Ukraine's decision to pursue closer ties with the European Union (EU) and NATO, which was met with resistance from Russia. As a result, tensions escalated into armed conflict, with Russia annexing Crimea and supporting separatist movements in eastern Ukraine. The conflict has been marked by territorial disputes, human rights violations, and the displacement of millions of people. However, this paper specifically focuses on the impacts of the war on the energy sector of the European Union, highlighting the interconnectedness between Ukraine and the EU in terms of energy infrastructure, supply routes, and geopolitical implications.

Ukraine's strategic location as a transit country for natural gas has made it a crucial player in the European energy landscape. Historically, Ukraine has been a major transit route for Russian gas exports to Europe, with pipelines traversing its territory. However, the conflict has introduced numerous challenges to the functioning of these pipelines, threatening energy security and stability in the region. One of the primary concerns arising from the war has been the disruption of energy supplies to the EU. With tensions escalating, Russia has used gas as a geopolitical weapon, reducing or cutting off gas supplies to Ukraine during critical moments, as was the case in 2006 and 2009. Such interruptions have raised concerns among European countries heavily dependent on Russian gas imports, highlighting the vulnerability of their energy systems to political disputes and the need for diversification.

The war has also led to the deterioration of energy infrastructure in Ukraine, affecting the reliability and safety of energy transportation. Pipeline explosions, damage due to military operations, and the diversion of resources to support military efforts have hampered the maintenance and modernization of Ukraine's energy networks. This has further exacerbated concerns about the stability and capacity of energy flows between Ukraine and the EU. Moreover, the war has heightened geopolitical tensions in the region, prompting the EU to reassess its energy security strategy. The EU has taken steps to reduce its dependence on Russian gas, such as diversifying its supply sources, increasing domestic production, and enhancing energy efficiency measures. These measures aim to minimize vulnerabilities and strengthen the EU's position in negotiations with external energy suppliers. Furthermore, the war has stimulated discussions on the importance of renewable energy and energy transition in the European context. The EU has recognized the need to reduce its reliance on fossil fuels and promote sustainable energy alternatives, which can enhance its energy security, reduce greenhouse gas emissions, and contribute to a more resilient and sustainable energy system.

The dependence on Russian energy supplies has presented both economic and geopolitical challenges for the EU. Price disputes, interruptions in gas flows due to geopolitical tensions, and concerns over energy diversification and security have been major issues. The EU's heavy reliance on Russian gas has raised concerns about potential supply disruptions, particularly during periods of political tension between Russia and Ukraine.
The conflict between Russia and Ukraine has had significant implications for the EU's energy sector. Ukraine, as a transit country, has faced disruptions in gas supplies during previous conflicts, leading to potential knock-on effects on gas flows to the EU. These disruptions highlighted the vulnerability of the EU's energy supply chain and the need for diversification.

In response, the EU has pursued various strategies to reduce dependence on Russian and Ukrainian energy supplies. Efforts have focused on diversifying supply routes, expanding liquefied natural gas (LNG) import capacities, enhancing interconnections between member states, and promoting renewable energy sources. The EU has also implemented energy efficiency measures and explored alternative partnerships with other energy-rich countries to enhance its energy security. Furthermore, the EU has sought to strengthen its position in negotiations with Russia and Ukraine by developing a common energy policy. The establishment of the Energy Union in 2015 aimed to coordinate member states' energy policies, enhance solidarity, and promote a more integrated and sustainable energy market. The Energy Union also emphasized the importance of diversification and reducing the EU's reliance on any single supplier.

Despite these efforts, achieving complete energy independence from Russia and Ukraine remains a complex and ongoing challenge for the EU. The region's energy infrastructure, supply contracts, and existing dependencies cannot be easily altered. However, the EU's emphasis on diversification, energy efficiency, and renewable energy sources signifies a commitment to reducing its reliance on these countries. The European Union has taken a multi-faceted approach to mitigate the impacts of high energy prices in Europe resulting from the invasion of Ukraine. Through efforts to diversify energy sources, enhance energy efficiency, strengthen energy cooperation, establish emergency response mechanisms, engage with international partners, and implement consumer protection measures, the EU aims to safeguard energy security and minimize the economic and social consequences of price increases. By pursuing these strategies, the EU seeks to create a more resilient and sustainable energy market that can withstand geopolitical disruptions and ensure the well-being of its member states.

As energy prices have increased, we refocus attention to the issue of energy price change and its impact on economic activities. Even though there are some related studies of the use of an asymmetric relation to examine the impact of an oil price change on an economy, research studies do not consider the speed of oil price adjustment before estimation and also neglect the impact from oil price shocks. To overcome the weakness of prior studies, we apply the Vector Error Correction and VAR models proposed by Tsay (1998 to explore the speed of response and the consequence of the impact of a positive energy price change and its shock.

The results of our analysis show that a price shock in Henry Hub natural gas has mixed effects on various macroeconomic variables in the short term. While the shock has a negative impact on exports, it has a positive impact on short-term interest rates, and a small negative impact on industrial production index and unemployment rate. However, the impacts of the shock generally dissipate within a few months. Our analysis also highlights the limited role that changes in exports and unemployment play in explaining the overall variability in the Henry Hub natural gas index.

Furthermore, our analysis reveals that Newcastle coal futures have a significant impact on the the EU economy. Specifically, a price shock in Newcastle coal futures has a positive impact on exports and industrial production index in the short term, while also leading to a small increase in the short-term interest rates. However, the shock has no significant impact on imports and unemployment rate. These findings suggest that diversifying the energy import base, reducing dependence on any one source of energy, and promoting the use of cleaner energy sources could help reduce the overall vulnerability of the EU economies to energy price shocks.

Overall, our analysis highlights the need for policy measures that promote energy security and diversification in the EU. Such measures could include investment in renewable energy sources, building new pipelines and liquefied natural gas (LNG) terminals, and promoting energy efficiency measures in various sectors of the economy. By reducing the dependence on any one source of energy, EU economies could become more resilient to energy price shocks and minimize the negative impacts on key macroeconomic variables.

The study found that Brent crude oil price shocks had a significant negative impact on the EU economy, particularly on exports and imports. The study also found that policies aimed at promoting stability in share prices, short-term interest rates, and financial stability could help mitigate the negative impact of Brent crude oil price shocks.

Monetary policy tools such as adjusting interest rates, open market operations, and reserve requirements can be used by central banks to stabilize short-term interest rates. By lowering interest rates, the central bank can encourage borrowing and spending, which can help stimulate economic growth and reduce the negative impact of coal price shocks on the economy.
Governments can use fiscal policy tools such as tax cuts, infrastructure spending, and direct investment to stimulate economic growth and reduce the negative impact of coal price shocks on the economy. By increasing government spending, the government can create jobs and boost economic activity, which can help offset the negative impact of coal price shocks.
Maintaining strategic reserves of energy resources such as coal can help stabilize prices during periods of price volatility. By maintaining stockpiles, the government can provide a buffer against sudden price increases, which can help stabilize short-term interest rates and reduce the negative impact of coal price shocks on the economy.

Policies aimed at reducing dependence on imports and promoting domestic production can help reduce the impact of external shocks on the economy. This could include initiatives to promote the development and export of alternative energy sources, as well as policies to encourage greater energy efficiency and conservation. Reducing dependence on natural gas imports from Russia can be achieved through various policy measures, including promoting energy efficiency, diversification of supply sources, promoting renewable energy, investment in infrastructure, development of domestic resources, and diplomatic efforts.

In conclusion, this study has highlighted the significant negative impact of energy price shocks on the EU economy due to the war in Ukraine. The study has identified several policies that could mitigate this impact, including monetary and fiscal policy tools, strategic stockpiling, promoting domestic production, and reducing dependence on natural gas imports from Russia. Implementing these policies could help reduce the vulnerability of the EU economy to external shocks and increase its resilience.

5.5 SCOPE AND LIMITATIONS OF THE STUDY.

There are several limitations to this study. Firstly, the research relies on secondary data sources, which may not provide a complete picture of the energy sector in the Eurozone. The study has addressed this limitation by using multiple sources and cross-checking the data to ensure accuracy. Secondly, the study focuses on the impact of the Russian invasion of Ukraine in 2022 on the Eurozone's energy sector. However, there may be other geopolitical events or factors that could also affect the region's energy security. The study acknowledges this limitation and highlight the need for further research. The study's findings may be subject to bias or interpretation. The study addresses this limitation by being transparent about the research methods and acknowledging the potential limitations of the study.

Even though we have found possible factors to explain the EU’s macroeconomic fluctuations and the speed of adjustment from the impact of energy price shocks, there are still some limitations to this research, including a host of possible exogenous factors that may affect macroeconomic variables and delay of the effect such as the degree of openness of the economy and fiscal and exchange rate policies (e.g., Bohi, 1991). These omitted variables may be included in future analyses for testing the robustness of the result. In addition, international energy price changes may impact open economies both directly and indirectly. Future research studies can identify these direct and indirect channels of oil price shocks on the labor market.

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LIST OF ILLUSTRATIONS:

GRAPHICAL REPRESANTION OF ALL THE USED VARIABLES

BRENT CRUDE OIL

LOG HENRY HUB

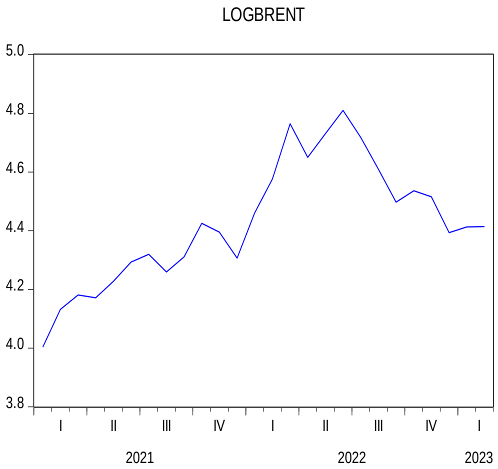


Figure 1

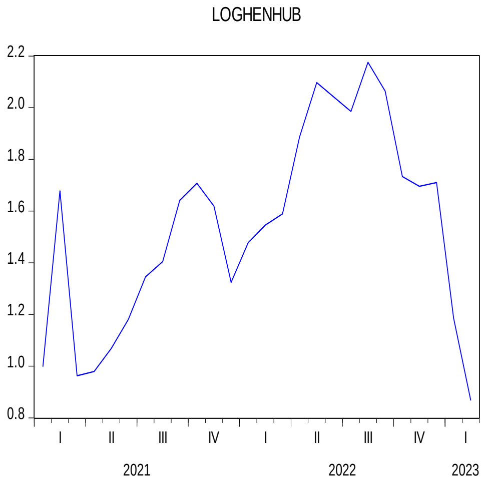


Figure 2

INDUSTRIAL PRODUCTION INDEX

LOG NEWCASTLE COAL FUTURE

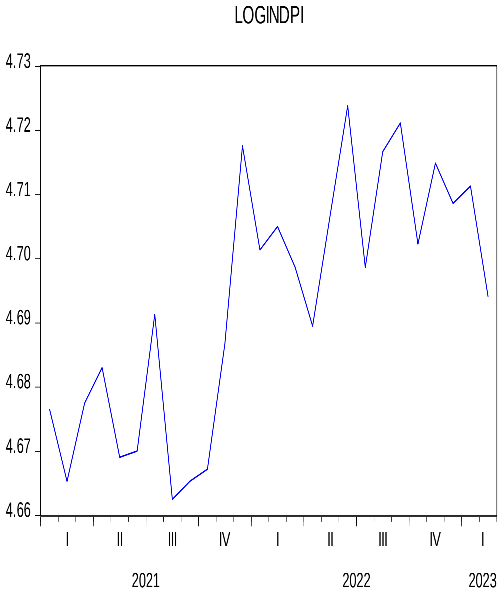


Figure 3

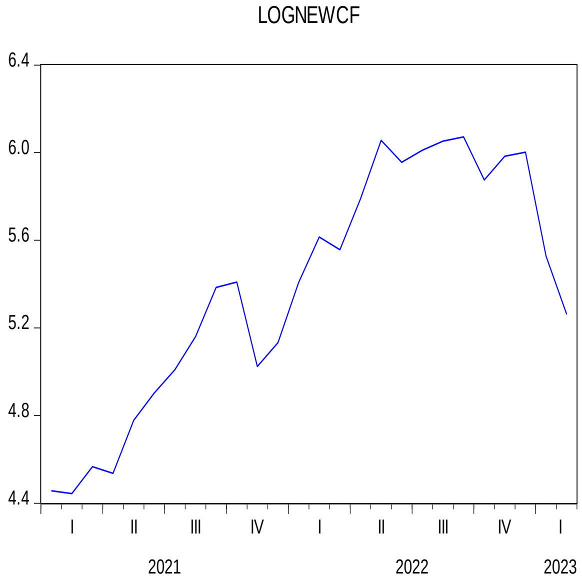


Figure 4

LOG SHARE PRICE

SHORT TERM INTEREST RATES

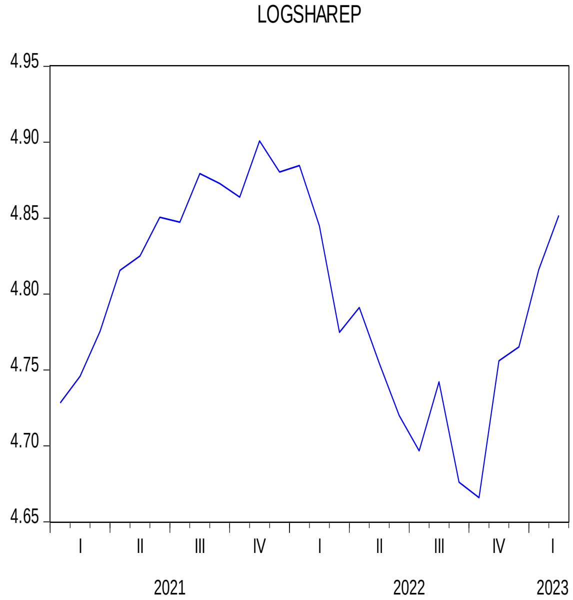


Figure 5

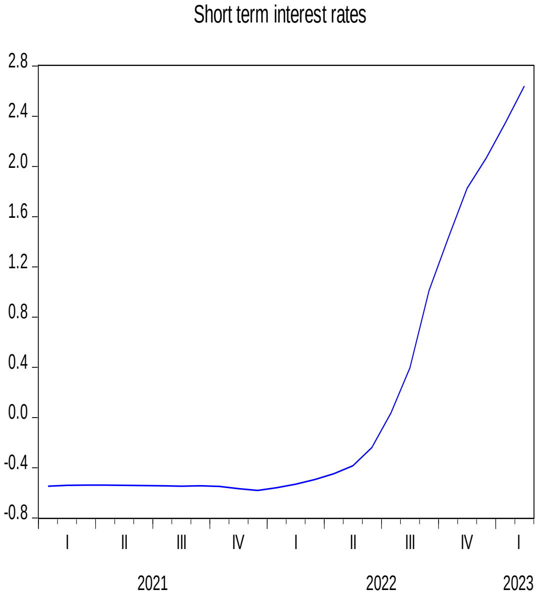


Figure 6

UNEMPLOYMENT

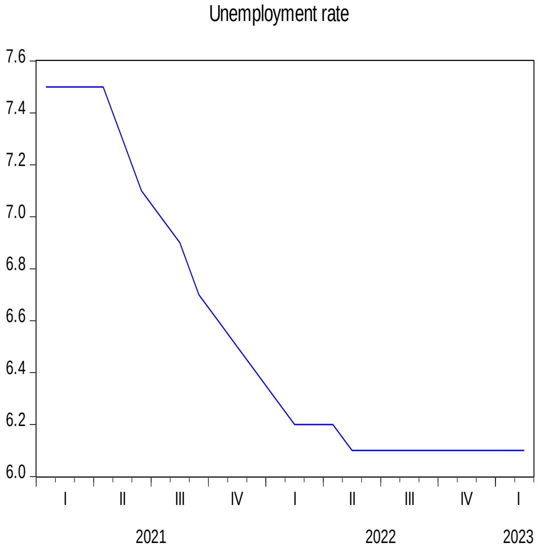


Figure 7

LOG OF EXPORTS

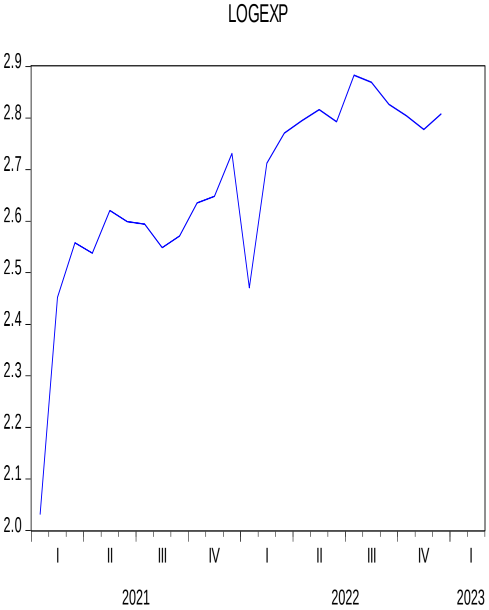


Figure 8

LOG OF IMPORTS

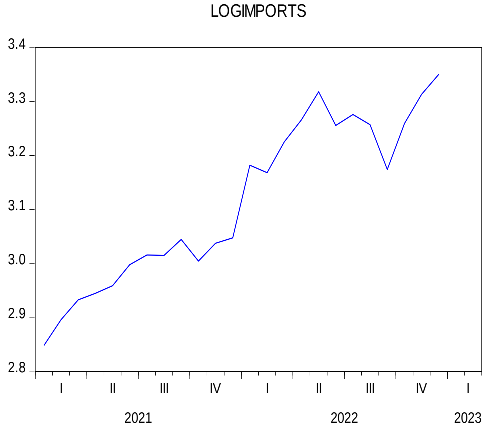


Figure 9

Table 1(a)

RESULTS OF ADF UNIT ROOT TESTS

VARIABLE	ADF Probability in LEVEL	ADF Prob after FIRST DIFFERENCE
Log of HenryHub Natural Gas	0.4399	0
Log of Brent crude oil	0.8804	0.0053
Log of Newcastle coal futures	0.8492	0.0011
Log of real industrial Production	0.7401	0
Log of share price	0.8462	0.0001
Unemployment	0.0441	0.0341
Short term Interest rate	0.8641	0
Log of Imports	0.9908	0.0003
Log of exports	0.8973	0

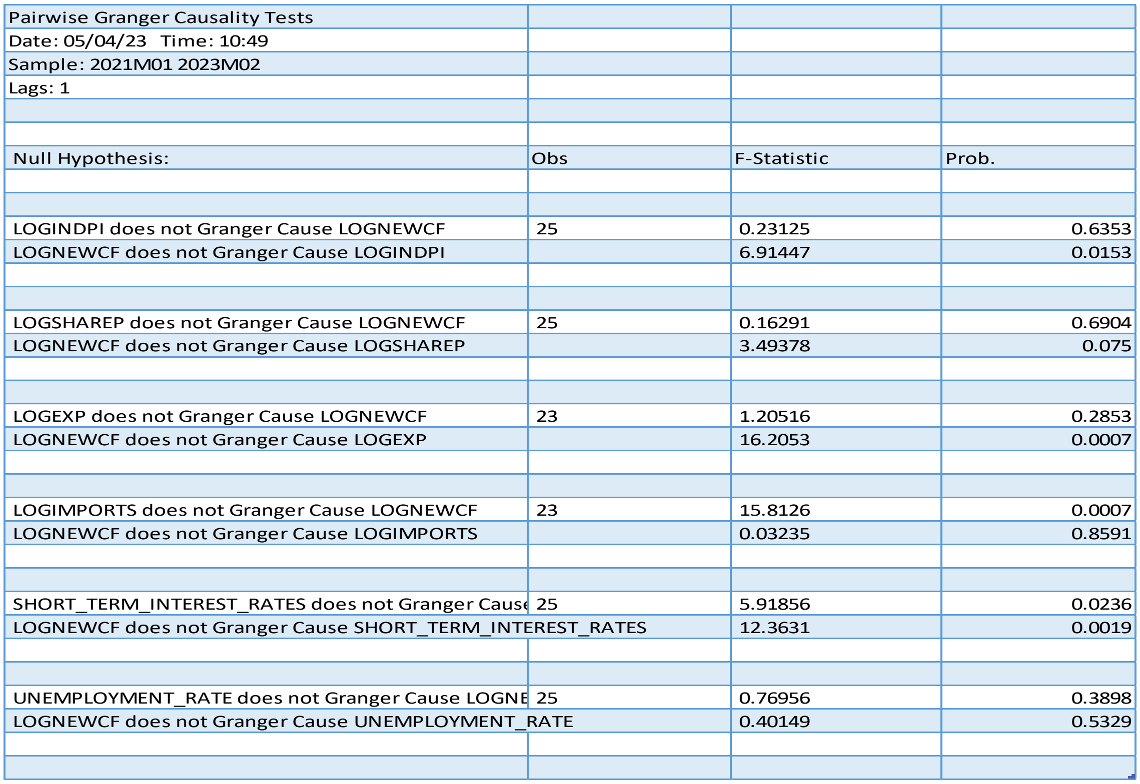
Table 1(b): Correlations

Variable	BRENT_CRUDE_	HENRY_HUB_NATURAL_GAS	NEWCASTLE_COAL_FUTURES	UNEMPLOYMENT_RATE	SHORT_TERM_INTEREST_RATES	SHARE_PRICE	INDUSTRIAL_PRODUCTION_INDEX	EXPORTS	IMPORTS
BRENT_CRUDE_OIL	1	0.760005099	0.792765282	-0.830304716	0.200330271	-0.36757267	0.638904964	0.77857038	0.8229668
HENRY_HUB_NATURAL_GAS	0.760005099	1	0.867897158	-0.755120815	0.375408278	-0.503295767	0.580383237	0.7355576	0.72944938
NEWCASTLE_COAL_FUTURES	0.792765282	0.867897158	1	-0.891570258	0.659464931	-0.552008427	0.74334015	0.83717226	0.9292607
UNEMPLOYMENT_RATE	-0.830304716	-0.755120815	-0.891570258	1	-0.504898796	0.245982008	-0.763417681	-0.81232	-0.9048922
SHORT_TERM_INTEREST_RAT	0.200330271	0.375408278	0.659464931	-0.504898796	1	-0.555383648	0.52563146	0.50832895	0.63509447
SHARE_PRICE	-0.36757267	-0.503295767	-0.552008427	0.245982008	-0.555383648	1	-0.426959896	-0.3713599	-0.4309898
INDUSTRIAL_PRODUCTION_I	0.638904964	0.580383237	0.74334015	-0.763417681	0.52563146	-0.426959896	1	0.6720084	0.74003475
EXPORTS	0.778570377	0.735557598	0.837172255	-0.812319963	0.508328949	-0.371359887	0.672008396	1	0.82013697
IMPORTS	0.822966796	0.729449382	0.929260704	-0.904892153	0.635094473	-0.430989794	0.74003475	0.82013697	1

NEWCASTLE COAL FUTURES

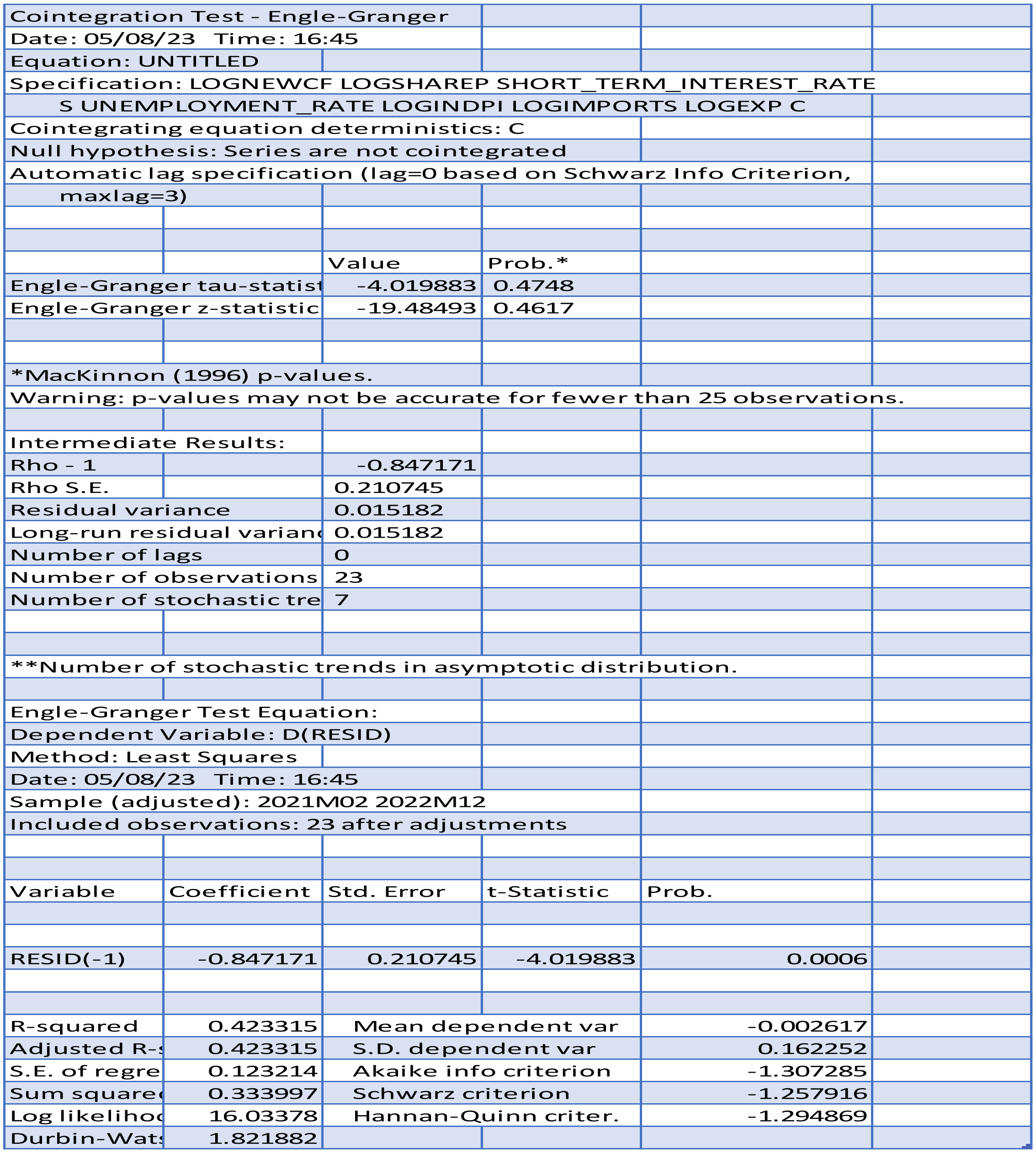
GRANGER CAUSALITY TESTS

Table 2



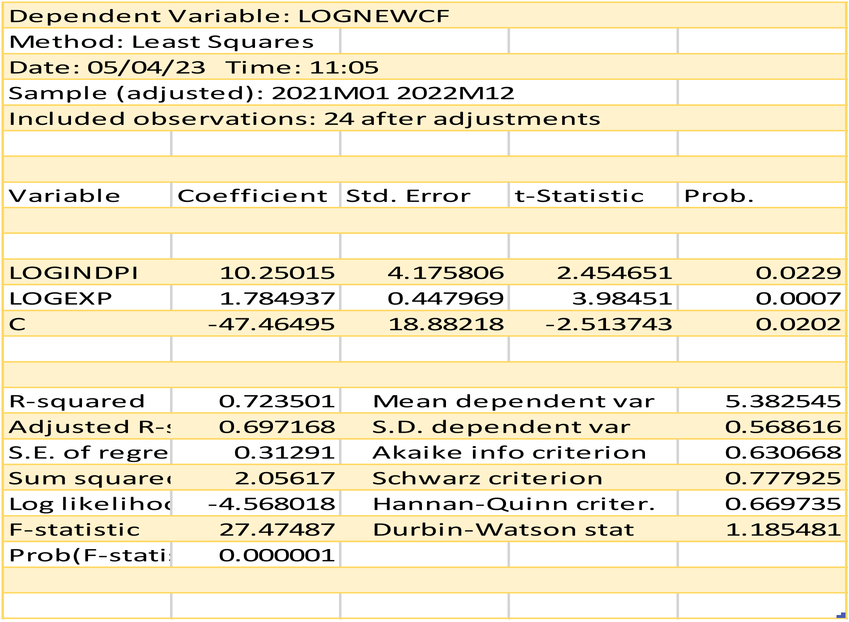
Pairwise Granger Causality Tests			
Date: 05/04/23 Time: 10:49			
Sample: 2021M01 2023M02			
Lags: 1			
Null Hypothesis:	Obs	F-Statistic	Prob.
LOGINDPI does not Granger Cause LOGNEWCF	25	0.23125	0.6353
LOGNEWCF does not Granger Cause LOGINDPI		6.91447	0.0153
LOGSHAREP does not Granger Cause LOGNEWCF	25	0.16291	0.6904
LOGNEWCF does not Granger Cause LOGSHAREP		3.49378	0.075
LOGEXP does not Granger Cause LOGNEWCF	23	1.20516	0.2853
LOGNEWCF does not Granger Cause LOGEXP		16.2053	0.0007
LOGIMPORTS does not Granger Cause LOGNEWCF	23	15.8126	0.0007
LOGNEWCF does not Granger Cause LOGIMPORTS		0.03235	0.8591
SHORT_TERM_INTEREST_RATES does not Granger Cause	25	5.91856	0.0236
LOGNEWCF does not Granger Cause SHORT_TERM_INTEREST_RATES		12.3631	0.0019
UNEMPLOYMENT_RATE does not Granger Cause LOGNE	25	0.76956	0.3898
LOGNEWCF does not Granger Cause UNEMPLOYMENT_RATE		0.40149	0.5329

NEWCASTLE COAL FUTURES COINTEGRATION TEST: Table 3



```
Cointegration Test - Engle-Granger
Date: 05/08/23   Time: 16:45
Equation: UNTITLED
Specification: LOGNEWCF LOGSHAREP SHORT_TERM_INTEREST_RATE
      S UNEMPLOYMENT_RATE LOGINDPI LOGIMPORTS LOGEXP C
Cointegrating equation deterministics: C
Null hypothesis: Series are not cointegrated
Automatic lag specification (lag=0 based on Schwarz Info Criterion,
      maxlag=3)


                                        Value        Prob.*
Engle-Granger tau-statist          -4.019883   0.4748
Engle-Granger z-statistic          -19.48493   0.4617


*MacKinnon (1996) p-values.
Warning: p-values may not be accurate for fewer than 25 observations.

Intermediate Results:
Rho - 1                            -0.847171
Rho S.E.                           0.210745
Residual variance                  0.015182
Long-run residual varianc          0.015182
Number of lags                     0
Number of observations             23
Number of stochastic tre           7


**Number of stochastic trends in asymptotic distribution.

Engle-Granger Test Equation:
Dependent Variable: D(RESID)
Method: Least Squares
Date: 05/08/23   Time: 16:45
Sample (adjusted): 2021M02 2022M12
Included observations: 23 after adjustments


Variable        Coefficient    Std. Error    t-Statistic    Prob.


RESID(-1)          -0.847171      0.210745      -4.019883              0.0006


R-squared           0.423315     Mean dependent var               -0.002617
Adjusted R-s        0.423315     S.D. dependent var                0.162252
S.E. of regre       0.123214     Akaike info criterion            -1.307285
Sum squared         0.333997     Schwarz criterion                -1.257916
Log likelihoc       16.03378     Hannan-Quinn criter.             -1.294869
Durbin-Wats         1.821882
```

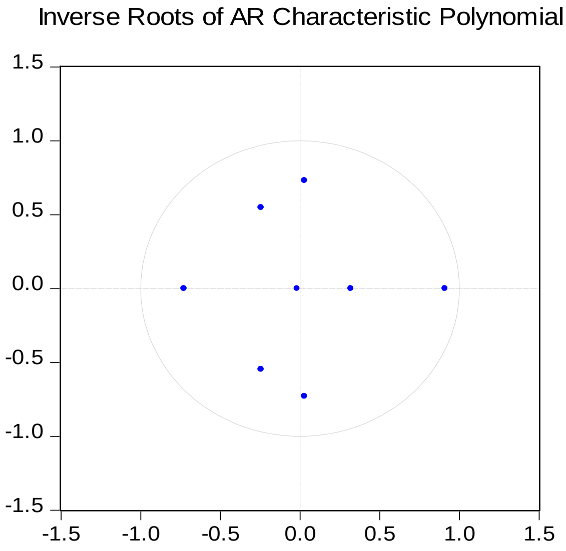
Table 3



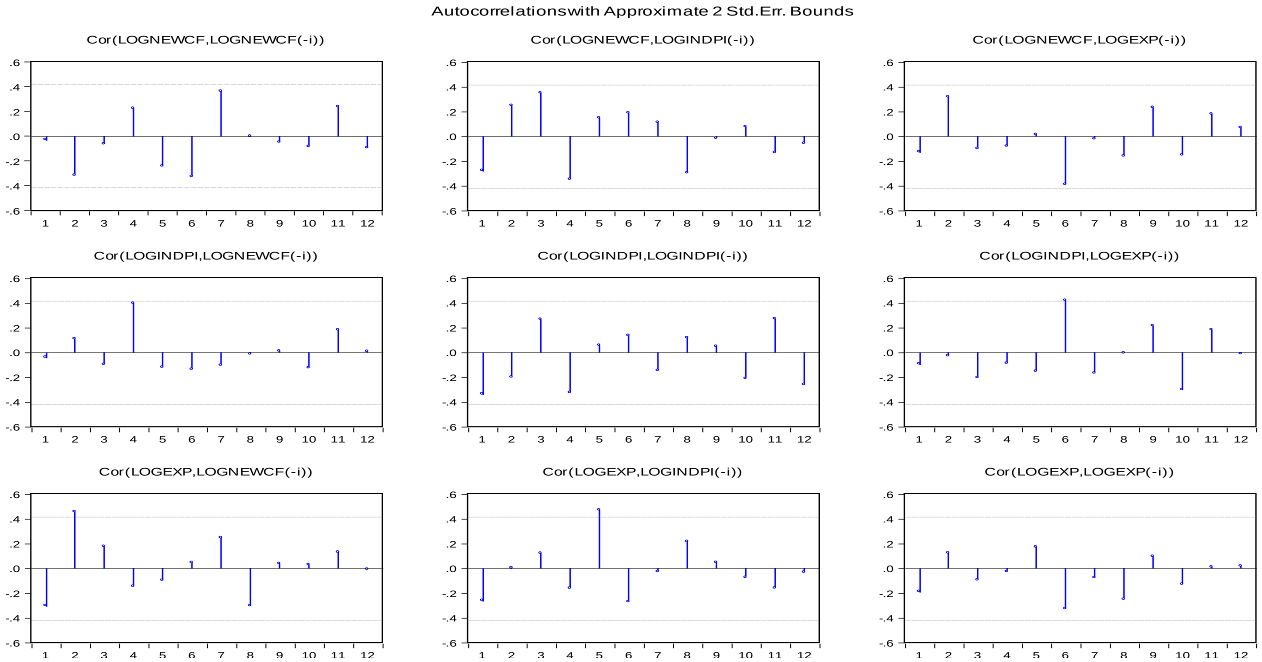
Dependent Variable: LOGNEWCF				
Method: Least Squares				
Date: 05/04/23 Time: 11:05				
Sample (adjusted): 2021M01 2022M12				
Included observations: 24 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGINDPI	10.25015	4.175806	2.454651	0.0229
LOGEXP	1.784937	0.447969	3.98451	0.0007
C	-47.46495	18.88218	-2.513743	0.0202
R-squared	0.723501	Mean dependent var		5.382545
Adjusted R-	0.697168	S.D. dependent var		0.568616
S.E. of regre	0.31291	Akaike info criterion		0.630668
Sum square	2.05617	Schwarz criterion		0.777925
Log likeliho	-4.568018	Hannan-Quinn criter.		0.669735
F-statistic	27.47487	Durbin-Watson stat		1.185481
Prob(F-stati	0.000001			

NEWCASTLE COAL FUTURES VAR STABILITY TESTS

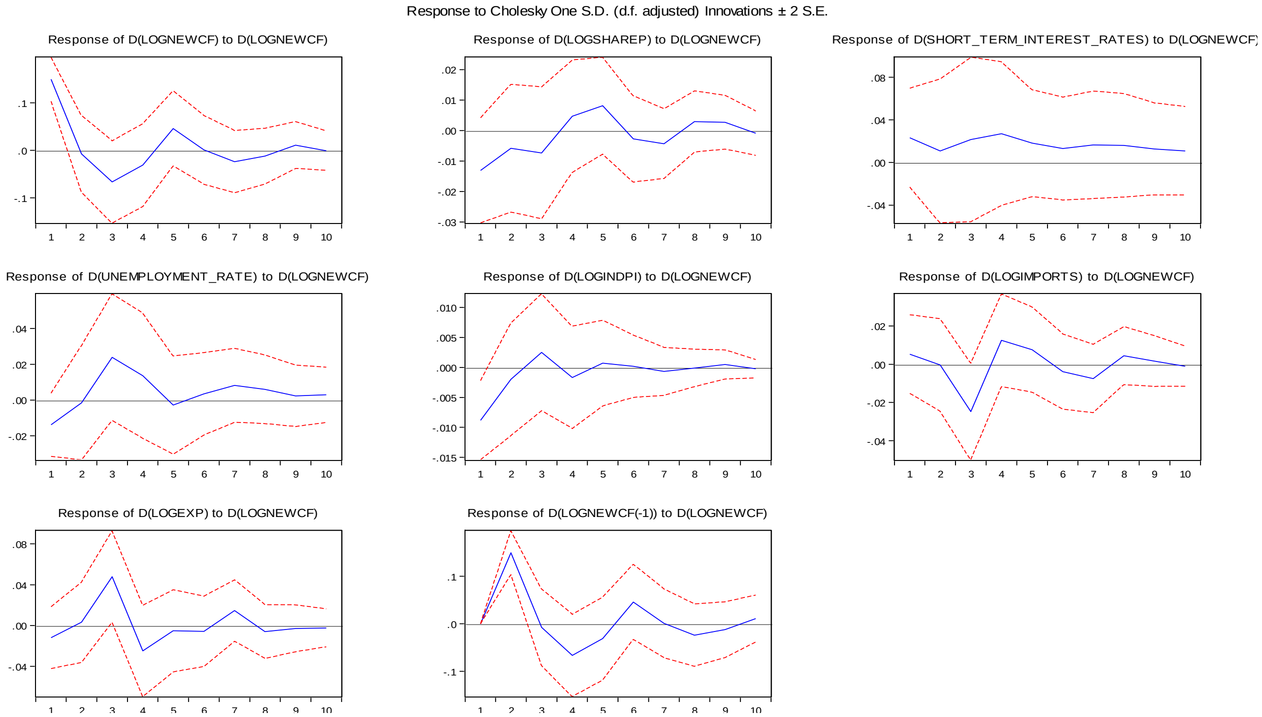
Figure 10



AUTOCORRELATIONS: Figure 11

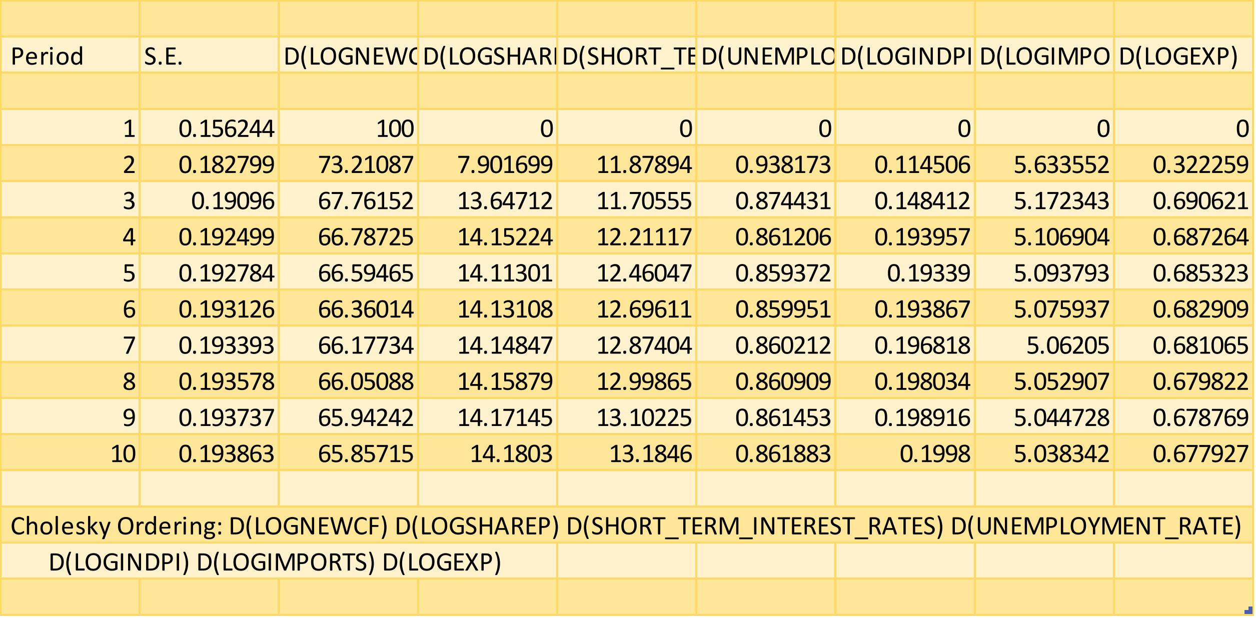


IMPULSE RESPONSE FUNCTIONS: Figure 12



VARIANCE DECOMPOSITION

Table 4

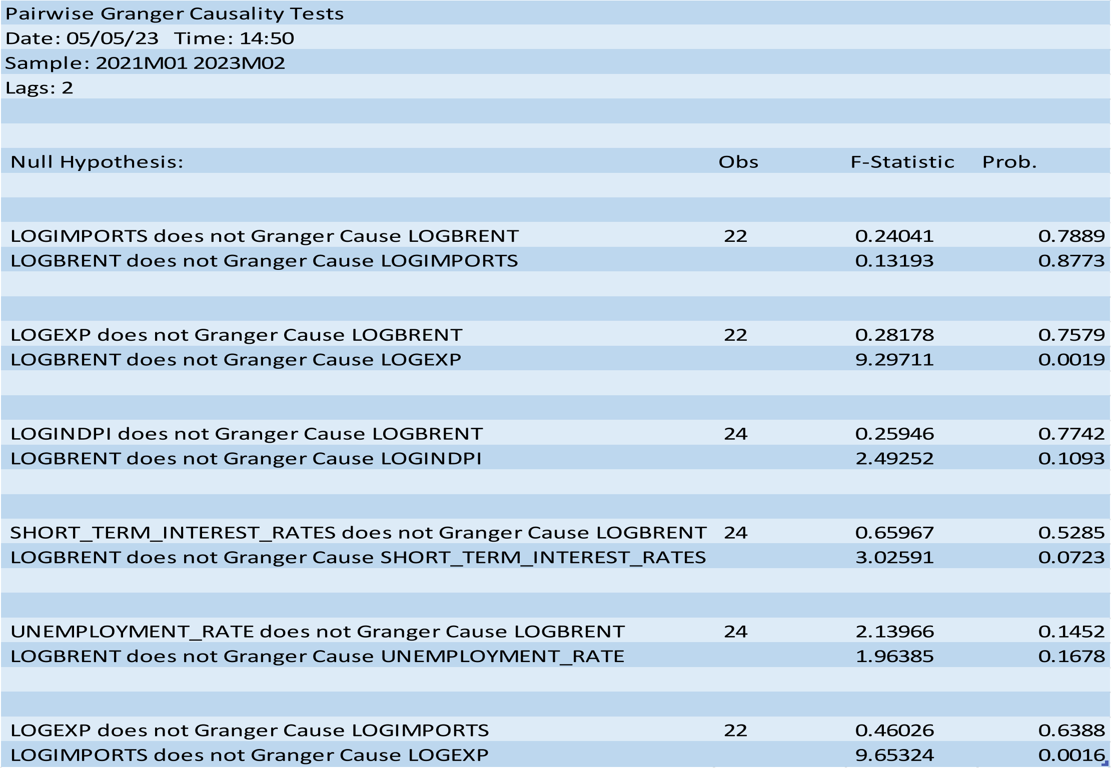


Period	S.E.	D(LOGNEWC	D(LOGSHARI	D(SHORT_TE	D(UNEMPLC	D(LOGINDPI	D(LOGIMPO	D(LOGEXP)
1	0.156244	100	0	0	0	0	0	0
2	0.182799	73.21087	7.901699	11.87894	0.938173	0.114506	5.633552	0.322259
3	0.19096	67.76152	13.64712	11.70555	0.874431	0.148412	5.172343	0.690621
4	0.192499	66.78725	14.15224	12.21117	0.861206	0.193957	5.106904	0.687264
5	0.192784	66.59465	14.11301	12.46047	0.859372	0.19339	5.093793	0.685323
6	0.193126	66.36014	14.13108	12.69611	0.859951	0.193867	5.075937	0.682909
7	0.193393	66.17734	14.14847	12.87404	0.860212	0.196818	5.06205	0.681065
8	0.193578	66.05088	14.15879	12.99865	0.860909	0.198034	5.052907	0.679822
9	0.193737	65.94242	14.17145	13.10225	0.861453	0.198916	5.044728	0.678769
10	0.193863	65.85715	14.1803	13.1846	0.861883	0.1998	5.038342	0.677927

Cholesky Ordering: D(LOGNEWCF) D(LOGSHAREP) D(SHORT_TERM_INTEREST_RATES) D(UNEMPLOYMENT_RATE)
D(LOGINDPI) D(LOGIMPORTS) D(LOGEXP)

BRENT CRUDE OIL.

Granger Causality Test: Table 5

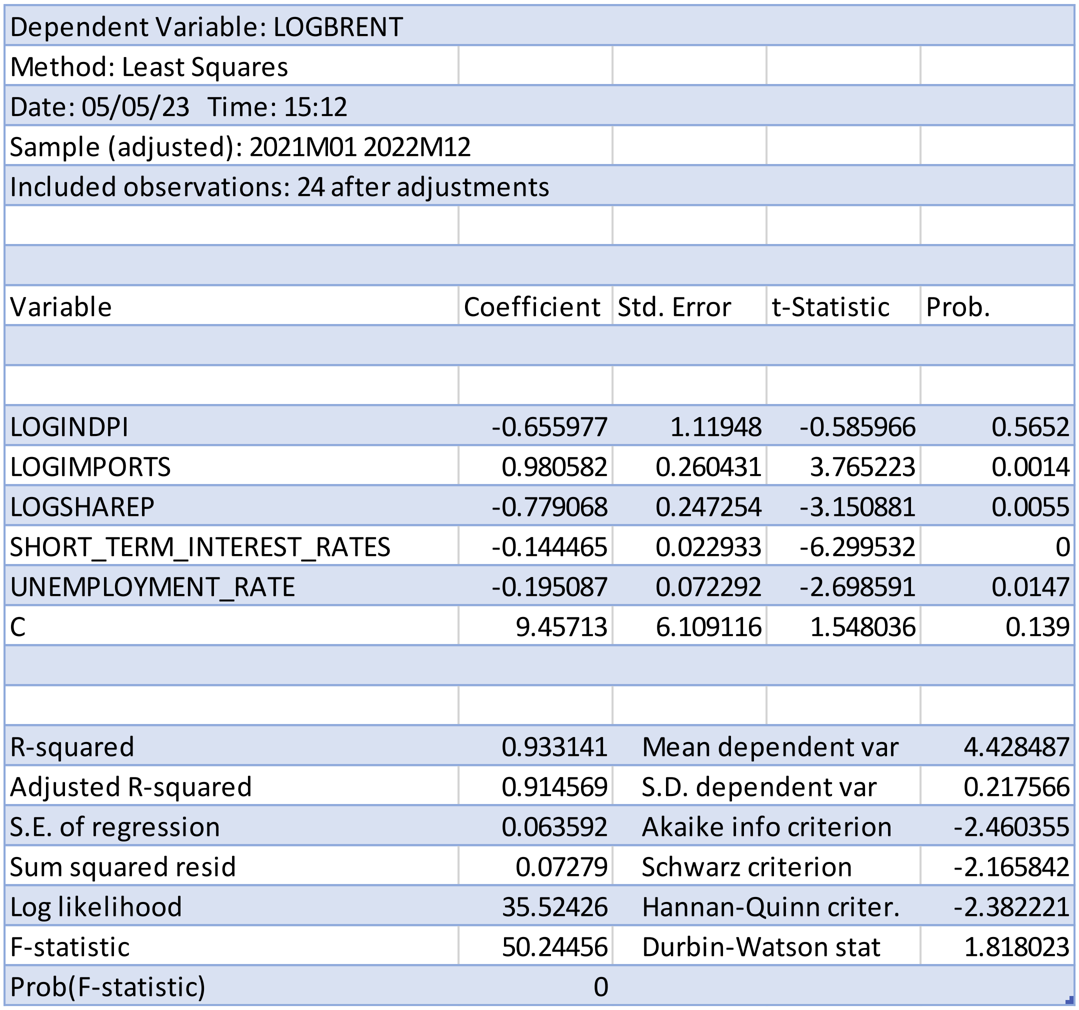


Pairwise Granger Causality Tests
Date: 05/05/23 Time: 14:50
Sample: 2021M01 2023M02
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
LOGIMPORTS does not Granger Cause LOGBRENT	22	0.24041	0.7889
LOGBRENT does not Granger Cause LOGIMPORTS		0.13193	0.8773
LOGEXP does not Granger Cause LOGBRENT	22	0.28178	0.7579
LOGBRENT does not Granger Cause LOGEXP		9.29711	0.0019
LOGINDPI does not Granger Cause LOGBRENT	24	0.25946	0.7742
LOGBRENT does not Granger Cause LOGINDPI		2.49252	0.1093
SHORT_TERM_INTEREST_RATES does not Granger Cause LOGBRENT	24	0.65967	0.5285
LOGBRENT does not Granger Cause SHORT_TERM_INTEREST_RATES		3.02591	0.0723
UNEMPLOYMENT_RATE does not Granger Cause LOGBRENT	24	2.13966	0.1452
LOGBRENT does not Granger Cause UNEMPLOYMENT_RATE		1.96385	0.1678
LOGEXP does not Granger Cause LOGIMPORTS	22	0.46026	0.6388
LOGIMPORTS does not Granger Cause LOGEXP		9.65324	0.0016

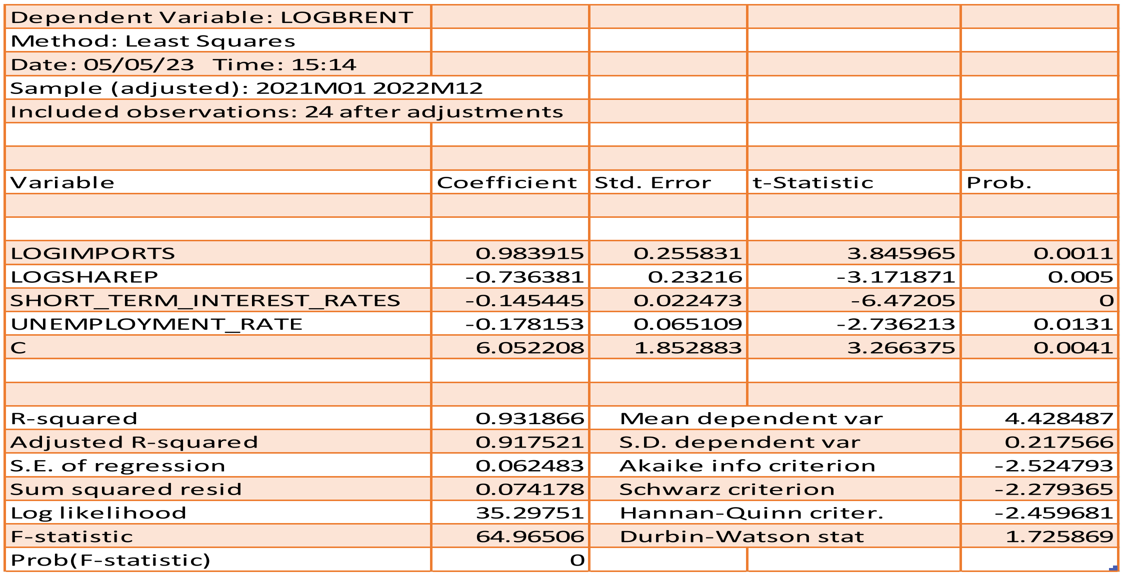
LONG RUN MODEL

Table 6



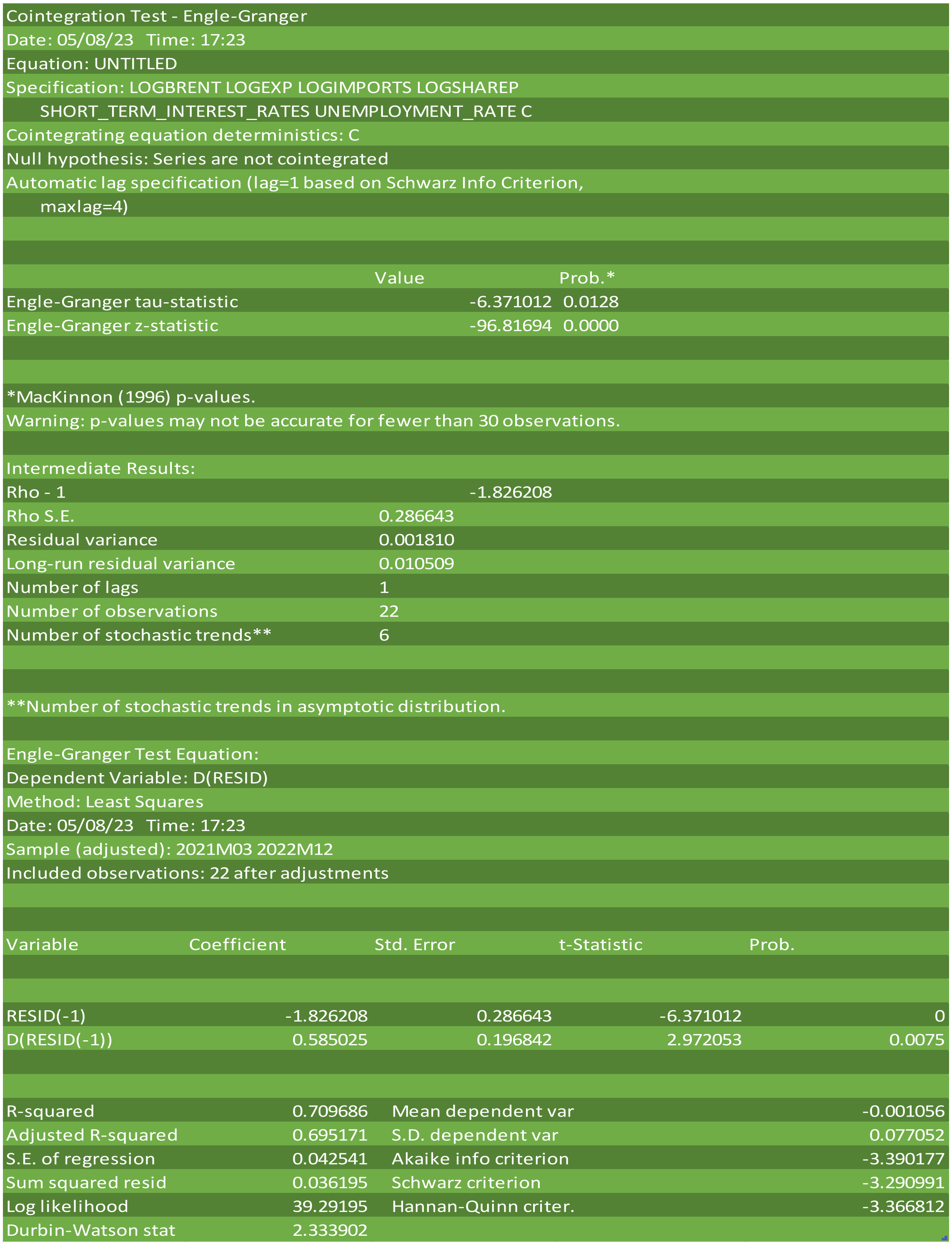
Dependent Variable: LOGBRENT				
Method: Least Squares				
Date: 05/05/23 Time: 15:12				
Sample (adjusted): 2021M01 2022M12				
Included observations: 24 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGINDPI	-0.655977	1.11948	-0.585966	0.5652
LOGIMPORTS	0.980582	0.260431	3.765223	0.0014
LOGSHAREP	-0.779068	0.247254	-3.150881	0.0055
SHORT_TERM_INTEREST_RATES	-0.144465	0.022933	-6.299532	0
UNEMPLOYMENT_RATE	-0.195087	0.072292	-2.698591	0.0147
C	9.45713	6.109116	1.548036	0.139
R-squared	0.933141	Mean dependent var		4.428487
Adjusted R-squared	0.914569	S.D. dependent var		0.217566
S.E. of regression	0.063592	Akaike info criterion		-2.460355
Sum squared resid	0.07279	Schwarz criterion		-2.165842
Log likelihood	35.52426	Hannan-Quinn criter.		-2.382221
F-statistic	50.24456	Durbin-Watson stat		1.818023
Prob(F-statistic)	0			

AFTER REMOVING LOGINDPI: Table 7



Dependent Variable: LOGBRENT				
Method: Least Squares				
Date: 05/05/23 Time: 15:14				
Sample (adjusted): 2021M01 2022M12				
Included observations: 24 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGIMPORTS	0.983915	0.255831	3.845965	0.0011
LOGSHAREP	-0.736381	0.23216	-3.171871	0.005
SHORT_TERM_INTEREST_RATES	-0.145445	0.022473	-6.47205	0
UNEMPLOYMENT_RATE	-0.178153	0.065109	-2.736213	0.0131
C	6.052208	1.852883	3.266375	0.0041
R-squared	0.931866	Mean dependent var		4.428487
Adjusted R-squared	0.917521	S.D. dependent var		0.217566
S.E. of regression	0.062483	Akaike info criterion		-2.524793
Sum squared resid	0.074178	Schwarz criterion		-2.279365
Log likelihood	35.29751	Hannan-Quinn criter.		-2.459681
F-statistic	64.96506	Durbin-Watson stat		1.725869
Prob(F-statistic)	0			

COINTEGRATION TEST OF BRENT CRUDE OIL: Table 8

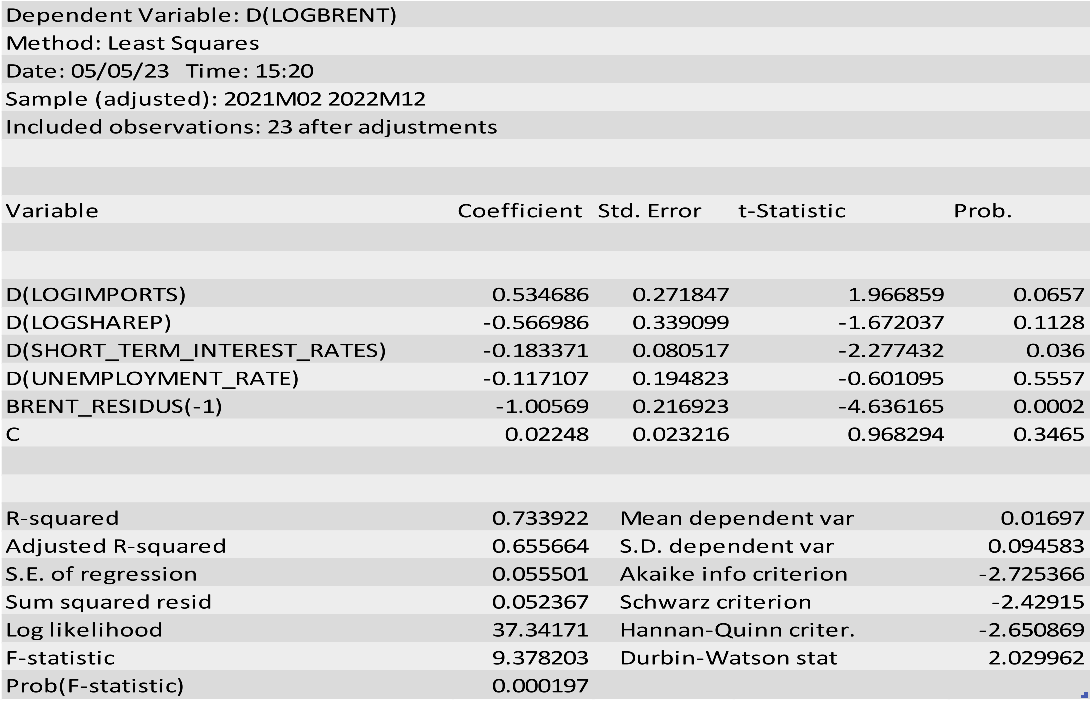


```
Cointegration Test - Engle-Granger
Date: 05/08/23   Time: 17:23
Equation: UNTITLED
Specification: LOGBRENT LOGEXP LOGIMPORTS LOGSHAREP
      SHORT_TERM_INTEREST_RATES UNEMPLOYMENT_RATE C
Cointegrating equation deterministics: C
Null hypothesis: Series are not cointegrated
Automatic lag specification (lag=1 based on Schwarz Info Criterion,
      maxlag=4)


                                                Value                Prob.*
Engle-Granger tau-statistic                        -6.371012  0.0128
Engle-Granger z-statistic                          -96.81694  0.0000


*MacKinnon (1996) p-values.
Warning: p-values may not be accurate for fewer than 30 observations.

Intermediate Results:
Rho - 1                                            -1.826208
Rho S.E.                                 0.286643
Residual variance                        0.001810
Long-run residual variance               0.010509
Number of lags                           1
Number of observations                   22
Number of stochastic trends**            6


**Number of stochastic trends in asymptotic distribution.

Engle-Granger Test Equation:
Dependent Variable: D(RESID)
Method: Least Squares
Date: 05/08/23   Time: 17:23
Sample (adjusted): 2021M03 2022M12
Included observations: 22 after adjustments


Variable             Coefficient          Std. Error           t-Statistic          Prob.


RESID(-1)                  -1.826208           0.286643           -6.371012                  0
D(RESID(-1))                0.585025           0.196842            2.972053             0.0075


R-squared                   0.709686  Mean dependent var                       -0.001056
Adjusted R-squared          0.695171  S.D. dependent var                        0.077052
S.E. of regression          0.042541  Akaike info criterion                    -3.390177
Sum squared resid           0.036195  Schwarz criterion                        -3.290991
Log likelihood              39.29195  Hannan-Quinn criter.                     -3.366812
Durbin-Watson stat          2.333902
```

The series are cointegrated.

SHORT RUN EQUATION

Table 9



Dependent Variable: D(LOGBRENT)
Method: Least Squares
Date: 05/05/23 Time: 15:20
Sample (adjusted): 2021M02 2022M12
Included observations: 23 after adjustments

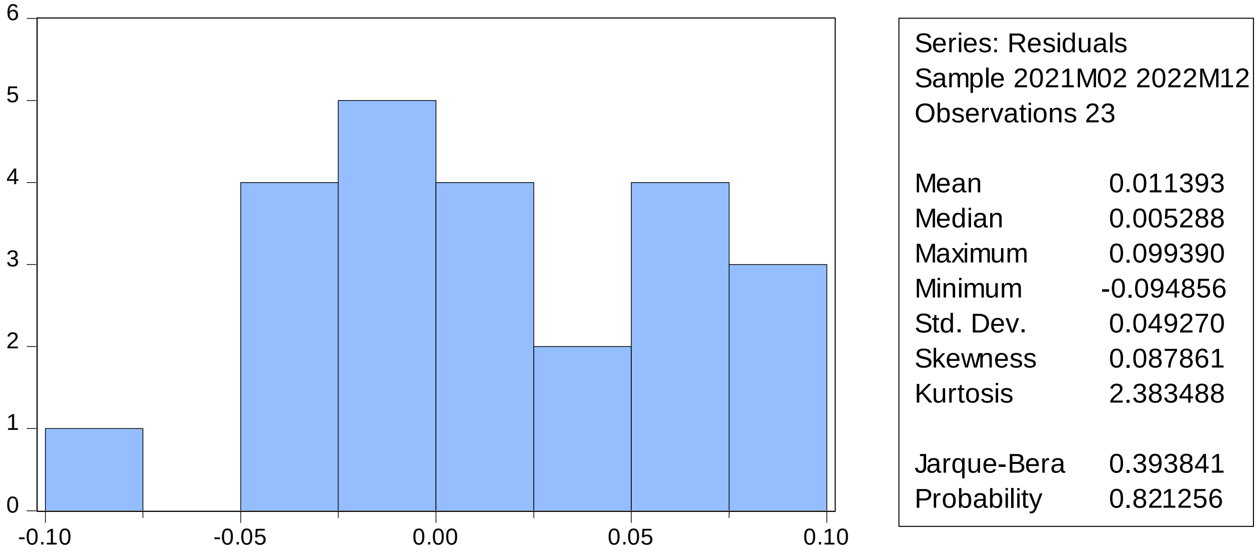
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LOGIMPORTS)	0.534686	0.271847	1.966859	0.0657
D(LOGSHAREP)	-0.566986	0.339099	-1.672037	0.1128
D(SHORT_TERM_INTEREST_RATES)	-0.183371	0.080517	-2.277432	0.036
D(UNEMPLOYMENT_RATE)	-0.117107	0.194823	-0.601095	0.5557
BRENT_RESIDUS(-1)	-1.00569	0.216923	-4.636165	0.0002
C	0.02248	0.023216	0.968294	0.3465

R-squared	0.733922	Mean dependent var	0.01697
Adjusted R-squared	0.655664	S.D. dependent var	0.094583
S.E. of regression	0.055501	Akaike info criterion	-2.725366
Sum squared resid	0.052367	Schwarz criterion	-2.42915
Log likelihood	37.34171	Hannan-Quinn criter.	-2.650869
F-statistic	9.378203	Durbin-Watson stat	2.029962
Prob(F-statistic)	0.000197		

MODEL DIAGNOSTICS

Normality Diagnostics

Figure 13



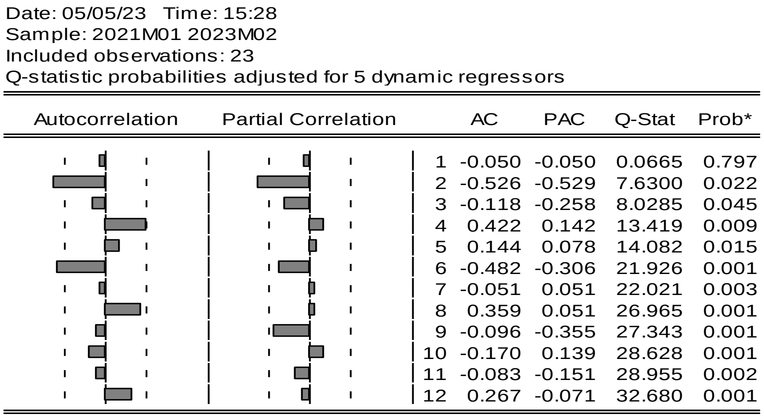
Series: Residuals
Sample 2021M02 2022M12
Observations 23

Mean	0.011393
Median	0.005288
Maximum	0.099390
Minimum	-0.094856
Std. Dev.	0.049270
Skewness	0.087861
Kurtosis	2.383488
Jarque-Bera	0.393841
Probability	0.821256

The probability of the jarque-bera statistic is greater than 0.05 suggesting that the residuals are normally distributed.

SERIAL CORRELATION:

Table 13

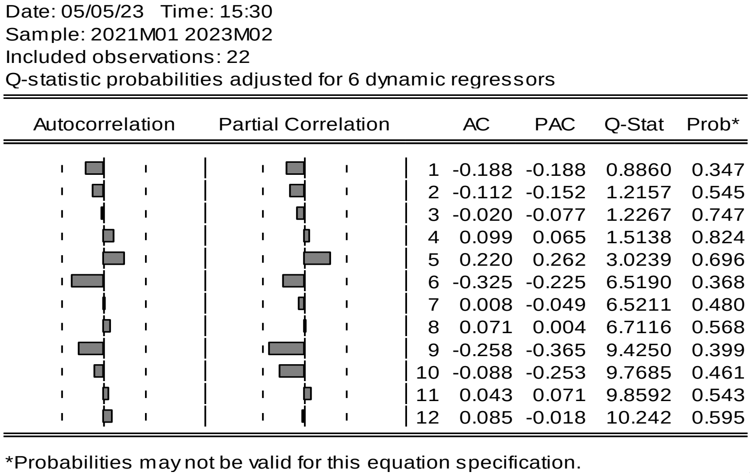


```
Date: 05/05/23   Time: 15:28
Sample: 2021M01 2023M02
Included observations: 23
Q-statistic probabilities adjusted for 5 dynamic regressors

  Autocorrelation    Partial Correlation       AC     PAC    Q-Stat   Prob*

                                           1 -0.050 -0.050  0.0665  0.797
                                           2 -0.526 -0.529  7.6300  0.022
                                           3 -0.118 -0.258  8.0285  0.045
                                           4  0.422  0.142  13.419  0.009
                                           5  0.144  0.078  14.082  0.015
                                           6 -0.482 -0.306  21.926  0.001
                                           7 -0.051  0.051  22.021  0.003
                                           8  0.359  0.051  26.965  0.001
                                           9 -0.096 -0.355  27.343  0.001
                                          10 -0.170  0.139  28.628  0.001
                                          11 -0.083 -0.151  28.955  0.002
                                          12  0.267 -0.071  32.680  0.001

*Probabilities may not be valid for this equation specification.
```

There’s evidence of serial correlation.

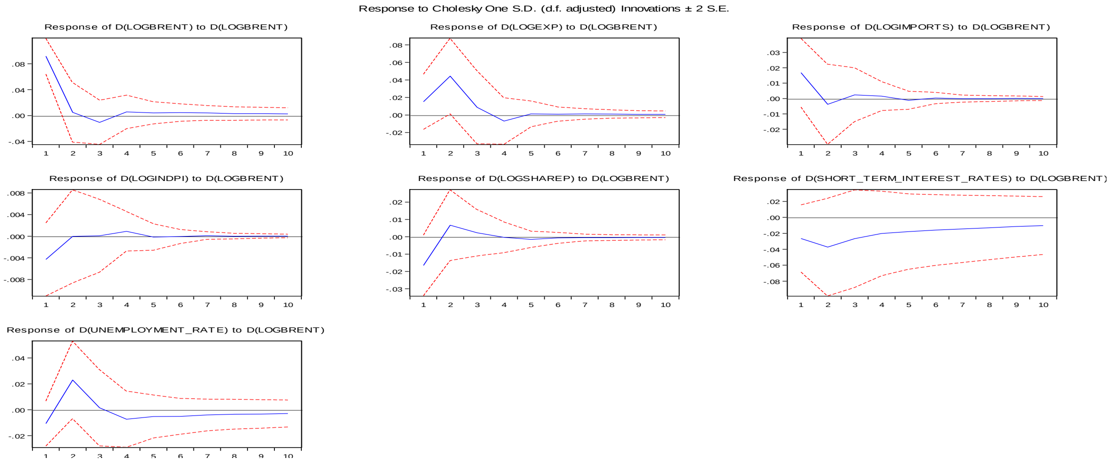
CORRECTING FOR SERIAL CORRELATION:Figure 14

Add the dependent variable lagged by one unit.

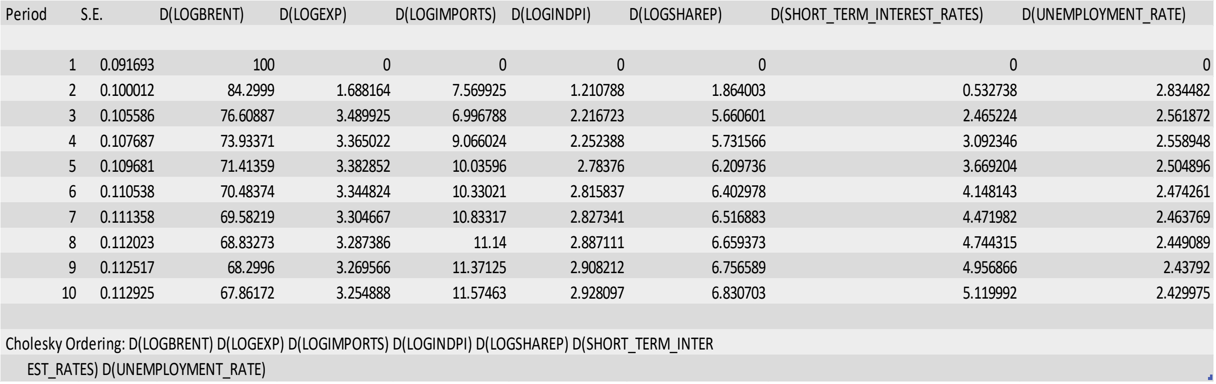


```
Date: 05/05/23   Time: 15:30
Sample: 2021M01 2023M02
Included observations: 22
Q-statistic probabilities adjusted for 6 dynamic regressors

  Autocorrelation    Partial Correlation      AC     PAC    Q-Stat   Prob*

                                          1 -0.188 -0.188  0.8860  0.347
                                          2 -0.112 -0.152  1.2157  0.545
                                          3 -0.020 -0.077  1.2267  0.747
                                          4  0.099  0.065  1.5138  0.824
                                          5  0.220  0.262  3.0239  0.696
                                          6 -0.325 -0.225  6.5190  0.368
                                          7  0.008 -0.049  6.5211  0.480
                                          8  0.071  0.004  6.7116  0.568
                                          9 -0.258 -0.365  9.4250  0.399
                                         10 -0.088 -0.253  9.7685  0.461
                                         11  0.043  0.071  9.8592  0.543
                                         12  0.085 -0.018  10.242  0.595

*Probabilities may not be valid for this equation specification.
```

IMPULSE RESPONSE FUNCTIONS: Figure 15



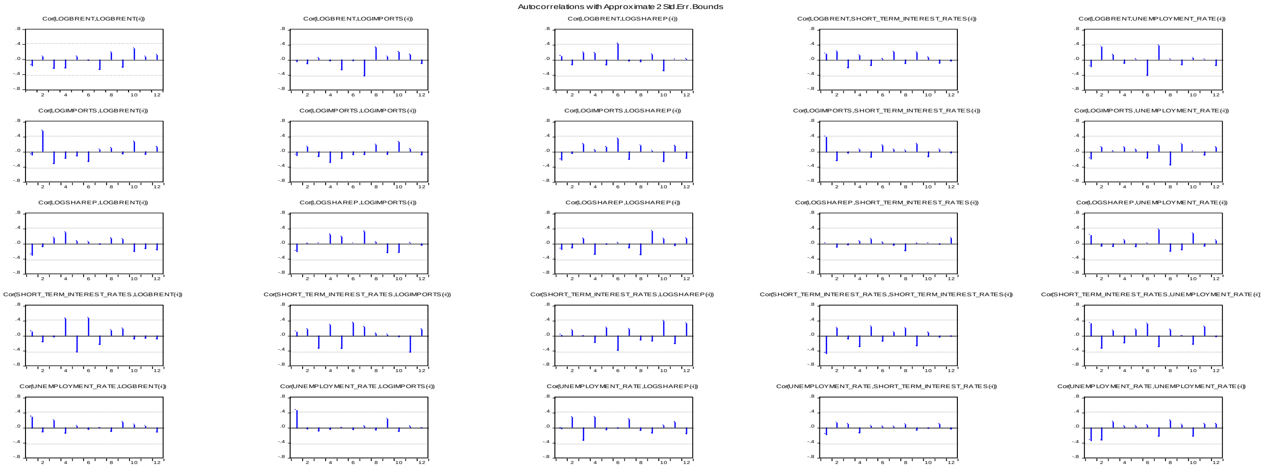
Cholesky Variance Decomposition: Table 14



Period	S.E.	D(LOGBRENT)	D(LOGEXP)	D(LOGIMPORTS)	D(LOGINDPI)	D(LOGSHAREP)	D(SHORT_TERM_INTEREST_RATES)	D(UNEMPLOYMENT_RATE)
1	0.091693	100	0	0	0	0	0	0
2	0.100012	84.2999	1.688164	7.569925	1.210788	1.864003	0.532738	2.834482
3	0.105586	76.60887	3.489925	6.996788	2.216723	5.660601	2.465224	2.561872
4	0.107687	73.93371	3.365022	9.066024	2.252388	5.731566	3.092346	2.558948
5	0.109681	71.41359	3.382852	10.03596	2.78376	6.209736	3.669204	2.504896
6	0.110538	70.48374	3.344824	10.33021	2.815837	6.402978	4.148143	2.474261
7	0.111358	69.58219	3.304667	10.83317	2.827341	6.516883	4.471982	2.463769
8	0.112023	68.83273	3.287386	11.14	2.887111	6.659373	4.744315	2.449089
9	0.112517	68.2996	3.269566	11.37125	2.908212	6.756589	4.956866	2.43792
10	0.112925	67.86172	3.254888	11.57463	2.928097	6.830703	5.119992	2.429975

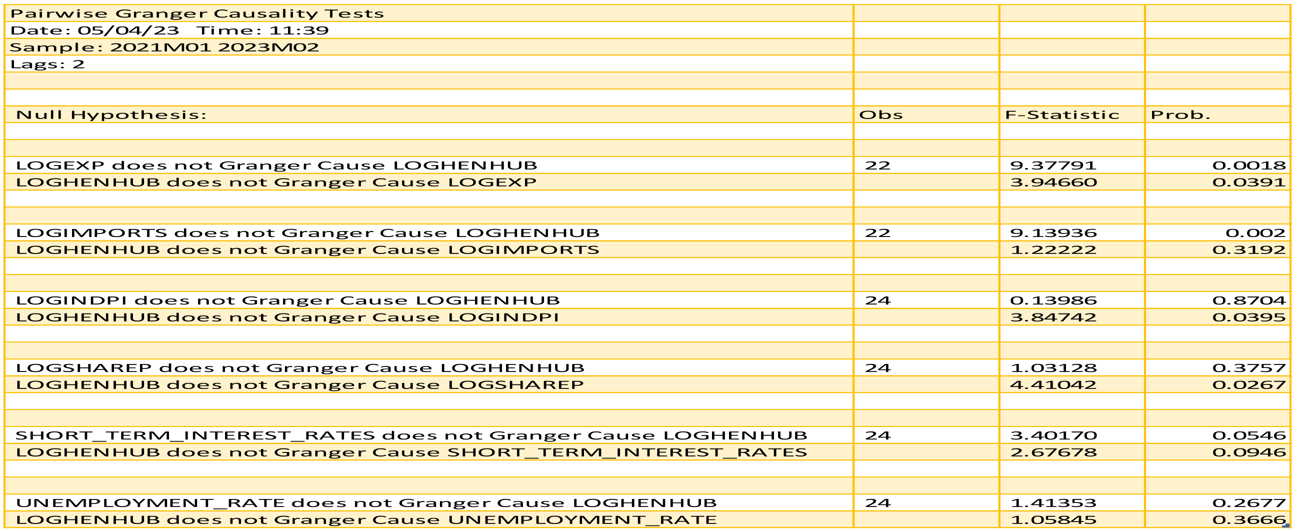
Cholesky Ordering: D(LOGBRENT) D(LOGEXP) D(LOGIMPORTS) D(LOGINDPI) D(LOGSHAREP) D(SHORT_TERM_INTEREST_RATES) D(UNEMPLOYMENT_RATE)

MODEL DIAGNOSTICS: Figure 16



HENRY HUB NATURAL GAS

GRANGER CAUSALITY ESTIMATION: Table 14



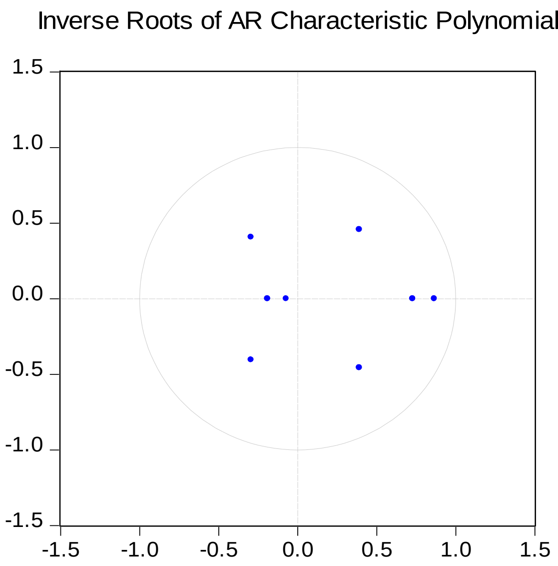
Pairwise Granger Causality Tests
Date: 05/04/23 Time: 11:39
Sample: 2021M01 2023M02
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
LOGEXP does not Granger Cause LOGHENHUB	22	9.37791	0.0018
LOGHENHUB does not Granger Cause LOGEXP		3.94660	0.0391
LOGIMPORTS does not Granger Cause LOGHENHUB	22	9.13936	0.002
LOGHENHUB does not Granger Cause LOGIMPORTS		1.22222	0.3192
LOGINDPI does not Granger Cause LOGHENHUB	24	0.13986	0.8704
LOGHENHUB does not Granger Cause LOGINDPI		3.84742	0.0395
LOGSHAREP does not Granger Cause LOGHENHUB	24	1.03128	0.3757
LOGHENHUB does not Granger Cause LOGSHAREP		4.41042	0.0267
SHORT_TERM_INTEREST_RATES does not Granger Cause LOGHENHUB	24	3.40170	0.0546
LOGHENHUB does not Granger Cause SHORT_TERM_INTEREST_RATES		2.67678	0.0946
UNEMPLOYMENT_RATE does not Granger Cause LOGHENHUB	24	1.41353	0.2677
LOGHENHUB does not Granger Cause UNEMPLOYMENT_RATE		1.05845	0.3666

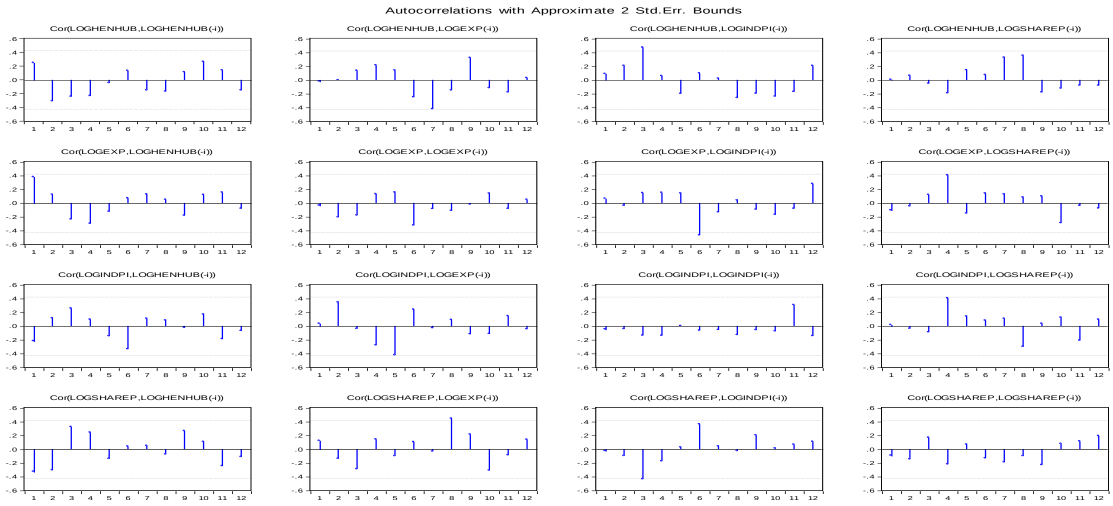
Cointegrated but the coefficient of the error correction term isn’t significant at 5% level. This calls for a VAR estimation.

MODEL STABILITY

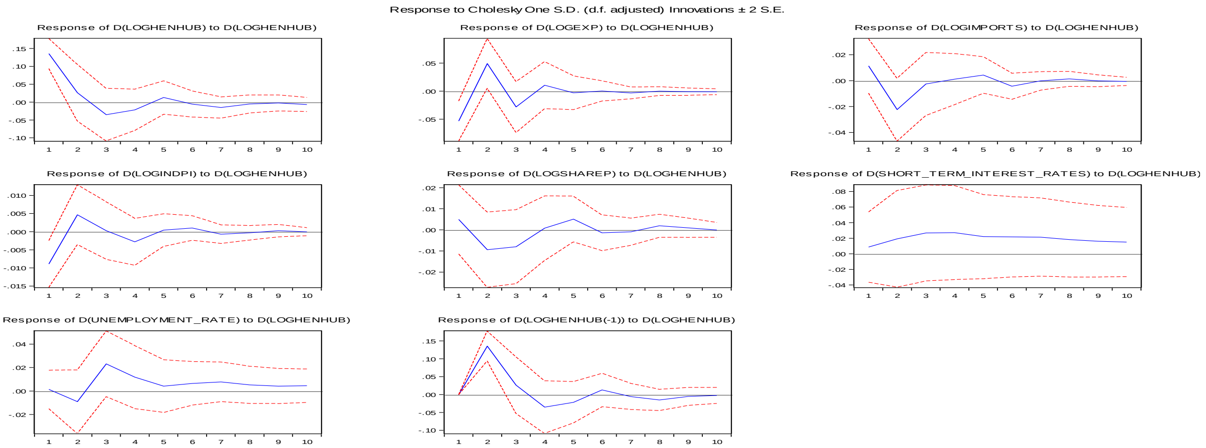
Figure 17



AUTOCORRELATIONS: Figure 18



HENRY HUB IMPULSE RESPONSE FUNCTIONS: Figure 19



CHOLESKY DECOMPOSITION
Table 15

Period	S.E.	D(LOGHENHUB)	D(LOGEXP)	D(LOGIMPORTS	D(LOGINDPI	D(LOGSHAREP)	D(SHORT_TER	D(UNEMPLOYMENT_RATE)
1	0.204815	100	0	0	0	0	0	0
2	0.222913	84.58631	2.815956	4.936347	5.498076	0.07112	2.056542	0.035653
3	0.231771	79.86345	3.214014	5.442686	8.842998	0.067209	2.401722	0.167922
4	0.241046	74.12057	3.381666	7.939598	10.02175	1.543807	2.753885	0.23872
5	0.243904	73.15344	3.348753	8.266693	10.16434	1.577486	3.23773	0.251565
6	0.244674	72.70621	3.343186	8.369135	10.1063	1.703036	3.51554	0.256589
7	0.246364	71.75587	3.300009	8.944873	10.17905	1.815754	3.73649	0.267953
8	0.247086	71.42051	3.292391	9.077757	10.15509	1.862479	3.918857	0.272918
9	0.247679	71.09592	3.277164	9.242249	10.13647	1.920974	4.050263	0.276964
10	0.248216	70.82124	3.263879	9.387207	10.1349	1.95794	4.154016	0.280822
Cholesky Ordering: D(LOGHENHUB) D(LOGEXP) D(LOGIMPORTS) D(LOGINDPI) D(LOGSHAREP) D(SHORT_TERM_INTE REST_RATES) D(UNEMPLOYMENT_RATE)								

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