CHANGES IN ENERGY PRICES DUE TO COVID AND DUE TO THE RUSSIA-UKRAINE WAR

By

Maria Katsigianni

Supervisor: Dimitrios Panagiotou

A thesis submitted in fulfillment of the requirements for the degree of

MASTER IN ECONOMIC ANALYSIS

DEPARTMENT OF ECONOMICS

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Contents

Abstract

Purpose: The purpose of this study is to examine and analyze the effects of Covid -19 and the Russia-Ukraine war on energy prices.

Methodology: A systematic literature review was conducted to collect and critically analyze the existing literature on the impact of the Covid-19 pandemic and the Russia-Ukraine war on energy prices. Studies of the last four years (2020-2023) that included empirical analyzes were selected and studied.

Results: Covid -19 had an impact on demand and supply, due to restrictive measures and a slowdown in economic activity, while the war in Ukraine caused geopolitical concerns and uncertainty. The coexistence of pandemic and war has caused complex fluctuations in energy prices, with different price reactions among different types of oil and derivatives, indicating the importance of geopolitical circumstances and specific characteristics of markets.

Conclusion: Both the Covid-19 pandemic and the Russia-Ukraine war have created significant disruptions and concerns in global energy markets, causing severe fluctuations in energy prices worldwide.

1. Introduction

The global energy landscape is characterized by great complexity as it is influenced by a variety of factors, such as technologies, resources and geopolitical dynamics that are constantly evolving (Chen & Wu, 2017).

Examining in more detail the main aspects of this landscape, it is first pointed out that the main energy sources are fossil fuels (oil, natural gas, coal), renewable energy sources (solar, wind, hydroelectric, geothermal, biomass) and nuclear energy. Due to growing environmental concerns, the previous dominance of fossil fuels in energy production is beginning to recede and there is an increasing shift to sustainable energy sources (Newell et al., 2020). The issue of climate change that has brought about a transformation of the energy landscape, in order to address and prevent the effects of this phenomenon, leading to a global energy transition. For example, several states are implementing policies aimed at sustainability (Chen et al., 2019). Also, the evolution of energy technologies (e.g. wind turbines, photovoltaics, etc.) has contributed to the transition to more sustainable energy sources.

Regarding energy consumption and demand, there is an increase in proportion to population growth, urbanization and increasing industrialization, while regarding energy production, various geopolitical factors play a role. These factors (e.g. supply and demand dynamics, existence or lack of resources in a geographical area, etc.) affect the global energy markets and the negotiations of energy commodities (oil, electricity, natural gas), with implications for price stability (Favennec, 2011). Particularly in case of geopolitical tensions, energy production and distribution are disrupted and prices fluctuate widely. In this context, the role of governments is crucial, shaping the global energy landscape according to the policies they follow (Austvik, 2018). For example, applied policies may focus on promoting energy efficiency, providing incentives for the adoption of renewable energy sources, etc.

The energy landscape today is faced with a variety of challenges, such as the issue of energy security. It is very important to ensure that the energy supply is reliable and stable. Other challenges are energy poverty, the lack of appropriate infrastructure to help transition to sustainable energy systems, etc. (Thrän et al., 2020).

The importance of energy commodities, both at the level of the global economy and at the level of everyday life, is particularly important. Energy products are the lifeblood of modern civilization, serving as a driving force for economic growth and global trade, as a foundation for technological advancements and human well-being. Energy commodities are the basis of the transport sector, the production of electricity, they are necessary for the cooling and heating of homes, the smooth operation of health facilities, educational institutions, agriculture, etc. (Uribe-Toril et al., 2019).

In general, energy commodities form the basis of modern society, affecting all areas of human activity. Due to the diverse and interrelated factors that shape the global energy landscape, the production, distribution and consumption of energy is determined by various types of crises that occur (Baffes & Nagle, 2022). In recent years, the two most important events affecting the whole world are the outbreak of the Covid-19 pandemic and the Russia-Ukraine war. These crises significantly affected the energy sector, disrupting energy prices, while highlighting the complex interactions between economics, geopolitics and energy markets (Zakeri et al., 2022).

The issue of changes in energy prices due to the pandemic and the Russia-Ukraine war is the subject of this paper. The purpose is to examine and analyze the effects of these two major crises on energy prices. To achieve this goal, international literature is examined that studies how energy prices are affected by specific global crises and that highlights the interaction between geopolitical tensions, public health crises and the energy sector. With the completion of the present study, it is sought to strengthen the existing knowledge regarding energy prices and the effects of their changes on the energy future of the world, as well as to highlight issues for further investigation.

The thesis consists of four chapters. The first chapter examines energy commodities (WTI crude oil, Brent, natural gas, gasoline). The method and countries of production of each product and their export countries are presented. In addition, the impact of energy commodities on global economies and societies is examined.

The second chapter analyzes the role of various crises (economic crises, geopolitical conflicts, natural disasters, public health emergencies) on energy prices.

The third chapter analyzes the methodology followed in the present research.

The fourth chapter presents the results of the research regarding the impact of Covid-19 and the Russia-Ukraine war on energy prices.

The discussion follows, where issues for further study are highlighted, and the paper concludes with the conclusions.

2. Literature review

2.1. Energy commodities

2.1.1 WTI crude oil

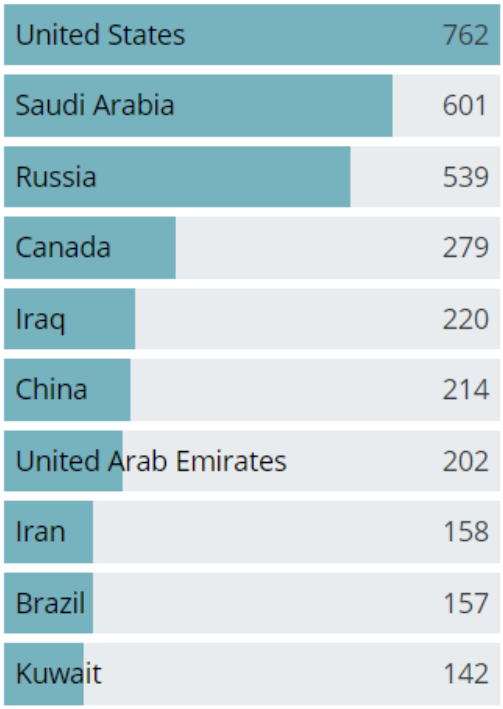
West Texas Intermediate (WTI) crude oil is one of the most widely traded types of oil in the world. Its main characteristics are that it is a very light and sweet high-quality crude oil, with a high API grade (American Petroleum Institute) and a low sulfur content. The API grade measures the density and degree of dilution of the oil. WTI's high API grade (39.6) means it has a low density, which makes it lighter and thinner compared to other types of crude oil. In addition, due to its low sulfur levels (0.24%), it is classified as a "sweet" crude oil. This characteristic makes it suitable for the production of clean fuels and light petroleum products (Devold, 2013). Due to its high quality, it is in high demand and is a key benchmark for oil prices.

The production of WTI crude oil is a complex process involving several stages. Initially, the relevant geological exploration is carried out based on geological studies and geophysical tests in order to identify natural sources of oil below the Earth's surface. When these areas are identified, drilling operations begin. Mining is the first phase of WTI production. With the use of drills, holes are drilled in the Earth's crust, reaching great depths below the surface to reach the oil-bearing layers. During drilling, oil is pumped from the core of the earth. Pumps are used to draw oil from underground reservoirs to the surface. This oil is mixed with gases and water and needs additional processing (Monge et al., 2017). Through pipelines and tankers, the extracted crude oil is transported to ports and processing facilities, where it undergoes various processing processes, including the removal of various undesirable substances such as sulfur compounds, minerals and hydrocarbons, and the improvement of its quality. In the refinery, crude oil undergoes further processing to separate various components, such as gasoline, diesel, etc. Refining is a complex process that involves distillation, cracking and other chemical processes to produce different petroleum products (Monge et al., 2017). After its refining process, crude oil is transferred to tanks for further storage and distribution.

On a global scale, more than 4 billion metric tons of oil are produced annually. The leading countries in crude oil production are the USA, Saudi Arabia, Russia,

Canada, followed by Iraq, China, etc. (Peng et al., 2020). In Table 1 below, the ten countries with the largest crude oil production for the year 2022 are presented.

Table 1. Ranking of countries in terms of crude oil production (Unit: Mt)



Source: https://yearbook.enerdata.net/crude-oil/world-production-statistics.html

Based on the above data, it is found that the largest oil producing country in the world is the USA, where 18.9% of global crude oil production is produced, followed by Saudi Arabia and Russia with 12% respectively (Enerdata, 2023).

Global crude oil production rebounded more than 5% in 2022, well above its historical trend. In 2022, there was a significant increase in global crude oil production compared to previous years, at a rate that exceeded 5% (Enerdata, 2023). Crude oil production increased in many regions and decreased in others. Table 2 shows in more detail the countries where crude oil production increased and decreased in 2022, as well as the percentage of increase.

Table 2. Areas where crude oil production increased and decreased (2022)

Increased production	
Saudi Arabia	+16%
Arab Emirates	+15%
Algeria	+11%
Kuwait	+8,1%
Iran	+5,9%
USA	+6,5%
Canada	+2,6%
Brazil	+3,9%
Russia	+2,1%
China	+2,7%
Reduced production	
Africa	-14%
Indonesia	-7%
Malaysia	-8,6%
Thailand	-19%
Norway	-4,1%
United Kingdom	-7,5%

Source: https://yearbook.enerdata.net/crude-oil/world-production-statistics.html

As mentioned above, the largest crude oil producing countries in the world are the USA, Saudi Arabia and Russia, as they account for almost half of global oil production (43%) by 2022. Given this, the main crude oil exporting countries are Saudi Arabia (14.5%), Russia (11.8%), Canada (8.54%), Iraq (7.57%) and the USA (7.11%) (Figure 1) (OEC, 2023). In fact, the largest exporting country, Saudi Arabia, aims to increase its production capacity by 2027 to 13 million barrels/day, while in 2021 its production reached almost 11 million barrels (Yang et al. , 2022).

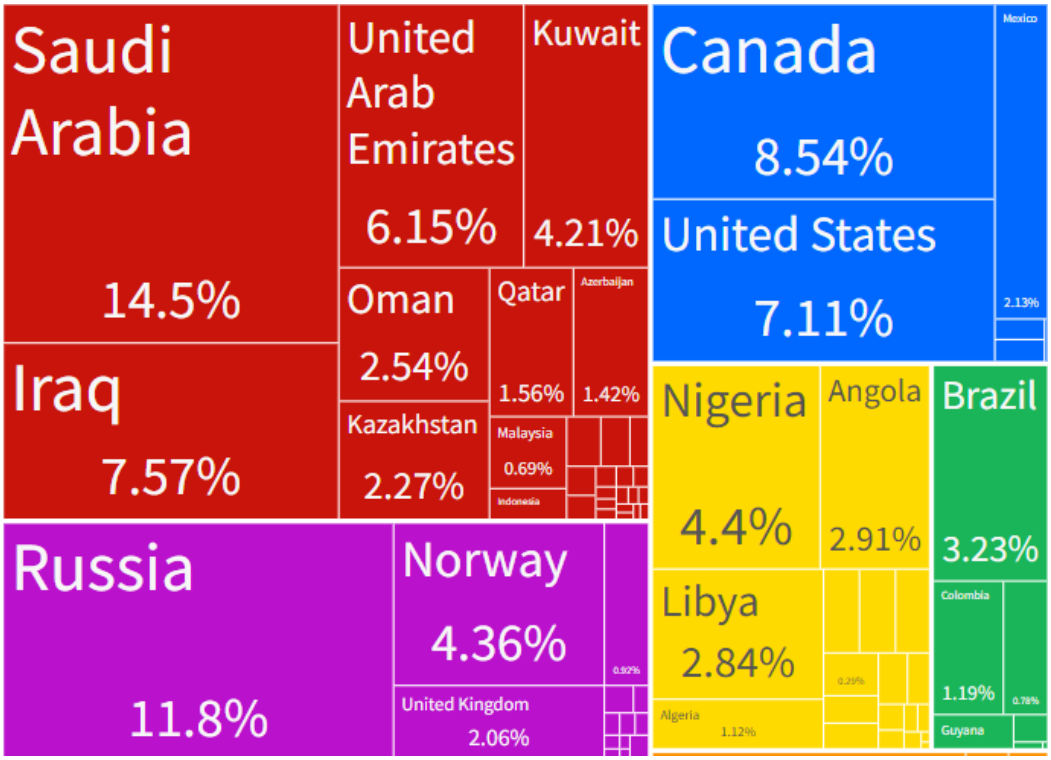


Figure 1. The main exporters of crude oil (2022)

Source: https://oec.world/en/profile/hs/crude-petroleum?latestTrendsScaleSelector=Trade+Value+Growth#exporters-importers

Regarding the price of WTI crude oil, it shows an extremely significant increase from 1976 to 2022, as shown in the figure below (Figure 2). However, the summer of 2023 saw a decrease in its average price compared to 2022, as from $94.9/barrel its price reached $74.9 (OEC, 2023).

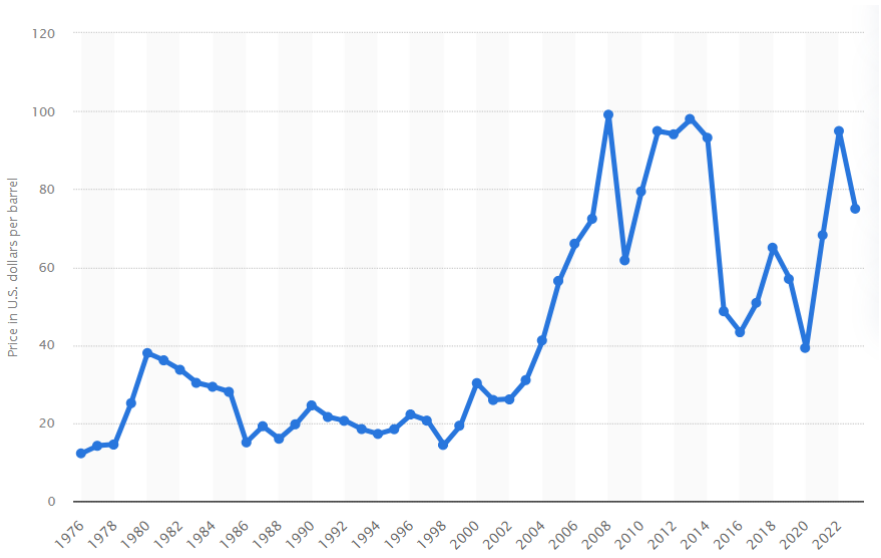


Figure 2. Average Annual WTI Crude Oil Price (1976-2023)

Source: https://www.statista.com/statistics/266659/west-texas-intermediate-oil-prices/

The following figure (Figure 3) shows the value of crude oil exports in the period 2011-2021.

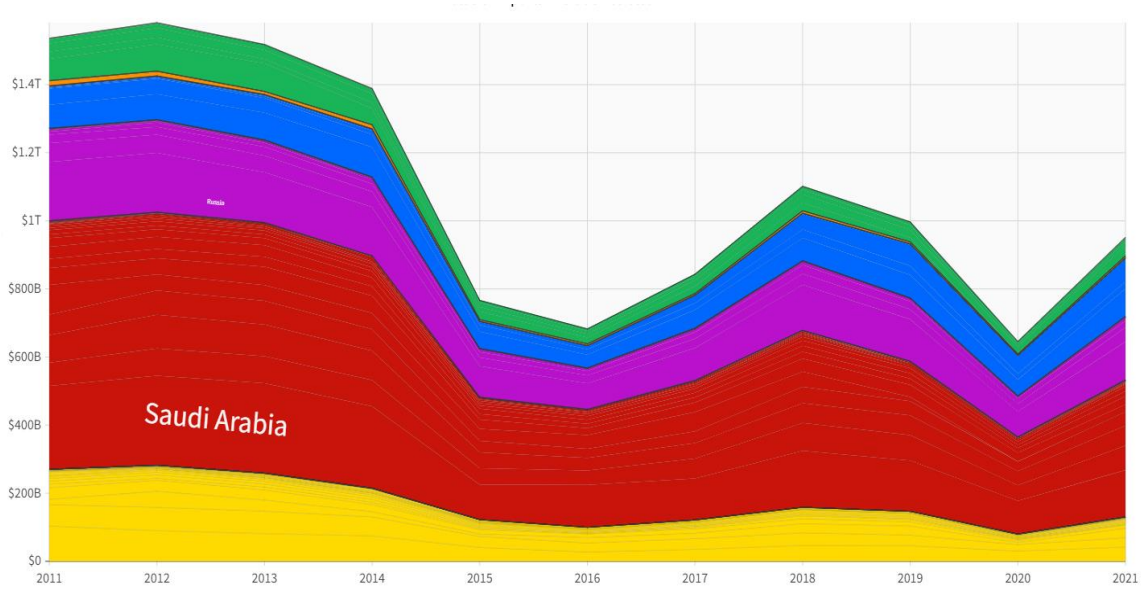


Figure 3. Crude oil export value (2011-2021)

Source: https://oec.world/en/profile/hs/crude-petroleum?latestTrendsScaleSelector=Trade+Value+Growth#exporters-importers

2.1.2 Brent

Brent crude oil is produced from fields located in various areas of the North Sea. The fact that it is mined from different areas off the coast of the UK, means mixing different grades of oil (Brent, Forties, Osberg, Ekofisk) making it heavier. Brent's API grade is at 38 and sulfur levels at 0.40%. In general, although heavier than WTI, Brent oil is considered relatively light and low in sulfur (FocusEconomics, 2016).

The production process of Brent is similar to that of WTI. However, due to the location from where it is mined, it is easier and less expensive to transport as it is waterborne. After mining, it is transported by floating vessel to the FPSO (Floating Production Storage & Offloading) platform (Figure 4). Brent is processed and stored there. From the FPSO platform, oil can easily be transported by tanker to various parts of the world or shipped by pipeline to UK storage facilities and refineries.

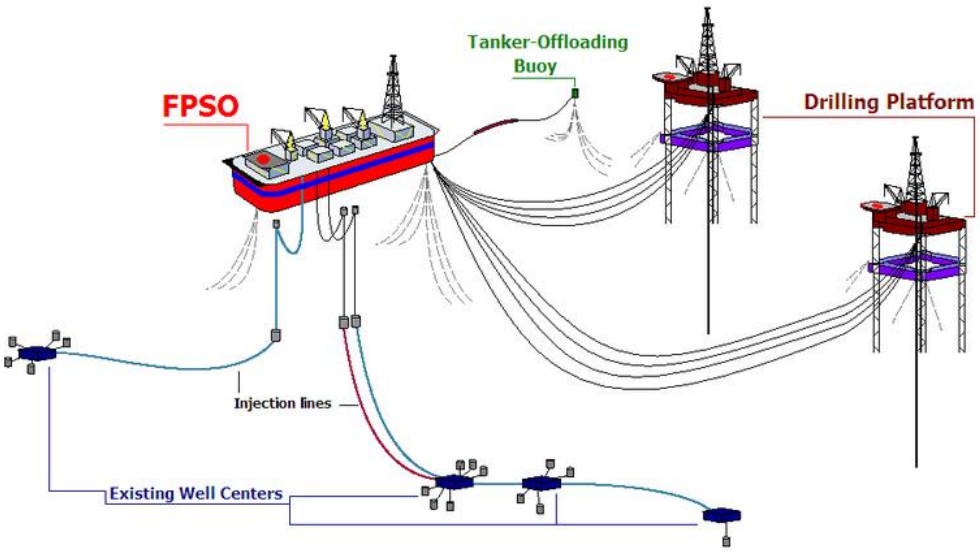


Figure 4. Brent crude oil production and storage process

Source: https://en.wikipedia.org/wiki/Floating_production_storage_and_offloading

Overall, Brent is a high-quality oil. Compared to WTI, it is less light and "sweet" but easier to mine and transport, which makes it an attractive investment. The main differences between Brent and WTI are shown below in Figure 5.

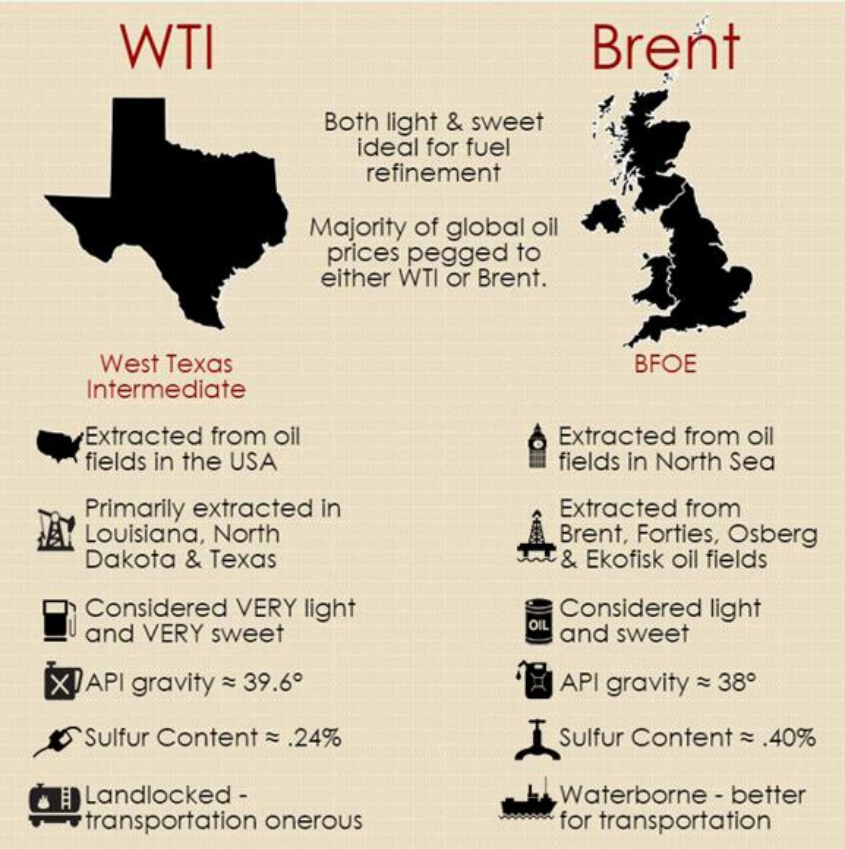


Figure 5. WTI and Brent differences

Source: focus-economics.com

As the Brent oil fields are located in the North Sea, it is produced and exported from the United Kingdom.

Like WTI, Brent is a key benchmark for determining oil prices worldwide. Brent turnover is an important indicator for monitoring oil market activity and prices and is affected by many factors (geopolitical developments, economic conditions, demand for energy, production activities in mining areas). Changes in the Brent turnover can have significant effects on crude oil prices and, therefore, on the economy worldwide (Katyukha & Mottaeva, 2022).

Crude oil prices have generally been volatile in recent years due to various geopolitical events (2009 financial crisis, Covid-19 pandemic, Russia-Ukraine war). In the summer of 2023, a decrease in the average annual price of Brent was observed compared to the previous year by $21, as it reached $79.75/barrel (Figure 6).

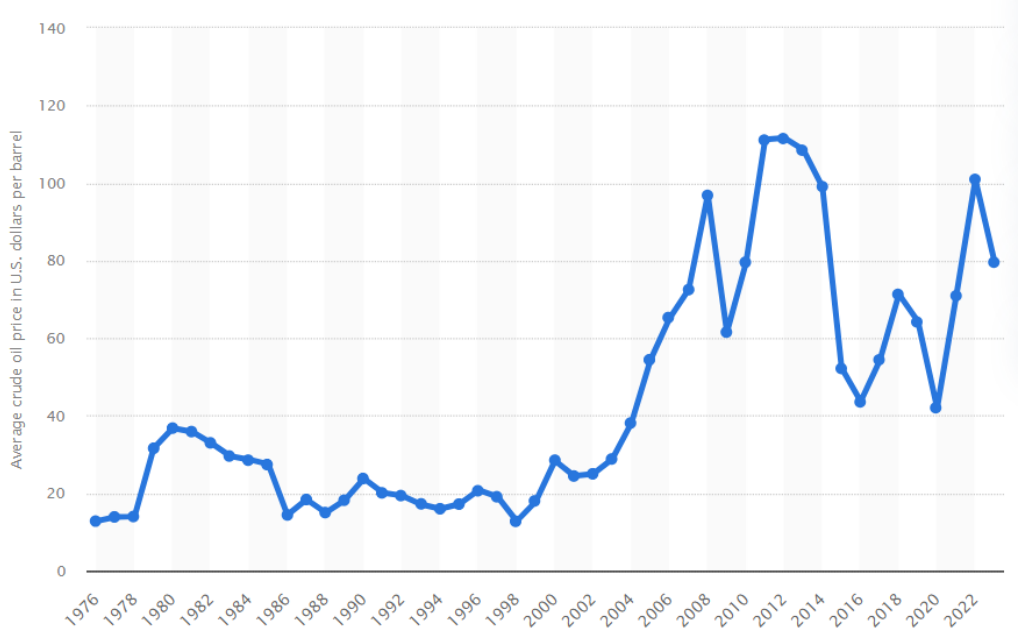


Figure 6. Average annual Brent price (1976 – 2023)

Source: https://www.statista.com/statistics/262860/uk-brent-crude-oil-price-changes-since-1976/

2.1.3 Natural Gas

Natural gas is a non-renewable resource resulting from the decomposition of organic matter under anaerobic conditions and the effect of high temperatures and underground pressure. The discovery of natural gas in underground geological formations is usually done alongside other fossil fuels (e.g. oil). Natural gas is very light, as its density is less than air (0.55). It consists mainly of methane, but also includes other hydrocarbons in low concentrations (oxygen, water, nitrogen, carbon dioxide, sulfur compounds) (Devold, 2013).

The production of natural gas involves many stages, from extraction to its storage and distribution. The first step is to extract the natural gas, since a suitable location has already been identified. In this stage, the volume of underground gas is extracted from the underground rock formations by various practices, such as drilling. During mining, pressure management is critical for effective gas release. For this

purpose, various techniques are used, such as impact pump and pressure regulation. Also, at this stage, the quantities of gas released are monitored and measured, and sampling is done for quality analysis (Morgan, 2015).

The transportation process in natural gas production refers to how extracted gas is transported from the extraction site to processing plants or storage facilities. There are several ways to transport natural gas, depending on the distance and local conditions. The use of pipelines is the most common mode of transport. The gases are transported over long distances in special pipelines connected to the processing and storage units. Also, natural gas is transported via ships. This method is mainly used to transport large quantities of natural gas between countries and continents. In smaller-scale transport, it is preferred to transport it by truck, in the form of compressed natural gas (CNG). To transport large quantities with a smaller volume, natural gas is transported in the form of liquid natural gas (LNG) with special vessels (Faramawy et al., 2016).

Before natural gas is ready for distribution and use, it must be processed. During processing, natural gas undergoes various processes to remove impurities and improve quality, as well as to adapt it for specific uses. Natural gas usually contains moisture, which must be removed, as it can cause various problems during transport and use. Removal of moisture is usually achieved by a cold or hot dewatering process. Also, the pressure of natural gas must be regulated to the appropriate levels for its safe transport and use (Coburn, 2020). Natural gas can contain various components such as ethane, methane, propane, etc. Various processes are used to separate the components by gas type to produce higher quality gases. Also, the gas may contain other impurities, such as carbon dioxide, sulfur and other gases. These impurities must also be removed to bring the gas up to quality specifications. During processing, the gas is subjected to quality analysis to ensure that it meets the specifications and quality standards set by the relevant authorities (Morgan, 2015).

With the completion of the natural gas processing procedures, it is stored in special facilities. It is mostly stored in underground storage systems, in special gas tanks, which are safe and offer a large storage capacity. In some cases, natural gas is stored in special tanks on the ground surface (Coburn, 2020).

Natural gas production has increased significantly in recent years, as shown in the figure below (Figure 7).

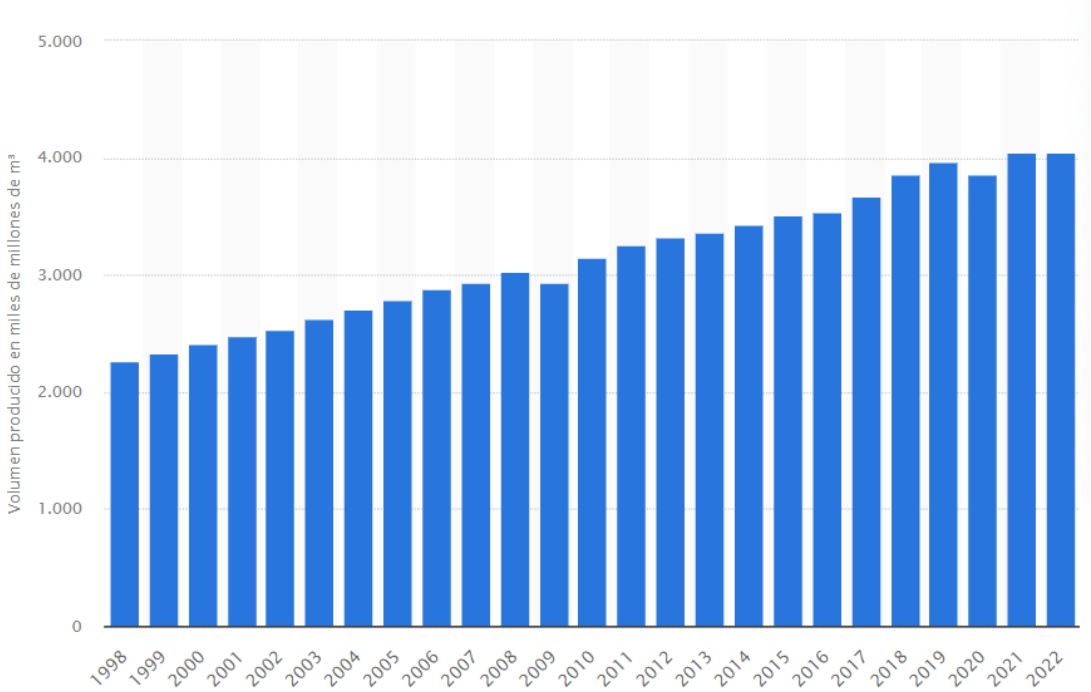


Figure 7. Total global natural gas production from 1998 to 2022

Source: https://www.statista.com/statistics/265344/total-global-natural-gas-production-since-1998/

Several countries are leading the way in natural gas production, with the US leading the way. A factor of almost 1.03 trillion. cubic meters, the US accounts for nearly 1/4 of world production. Additionally, in early 2022 due to the Russia-Ukraine war, natural gas shipments to Europe increased, making the US the world's largest LNG (liquefied natural gas) exporter. Russia, possessing the largest natural gas reserves and producing approximately 699 billion cubic meters, is the second most important country in the production and export of natural gas. The third place in the production of natural gas is held by Iran, which represents almost 6% of the world production producing about 244 billion cubic meters. After Russia, the Middle East has the most natural gas reserves, but due to insufficient infrastructure, the region is far behind the US and Russia. It is pointed out that in 2022 the natural gas produced in Iran corresponded to 1/4 of the US production and 1/3 of the Russian production.

In the last decade, there has been a doubling of natural gas production in China, reaching almost 219 billion cubic meters. However, the country remains dependent on

imports to meet its demand. Another important country in the production and export of natural gas is Canada. It has reserves and produces about 205 billion cubic meters. Qatar also holds an important position in the production of natural gas, as its reserves are the third largest in the world and it produces approximately 170 billion cubic meters. It is also the third largest natural gas exporting country. Australia (production 162 billion cubic meters), Norway (production 128 billion cubic meters), Saudi Arabia (production 105 billion cubic meters) and Algeria (production 102 billion cubic meters) (Enerdata, 2023b).

In 2021, global natural gas production had increased (4.3%), but in 2022 it remained overall stable (4.09 trillion cubic meters). In 2022, several countries cut gas production and others increased it. A significant decrease was observed in Russian production (-12%). However, Russia remains the second largest producer and exporter of natural gas (Investing News Network, 2023).

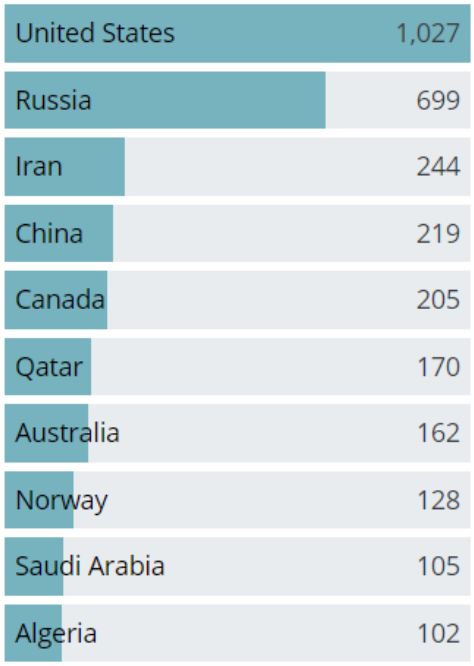
The following table (Table 3) shows the countries in which production decreased and those in which it increased, while Table 4 shows the total global natural gas production for the year 2022.

Table 3. Reduction and increase in natural gas production by region in 2022

Reduced production	
Russia	-12%
Netherlands	-15%
Brazil	-7%
Africa (Egypt, Algeria, Nigeria)	-4,8%
Increased production	
USA	+4,3%
Canada	+7,3%
Australia	+7,3%
China	+6%
Latin America	+3,7%
Middle East	+3,2%

Source: https://yearbook.enerdata.net/natural-gas/world-natural-gas-production-statistics.html

Table 4. Total natural gas production by country in 2022 (unit: Bcm - billion cubic meters)



Source: https://yearbook.enerdata.net/natural-gas/world-natural-gas-production-statistics.html

Recent geopolitical developments, specifically the Russia-Ukraine war, have had an impact on natural gas supplies, imports and exports worldwide. In Europe, natural gas supplies from Russia fell significantly, but higher supply from Norway offset this loss so that the overall decline in European imports in 2022 will reach only 1.3%. A contraction of imports by 6.4% was observed in Asia and by 24% in Latin America. On the other hand, there was an increase in exports by 23% to the Middle East, by 12% to Canada and by 9.2% to Australia (Enerdata, 2023b).

In Table 5, the trade balance of natural gas is presented, and in Figure 9, the global natural gas price index for the period 1992 – 2022.

Table 5. Natural gas trade balance

China	133.4
Japan	94.8
Germany	83.8
Italy	68.1
South Korea	61.5
Mexico	60.9
Turkiye	54.1
France	41.2
Spain	33.9
United Kingdom	33

Source: https://yearbook.enerdata.net/natural-gas/balance-trade-world-data.html

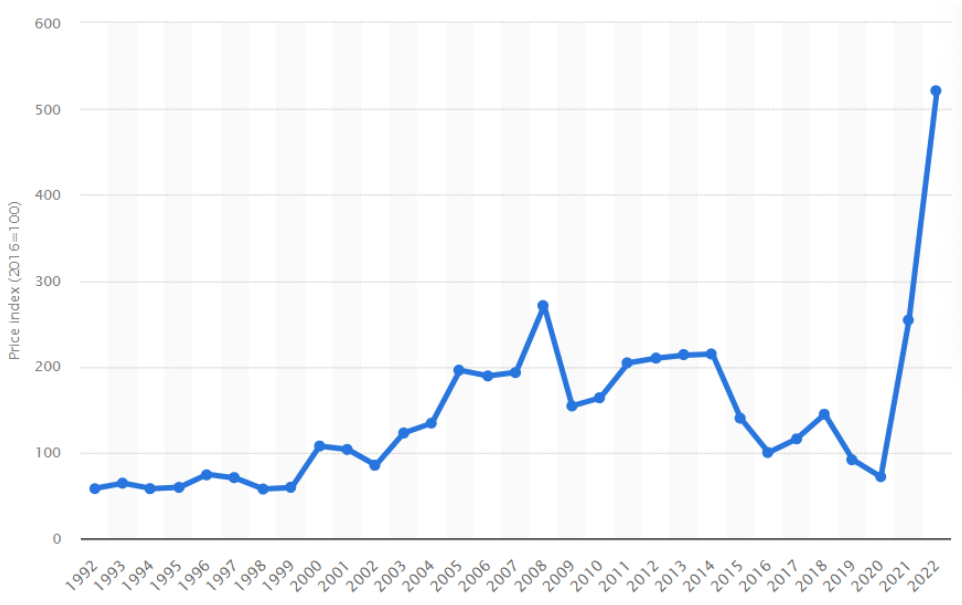


Figure 9. Global natural gas price index (1992 – 2022)

Source: https://www.statista.com/statistics/1303056/natural-gas-price-index-worldwide/

2.1.4 Gasoline

Gasoline is a colorless, light liquid, volatile and flammable. It comes mainly from oil refining. It has a characteristic odor and distills at a temperature between 40° and 210° C.

Gasoline production is a complex process involving many stages and various processes. The distillation process is the first step in the production of gasoline. In distillation, the oil is heated to high temperatures in a separator column, and the various liquid and gaseous products are separated based on the temperature. Distilled petroleum enters the stage where the liquid products are separated according to their density into various products such as gasoline, diesel and fuel oil (Ayanoğlu & Yumrutaş, 2016). The distilled oil is then subjected to hydrogenation, a process in which hydrogen is added to the oil to improve the quality and yield of the product. This is an important step in improving the quality of gasoline. The distilled oil is then subjected to various processes to remove impurities and by-products such as sulfur and aromas. In the final phase, various additives are added to gasoline to improve its performance and quality, such as antimony to increase the octane number and anti-corrosion additives (Ayanoğlu & Yumrutaş, 2016).

There are different types of gasoline, with different composition and value, depending on the type of oil used to produce it. In order to compare types of gasoline, the octane scale is used, characterizing each type of gasoline by its octane number (the higher the octane number, the better the performance of the gasoline).

Since gasoline is derived from oil, it is produced in the leading oil producing countries. Thus, the USA, Saudi Arabia, Russia and Canada are the main gasoline producing countries. Accordingly, the above countries are also the largest exporters of gasoline in the world (Eia, 2023).

Additionally, the price of gasoline is directly related to the price of crude oil. Thus, in 2022 as raw materials increased significantly, so did the price of petrol, which doubled in the UK and in Japan saw a 40% increase (Eia, 2023).

2.2. The role of various crises on energy prices

2.2.1 Financial crises

Financial crises can affect energy prices in a number of ways, as they create uncertainty, demand impacts and pressures on financial markets.

More specifically, financial crises have serious effects on energy demand. During financial crises, economic activity usually declines. Businesses are reducing production and consumers are cutting back on spending as they face uncertainty about their financial situation. This decrease in economic activity leads to a decrease in demand for energy (Chang et al., 2020). At the same time, in times of crisis, consumers and businesses may revise their energy standards. They may reduce their energy use through conservation, seek more efficient energy options such as renewables, reduce their commutes, thus affecting the demand for oil and other fuels. Some industries, such as construction and processing, react more strongly to economic downturns by reducing their activities and consequently affecting the demand for energy (Timma et al., 2016). Also, consumer confidence plays an important role in energy demand. During crises, uncertainty and fear about the future can lead to curbs on consumer spending, including on energy. In addition, the reduction in energy demand reinforces oversupply, thus affecting energy prices in markets (Bhar & Malliaris, 2011).

Financial turmoil can increase risk for investors. Investors' reaction to uncertainty and economic volatility can affect the flow of capital into the energy sector. More specifically, during financial crises, companies and investors are more hesitant about their investments. High risks and uncertainty accompanying investment decisions may reduce investment in new energy projects (Shahbaz et al., 2021). The effect of economic crises is also significant in the field of financing. During crises, banks and financial institutions may be less willing to provide loans for energy projects due to uncertainty and high risk. This can affect the implementation of new projects and the development of the sector. Also, capital markets often react negatively to crises, reducing the value of investments. Companies operating in the energy sector may face a fall in the value of their shares, thus reducing the possibility of financing their investments (Vatsa & Miljkovic, 2022). It is even possible that companies will review their operations and investment strategies and focus on lower risk projects or choose to keep existing projects running instead of investing in new ones. Overall, investment risk during

financial crises affects energy market dynamics, affecting investor decisions and the availability of capital for the sector (Bencivenga et al., 2012).

Since oil and natural gas are key components of the global energy system, their prices are significantly affected by financial crises. First, reduced demand for energy can push prices down, as mentioned above. In addition, due to uncertainty and reduced demand during crises, companies may limit their investments in oil and gas extraction and production. Thus, supply is reduced and prices are affected accordingly (Shahbaz et al., 2021). At the same time, the difficulty of financing oil and natural gas companies, which usually use financial capital to finance their investments, slows down developments in the sector, potentially increasing prices (Bencivenga et al., 2012). The fall in the share prices of these companies, due to the general decline in the capital markets, also affects the value of them and their investments.

The renewable energy sector is also affected by financial crises. During such times, investment in renewable energy sources may decline, as companies and investors often focus on more traditional forms of energy that are considered more stable and profitable in the short term. In some cases, the reduction in energy demand during crises can lead to a drop in prices in energy markets, including renewables (Shahbaz et al., 2021). This can pose a challenge for renewables, as some of them depend on subsidies and other incentives to be economically competitive.

Financial crises often affect policy interventions in the energy sector. Governments may react with changes in subsidies and incentives particularly for renewable energy sources, reducing or increasing support for the development of renewable projects, depending on economic conditions (Timma et al., 2016). Also, there may be changes in legislation affecting renewable energy sources, such as the imposition of new environmental standards or changes in renewable energy policies (Vatsa & Miljkovic, 2022). In general, political interventions during financial crises can affect the operating framework of renewable energy sources, either positively or negatively, depending on the policy choices of governments.

A typical example is the financial crisis of 2008, which had wide-ranging effects on energy prices worldwide (Bhar & Malliaris, 2011). It affected most countries, either through the reduction in demand due to the recession or through the financial impact on energy investment. During the economic crisis, industrial activity was significantly

reduced in many countries, leading to reduced demand for energy and affecting prices. China, as a major energy consumer, has been hit by a decline in its export activity, resulting in lower energy demand. The recession in the United States reduced industrial activity and energy demand, leading to a drop in oil and natural gas prices. For example, the price of WTI crude oil fell from around $145 per barrel in 2008 to less than $40 per barrel by the end of 2008 (Bhar & Malliaris, 2011). The drop in oil prices had a serious impact on the revenues of Russia, which was heavily dependent on oil exports. Overall, the 2008 financial crisis had a multidimensional impact on energy prices, affecting energy demand, supply and investment worldwide.

2.2.2 Geopolitical conflicts

Geopolitical crises refer to situations where political instability or conflict affects relations between countries or regions. These crises are usually closely related to energy, especially when the countries involved have significant energy resources or are dependent on energy imports (Pascual & Zambetakis, 2010). Resources, such as oil and natural gas, are often the subject of competition between countries. Thus, access and control of these resources can be a source of conflict. For example, crises in regions that are major energy producers, such as the Middle East, can lead to a reduction in oil and natural gas production, affecting supply and prices (Mansson, 2014).

A critical factor for the stability and economic development of a country or region is energy security. Energy security refers to the ability of a community to ensure safe and stable access to energy in a reliable, sustainable and cost-effective manner (Bradshaw, 2009). In times of geopolitical unrest, there is strong concern about energy security, which can lead governments to take measures to limit energy exports or impose restrictive measures, thus affecting supply and demand (Radovanović et al., 2018). As a consequence, energy security is seriously threatened due to limited production, uncertainty and the risk of supply disruptions, with a direct impact on energy market prices.

More specifically, an important factor affecting energy prices during geopolitical crises is limited production. The productivity effect - the effect that energy use has on increasing output and economic growth in a country or region - is a critical issue in the energy sector, as it has important consequences for countries' economic well-being,

industrial activity and competitiveness (Noguera-Santaella, 2016). In times of geopolitical crises, energy producing regions may be faced with political unrest, conflict or other instabilities that affect production potential. In this case, the energy supply may be limited. Limiting production leads to increased demand for existing energy reserves and can create competition for limited availability, resulting in higher prices (Kolb, 2011). Typically, limited production leads to increased energy prices in global markets and can have serious implications for the energy security of some countries, raising concerns about the adequacy of supplies (Campos & Fernandes, 2017).

Uncertainty about energy supply affects both supply and demand. Consumers and companies may increase demand for alternative energy sources or adopt energy-saving practices, while supply may decrease due to supply uncertainty. Concern about possible supply disruptions can lead to increased investment in alternative energy sources or technologies, resulting in higher prices (Noguera-Santaella, 2016). Overall, supply uncertainty creates complex and structural effects on energy markets during geopolitical crises.

Instability in energy transmission and distribution is another important factor that can during geopolitical crises have significant effects on energy prices. In particular, instability in energy transmission due to disasters in the energy network, technical failures or even attacks, can lead to interruptions in supply, with a corresponding increase in prices (Campos & Fernandes, 2017). During periods of volatility in transmission, it may be necessary to take alternative routes to transport energy, sometimes at increased cost. This can also affect prices. If crises affect maritime energy transport routes (as in oil and natural gas), distribution problems can arise, leading to higher prices. An increase in energy prices can also be caused by a decrease in the supply of regional markets, affecting the availability of energy (El-Gamal & Jaffe, 2018).

Energy prices are still affected by changes in pricing policies, which often occur during geopolitical crises. In particular, the financial impact of geopolitical unrest on the energy sector concerns how economic conditions, financial markets, and investment decisions affect the production, transportation, and consumption of energy. Financial conditions can affect energy prices. In particular, an increase in interest rates, instability

in financial markets or a change in the value of currencies can lead to increases or decreases in fuel and electricity prices (Gong, 2022). In times of geopolitical crises, countries may decide to impose additional taxes or duties on energy products to protect domestic production or face economic difficulties, which may cause prices to rise. Also, devaluation or overvaluation of countries' currency, as a means of influencing energy prices, can increase the cost of importing energy or reduce it respectively. During crises, many countries may change their energy policy to reduce their dependence on external suppliers or promote the use of alternative energy sources, thus affecting energy demand and supply (Alsagr & van Hemmen, 2021). Political changes may still affect investments in the energy sector. Companies and countries may avoid investing in specific areas, thus affecting the evolution of energy markets. In general, financial impacts are an important factor related to energy policy and economic performance, and have broad implications at the level of the national and global economy (Gong et et al., 2023).

Until the recent past, there have been several examples of geopolitical crises affecting energy prices. The Gulf War (1990-1991) had a major impact on oil prices. The Iraqi invasion of Kuwait in 1990 raised concerns about monitoring oil production in the Middle East. The reaction of international markets led to a significant increase in oil prices. The uprisings and unrest that began in the Middle East during the Arab Spring (2010-2011), also had an impact on oil prices. Fears about the stability of oil production and worries about further spreading of the conflicts affected the global energy markets. The most recent political instability and economic crisis in Venezuela (since 2014), have affected oil production, resulting in lower exports. This resulted in an increase in oil prices in world markets (Khan et al., 2023). These examples show how geopolitical crises can affect energy prices through fluctuations in production, supply and volatility in global markets. The most recent geopolitical crisis, the Russia-Ukraine war, is part of the research and will be analyzed in the research part of the work.

2.2.3 Natural disasters

Natural disasters have varied effects on the energy market, affecting production, transportation, demand and general uncertainty in the energy sector (Rakshit, 2021). Natural disasters, such as earthquakes, hurricanes, floods and fires, can strike energy production and export facilities, cause damage to energy infrastructure such as storage

tanks, production facilities and transmission networks. Rehabilitating these infrastructures usually takes time and resources, causing increased demand for energy and potentially increasing prices (Wen et al., 2021).

A typical example of how natural disasters can affect energy prices is the case of Japan. By 2011, Japan met about 1/4 of its energy needs from its nuclear infrastructure and was the world's third largest producer of electricity from nuclear reactors (Otsuka, 2019). After the major earthquake and subsequent tsunami in 2011, many nuclear power facilities were damaged and as a result, the country's dependence on Arab oil increased. As the country is forced to use more fossil fuels to replace nuclear power generation, it imports oil at very high prices. In addition, increased Japanese demand puts upward pressure on oil prices, contributing to an even greater increase in international oil prices and affecting global growth (Mochizuki & Chang, 2017). Another example of natural disasters affecting energy prices is Hurricane Katrina (2005) and Hurricane Harvey (2017) in the USA. These extreme natural events caused damage to oil tankers, oil facilities and power generation infrastructure in coastal areas of the United States, curtailing oil and natural gas production, causing the price of oil and gasoline to skyrocket (Liu et al., 2021).

2.2.4 Public health emergencies

Public health emergencies, such as epidemics or pandemics, can affect energy prices in a number of ways. Although the specific effects may depend on the nature and severity of the situation (Cheng et al., 2021), some general ways that might affect energy values are discussed below.

First, in times of public health crises energy demand decreases. Economic activity is usually limited due to isolation measures and restrictions. This can lead to a reduction in energy demand, especially in the transport and industry sectors. When the demand for energy decreases, especially on a large scale, the pressure on prices decreases. If producers cannot sell their energy at high prices due to limited demand, there may be a fall in energy product prices (Chang et al., 2020). The above factors can contribute to the volatility of energy prices, affecting the global economy.

The most typical example of a public health emergency is the recent Covid-19 pandemic which had wide-ranging effects on a global level, including energy prices, which will be analyzed next, as it is part of the research of this paper.

3. Methodology

3.1 Research purpose

The purpose of this study is to examine and analyze the effects of Covid -19 and the Russia-Ukraine war on energy prices.

3.2 Research Method

To achieve the above purpose, international literature is examined that studies how energy prices are affected by specific global crises and that highlights the interaction between geopolitical tensions, public health crises and the energy sector. A systematic literature review is a research method that aims to collect, critique and summarize the existing literature on a specific issue. The predetermined methodology followed ensures a systematic and objective analysis of the literature.

In this case, the steps followed are the following.

3.2.1 Defining research questions

The research questions sought to be answered with this research are:

1. What has been the impact of the Covid -19 pandemic on energy prices?
2. What was the impact of the Russia-Ukraine war on energy prices?

3.2.2 Search for relevant studies based on specific criteria

In order to answer the defined research questions, relevant studies were searched in the online databases Google Scholar and Science Direct. The selection and inclusion criteria of the studies were to have been published from 2020 to 2023, in Greek or English, and to include empirical analyses.

The procedure followed for the selection of the studies is presented in detail in the flow chart (Figure 10).

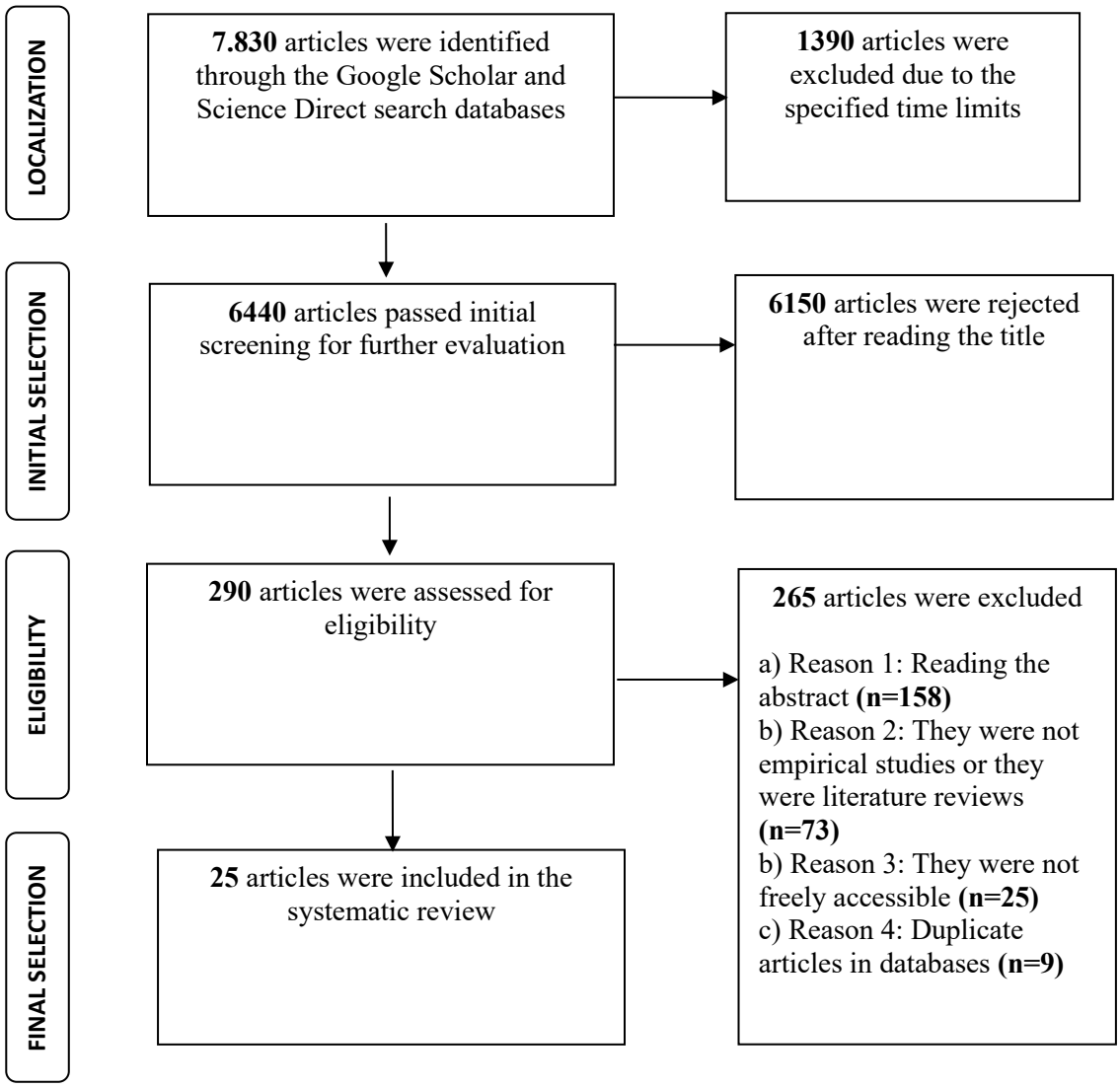


Figure 10: Chart flow

4. Results - The effects of COVID-19 and the Russia-Ukraine war on energy prices

In this section, the results of the research are presented. The following table (Table 6) summarizes the selected articles that were included in this systematic review and their analysis follows.

Table 6: Studies on the impact of Covid -19 and the Russia-Ukraine war on energy prices

N/A	Editors	Time elements	Article title	Results
1.	Dutta et al.	2020	Impact of Covid-19 on global energy markets.	International crude oil markets are negatively affected by the pandemic, as a sharp negative downturn is seen in energy markets following the outbreak of Covid -19.
2.	Shaikh et al.	2022	Impact of Covid-19 pandemic on the energy markets.	Indicators of uncertainty caused by Covid-19, (increased infection, economic policy uncertainty, market volatility) have strong implications for the historical volatility of energy markets. In particular, the WTI crude oil market experienced an unprecedented overreaction reaching extreme levels of volatility.
3.	Bourghelle et al.	2021	Oil price volatility in the context of Covid-19.	The impact of uncertainty, caused by Covid supply and demand shocks and investor anxiety, on oil price volatility is documented. Greater uncertainty leads to greater oil price volatility.
4.	Bildirici et al.	2020	Analyzing crude oil prices under the impact of Covid-19 by using lstargarchlstm.	Oil supply and demand shocks related to Covid-19 are likely to be short-lived, but their effects in many sectors and countries are persistent.
5.	Albulescu	2020	Coronavirus and oil price crash.	A negative and significant impact of the Covid-19 crisis is documented, but relatively small compared to the impact of financial instability and economic policy uncertainty on oil prices. The impact of Covid-19 on oil prices appears to be rather indirect, first affecting the volatility of financial markets.

6.	Foglia & Angelini	2020	Volatility connectedness between clean energy firms and crude oil in the Covid-19 era.	A significant change in the static and dynamic volatility connectivity between oil price and clean energy firms is found with the outbreak of Covid-19, highlighting the strong impact of the pandemic on these financial markets. Also, WTI crude oil turns from a transmitter of volatility to a receiver of risk (after the outbreak of the pandemic).
7.	Echaust & Just	2021	Tail dependence between crude oil volatility index and WTI oil price movements during the COVID-19 pandemic.	Negative shocks to the oil price depend on extreme changes in the crude oil volatility index (OVX), while positive shocks and OVX changes are independent. The greatest reliance on queuing is recorded in the Covid-19 crisis.
8.	Nyga-Łukaszewska & Aruga	2020	Energy prices and Covid-immunity: The case of crude oil and natural gas prices in the US and Japan.	The Covid-19 pandemic has proven that the oil market is volatile and fragile. In the US, the Covid-19 pandemic had a statistically negative impact on the price of crude oil while it had a positive impact on the price of natural gas. On the other hand, for Japan, only a short-term lagged shock was evident in the crude oil market, while the same is not true in the natural gas market.
9.	Zhang et al.	2022	Does something change in the oil market with the Covid-19 crisis?	Brent futures price mainly plays a leading role in WTI and INE futures prices and holds an absolutely dominant position continuously in the three crude oil futures markets.
10.	Erias & Iglesias	2022	Price and income elasticity of natural gas demand in Europe and the effects of lockdowns due to Covid-19.	A European pattern of behavior (ESB) with three different patterns was found to exist: a) France, Denmark and Estonia show slightly positive elasticities in the short run and insensitivity to the same price fluctuations in the long run. b) Latvia is less sensitive to same price fluctuations than ESB. c) In Portugal, natural gas showed the highest elasticities for the same price. Finally, it found that lockdowns due to Covid-19 greatly affected natural gas demand, confirming the "double warming effect".
11.	Setiawan	2021	Changes in demand and supply of the crude oil market during the Covid-19 pandemic and its effects on the natural gas market.	Uncertainty in oil supply due to the Covid-19 pandemic has caused the oil market to shift towards the natural gas market and increased the price of natural gas as the main substitute for oil.
12.	Quintino et al.	2023	An Analysis of Dynamic Correlations among Oil, Natural Gas and	It found that in the post-pandemic period, oil and gas were uncorrelated, both in the short and long term. On the other hand, ethanol was negatively correlated with natural gas in

			Ethanol Markets: New Evidence from the Pre-and Post-Covid-19 Crisis.	the most recent post -pandemic period, especially on short time scales.
13.	Wang & Su	2021	Asymmetric link between Covid-19 and fossil energy prices.	Covid-19 is affecting oil and gas prices at extremely volatile rates. However, there is no significant causality in the carbon market which is largely due to the dependence of global economies on it.
14.	Roy et al.	2023	A wavelet-based methodology to compare the impact of pandemic versus Russia–Ukraine conflict on crude oil sector and its interconnectedness with other energy and non-energy markets.	Brent crude suffers more during the Russia-Ukraine war than during the pandemic, while natural gas suffers more during the pandemic than the war, and WTI suffers equally in both crises.
15.	Shaik et al.	2023	Impact of geo-political risk on stocks, oil, and gold returns during GFC, Covid-19, and Russian–Ukraine War.	The Geopolitical Risk Index (GPR) has high fluctuations during the Russia-Ukraine war period compared to the Covid-19 period. During periods of Covid-19 and the Russia-Ukraine war, there is a strong correlation between GPR and crude oil (WTI), with GPR leading WTI during these periods.
16.	Umar et al.	2022	Impact of Russian-Ukraine war on clean energy, conventional energy, and metal markets: Evidence from event study approach.	A significant increase in abnormal returns associated with the renewable energy industry was found. Other than the diesel index, none of the conventional energy or metals markets tend to show large abnormal returns on the day of the event. In addition, Europe was one of the first clean energy markets to react to the war, with a higher impact on day t+1 than the other markets.
17.	Garzón Gordon et al.	2019	External Effects of the War in Ukraine: The Impact on the Price of Oil in the Short-term.	The events that affected daily oil prices were rare and occurred in very specific phases of the conflict. WTI price was more affected than Brent prices. The market absorbed the impact of the relevant events very quickly.
18.	Ha	2023	Dynamic interlinkages between the crude oil and gold and stock during Russia-Ukraine War: evidence from an extended TVP-VAR analysis.	Oil is the most volatile market during wartime, constantly transmitting shocks of volatility to other markets. During the Russia-Ukraine conflict, oil price fluctuations are becoming more intense and harder to predict.

19.	Appiah-Otoo	2023	Russia–Ukraine War and US oil prices.	The Russia-Ukraine war has pushed up US oil prices. A one-way street was also found causal flow from the Russia-Ukraine war to oil prices in the long run.
20.	Pan & Sun	2023	Changes in volatility leverage and spillover effects of crude oil futures markets affected by the 2022 Russia-Ukraine conflict.	The Russia-Ukraine war has significantly changed the leverage effect in the three crude oil futures markets (WTI, Brent, Oman), slightly increased and stabilized the dynamic conditional correlation and weakened the volatility spillover effect between each pair of them.
21.	Enescu & Szeles	2023	Discussing energy volatility and policy in the aftermath of the Russia–Ukraine conflict.	The spike in energy price volatility during the Russia-Ukraine war, especially for natural gas, illustrates the vulnerability at this particular time frame for the European energy market and dependence on Russian gas. Of the three energy commodities analyzed (Brent crude oil, TTF natural gas and UK natural gas), TTF gas showed the most significant fluctuations.
22.	Nerlinger & Utz	2022	The impact of the Russia-Ukraine conflict on energy firms: A capital market perspective.	Energy firms showed positive cumulative average abnormal returns around the event date (start of Russia-Ukraine war).
23.	Huang et al.	2023	Correlations between the crude oil market and capital markets under the Russia–Ukraine conflict: A perspective of crude oil importing and exporting countries.	Crude oil market efficiency has been weaker since the Russia-Ukraine conflict. Cross-correlations between the crude oil market and stock markets were stronger after the conflict for crude oil importers, but did not change significantly for crude oil exporters.
24.	Inacio et al.	2023	Assessing the impact of the Russia–Ukraine war on energy prices: A dynamic cross-correlation analysis.	The prices of crude oil and refined products showed a significant difference in the period 2019-2020, before the Covid-19 pandemic and before the Russia-Ukraine war, compared to period 1 (during the Covid-19 pandemic and before the Russia-Ukraine war, 2021 - 2022,) and period 2 (during the Covid-19 pandemic and the Russia-Ukraine war, 2022 - 2023). When comparing periods 1 and 2, there was no significant difference for the pair Heating Oil - Brent Crude Oil, but a significant difference was observed for Gasoil - Brent Crude Oil, indicating a higher impact of the war on diesel oil prices in Europe compared to US diesel.
25.	Basdekis et al.	2022	The impact of the Ukrainian war on stock and energy markets: A wavelet coherence analysis.	Strong correlations were found between all variables (stock indices, exchange rates and crude oil), at different time periods and for different frequencies during the period considered (January 2021 - July 2022). Capital constraints in the Russian stock market, combined with increased demand for crude oil, determine the interdependence between RTSI and crude oil.

Then, the above studies are analyzed.

The research conducted by Dutta et al. (2020) explores the impact of the Covid-19 pandemic on returns in the energy market, particularly focusing on three oil markets: WTI, Brent, and Dubai. Utilizing a standard event study methodology, their study delves into three central issues. Initially, the study probes the extent to which the pandemic has adversely influenced global crude oil prices, including an analysis of the degree of price declines attributable to the pandemic. Subsequently, it compares the pandemic's negative effects on different international crude oil indices, namely WTI, Brent, and Dubai, to determine if these effects are uniform or vary across these indices. The third aspect of their inquiry concentrates on the repercussions of Covid-19 on the XLE index. Their findings reveal that the pandemic has precipitated a considerable downturn in the energy markets, leading to notable negative impacts.

In their 2022 study, Shaikh et al. investigate the effects of the Covid-19 pandemic on the energy sector by analyzing various components such as energy stock indices, futures, Exchange-Traded Funds (ETFs), and implied volatility indices. They focus on modeling the volatility in energy markets and illustrate the pandemic's diverse impacts during different phases. Their empirical research explores the relationship between returns and volatility in energy markets during the pandemic, scrutinizing energy stock indices, futures, ETFs, and forward-looking volatility indices.

The study includes daily market prices from January 1, 2011, to May 31, 2020. It examines specific energy market-related stock indices like the Dow Jones US Oil and Gas Index (DJUSEN), which tracks U.S. oil and gas company performance, and the S&P 500 Energy Index (SPN), comprising S&P 500 companies within the energy sector. Additionally, the research considers the Dow Jones Commodity Index (DJCI), a broad measure of the commodity futures market, emphasizing diversity and liquidity.

Moreover, Shaikh et al. analyze the daily prices of WTI Futures and Brent Crude Oil Futures. The study also delves into the performance of energy ETFs and investor sentiment in the energy market, as indicated by volatility indices such as OVX, VXXLE, and OIV.

The findings of the study reveal that indicators of uncertainty brought on by Covid-19, like rising infection rates, economic policy uncertainty, and market volatility, have a pronounced impact on the historical volatility of the energy markets. The volatility of

Energy ETFs showed resilience, aligning with the S&P 500 energy stocks. The WTI crude oil market, in particular, exhibited extraordinary overreaction and high volatility levels during the pandemic. Investor fear and anxiety reached extreme levels, evidenced by significant positive trends in OVX, VXXLE, and OIV. The pandemic's death toll news adversely affected energy stocks and the futures market.

Concluding, Shaikh et al. (2022) point out that this heightened volatility in energy markets suggests a deficiency in the availability of futures and options within this market segment.

Bourghelle et al.'s 2021 research delves into how the Covid-19 pandemic influenced oil prices, particularly focusing on the volatility of these prices. Their investigation sheds light on the volatility dynamics, attributing it to the dual impact of the pandemic: initially triggering a demand shock, followed by a supply shock, particularly in the crude oil (WTI) market. The study examines the correlation between oil price volatility and economic policy uncertainty using daily data spanning from January 2, 2014, to April 1, 2020.

The study observes that the pandemic led to disruptions in both supply and demand, intensifying uncertainty in these sectors. The findings indicate that oil price volatility was significantly impacted by the shocks induced by the pandemic. Employing a Vector Autoregressive (VAR) model, Bourghelle et al. (2021) provide evidence of the pandemic’s dual negative impact on the oil industry. Firstly, it resulted in a diminished global demand for crude oil and heightened uncertainty across numerous economies. Secondly, it sparked a supply shock, reigniting trade tensions among leading oil producers, notably Russia and Saudi Arabia, thereby causing considerable fluctuations in oil prices.

The research concludes that increased uncertainty is associated with higher volatility in oil prices, underscoring the significant effects of the pandemic on the oil market.

In 2020, Albulescu conducted a study to examine how the Covid-19 pandemic affected crude oil prices, with a particular focus on the influence of financial volatility and US economic policy uncertainty. The research utilized the Autoregressive Distributed Lag (ARDL) model, which is adept at determining whether various factors converge towards a long-term equilibrium, even in scenarios involving both stable and non-stationary data series.

The findings of the study reveal that the Covid-19 crisis has a substantial and negative impact on oil prices. However, this impact is relatively minor when compared to the effects of financial instability and economic policy uncertainty. The study suggests that the pandemic's influence on oil prices is predominantly indirect, primarily affecting oil prices through its impact on the volatility of financial markets. This highlights the interconnected nature of global health crises, financial market stability, and commodity prices.

Foglia & Angelini's 2020 study focuses on examining the volatility relationship between oil prices and clean energy firms during the period from 2011 to 2020. To analyze the volatility spillover between these financial markets and its implications for portfolio diversification, the researchers employed volatility spillover models and dynamic conditional correlation techniques.

The study's findings highlight a significant shift in both the static and dynamic volatility connections between oil prices and clean energy firms around the Covid-19 pandemic period. Notably, the overall connectivity index experienced a substantial change, increasing from 21.36% before Covid-19 to 61.23% during the pandemic. This notable shift underscores the profound impact of the Covid-19 pandemic on these financial markets.

Furthermore, the study investigates the transformation of WTI crude oil from being a transmitter of volatility before the pandemic to becoming a receiver of risk following the onset of the global Covid-19 crisis. The results of the research indicate that the pandemic has intensified volatility spillovers, supporting the notion of economic contagion effects. This implies that the pandemic has not only affected the individual markets but also altered the dynamic interplay between different sectors in the financial markets.

In their 2021 study, Echaust and Just explored the relationship during the Covid-19 pandemic between the extreme returns of crude oil prices (WTI) and the changes in the crude oil volatility index (OVX), particularly focusing on the OVX's capability to produce accurate Value at Risk (VaR) forecasts for crude oil. VaR is a widely utilized metric for assessing tail risk, indicating the maximum potential loss of an asset or portfolio over a specified timeframe at a given confidence level. In the context of the

oil market, VaR serves as a tool to estimate the maximum possible price change in oil relative to a certain confidence level.

The research employed two methodologies - static and dynamic one-pair dependent - to calculate the tail dependence coefficient (TDC) between these variables. The findings revealed a correlation between negative oil price shocks and extreme changes in the OVX index, while no correlation was found between positive price shocks and changes in OVX. This asymmetry in tail behavior suggests that the OVX index acts as a 'fear indicator' in the oil market, with this effect being particularly pronounced during the Covid-19 crisis.

The study concludes that implied volatility, as represented by the OVX, has a stronger relation to WTI oil prices than ex-ante volatility. This highlights the significant role that market sentiment and expectations, as encapsulated by implied volatility, play in the oil market, especially under extraordinary circumstances such as the Covid-19 pandemic.

Nyga-Łukaszewska and Aruga's 2020 study set out to evaluate the impact of the Covid-19 pandemic on oil and natural gas prices, focusing on how the energy markets in the United States and Japan reacted to the crisis. To assess the influence of Covid-19 outbreaks on the crude oil and natural gas markets, they utilized the Auto-Regressive Distributive Lag (ARDL) approach, correlating the number of Covid-19 cases in the US and Japan with energy prices. Their analysis spanned from January to June 2020, a period marking the initial "first wave" of the pandemic.

The study's findings indicate distinct short-term and long-term impacts of the Covid-19 pandemic on crude oil and natural gas markets. In the US, the increasing number of pandemic cases negatively influenced crude oil prices but had a positive effect on natural gas prices. In contrast, Japan's crude oil market only exhibited a short-term lagged shock, while its natural gas market showed no significant impact from the pandemic.

These divergent results might stem from the differing trajectories of the pandemic in the US and Japan and the unique roles these countries play in the global energy markets. The study ultimately concludes that the Covid-19 pandemic has highlighted the vulnerability and volatility of the oil market, underlining the complex interplay between global health crises and energy economics.

In their 2022 study, Zhang and colleagues focused on the price discovery process in three key international crude oil futures markets: WTI, Brent, and INE (Shanghai International Energy Exchange). The research utilized the Information Sharing (IS) and Evidence Sharing (CS) models to analyze the dynamics of these markets before and after the outbreak of Covid-19.

The findings from the IS and CS measurements revealed that, historically, the Brent futures price predominantly led the price discovery process for WTI and INE futures. Brent occupied a continuously dominant position across all three crude oil futures markets. However, in the period following the coronavirus outbreak, there was a notable change. While the price discovery efficiency of INE futures slightly improved, it remained weak compared to the WTI and Brent markets.

Most interestingly, post-Covid-19, the study observed a shift in the dominant influence on the price dynamics of the INE market. Initially led by Brent, the influence shifted towards WTI. This indicates a significant change in the interdependencies of these global oil markets in response to the pandemic. The study highlights how external shocks like the Covid-19 pandemic can alter established market dynamics and influence the relative importance of different markets in global price discovery processes.

Erias and Iglesias's 2022 study delves into the price and income elasticity of natural gas demand in Europe, as well as the impacts of the Covid-19 pandemic on this demand. The researchers employed an autoregressive distributed lag (ARDL) model to analyze data from a panel of 25 European countries, covering the period from 2005 to 2020. Their goal was to provide updated estimates of monthly same-price, cross-price, and income elasticities of natural gas demand.

The study's findings are multi-faceted. First, they discerned a European behavior pattern (ESB) characterized by a strong seasonal component in natural gas demand. From this overarching pattern, three distinct sub-patterns emerged:1. France, Denmark, and Estonia displayed slightly positive elasticities in the short run, but showed insensitivity to same-price fluctuations in the long run. 2. Latvia exhibited less sensitivity to same-price fluctuations compared to the overall European pattern. 3. Portugal presented the highest same-price elasticities for natural gas. Moreover, the study highlighted that the Covid-19 pandemic lockdowns significantly impacted natural gas demand, confirming the "double effect of warming". This refers to the combined

effect of warmer temperatures reducing natural gas demand for heating, and lockdown measures further diminishing demand.

The researchers emphasize the importance of these findings, particularly the "double warming effect", for long-term policy considerations. They suggest that if new consumption patterns solidify due to these factors, it could have lasting implications for energy policy and market dynamics in Europe. The study provides critical insights into the complex interplay between economic factors, environmental conditions, and global events like the Covid-19 pandemic in shaping energy demand.

In their 2021 research, Setiawan and colleagues focused on how crude oil prices influenced the natural gas market in Indonesia during the Covid-19 pandemic. The study employed an explanatory methodology that involved the real decomposition of crude oil prices. It analyzed four variables pertinent to the natural gas and oil markets using a structural vector autoregressive (SVAR) model.

The findings from this research indicate that, in Indonesia, the natural gas market's dynamics were influenced by the oil market. This influence was primarily due to specific changes in demand rather than alterations in oil supply during the pandemic. The study suggests that the uncertainty surrounding oil supply due to Covid-19 led to a market shift towards natural gas. This shift increased the price of natural gas, positioning it as the primary alternative to oil.

Furthermore, the research showed that both crude oil and natural gas prices in Indonesia were impacted during the Covid-19 pandemic. Changes in demand led to similar price fluctuations in both commodities. This highlights the interdependent nature of these two energy markets, especially in the context of unprecedented global events like the Covid-19 pandemic. The study provides valuable insights into the complexities of market dynamics and the interplay between different energy sources in times of global crises.

Quintino et al.'s 2023 study focused on the behavior of energy prices during the Covid-19 pandemic, recognizing them as indicators of structural energy supply and demand conditions. To gain a deeper understanding of the relationships between energy prices, the researchers conducted an analysis of the dynamics among weekly benchmark prices for oil, ethanol, and natural gas in the United States. The time frame for their analysis spanned from June 23, 2006, to June 10, 2022.

The methodology employed in the study was the dynamic use of the DMCA (Dynamic Multi-scale Cross-correlation Analysis) cross-correlation coefficient. This approach allowed for a nuanced examination of the interrelationships between these energy commodities over time and at different scales.

The key findings of the study revealed distinct correlation patterns in the post-pandemic period. Notably, natural gas and oil were found to be uncorrelated during this time. This indicates that the relationship between these two energy sources may have decoupled or evolved independently in response to pandemic-related factors. In contrast, the study observed a negative correlation between ethanol and natural gas, particularly at shorter time scales. This suggests that the dynamics between these two energy sources were inversely related, with movements in the price of one potentially having an opposing effect on the price of the other.

These insights are crucial in understanding the complexities of energy markets, especially how they respond and adapt to extraordinary global events such as the Covid-19 pandemic. The study contributes to the broader knowledge of energy market dynamics, providing valuable information for stakeholders, policymakers, and analysts involved in energy economics and planning.

In Wang's 2021 study, the focus was on examining the asymmetric relationship between the Covid-19 pandemic and fossil energy prices, specifically oil and gas. The research utilized the Bootstrap Fourier Granger Causality test in Quantiles (BFGC-Q) to delve into this relationship.

The empirical findings of the study revealed that Covid-19 had an impact on oil and gas prices, particularly at highly volatile rates. This relationship was found to be asymmetric, with significant effects observed in specific volatility ranges, specifically [0.6, 0.8] and [0.8, 1]. These results indicate that it is primarily the higher volatility phases of Covid-19 case numbers that have a notable impact on the prices of oil and gas.

On the other hand, the study discovered no significant causal relationship in the carbon market. This lack of a significant impact is attributed to the heavy reliance of global economies on the carbon market, which might make it more resilient or buffered against such external shocks as the Covid-19 pandemic.

Wang's research sheds light on the complex and nuanced ways in which a global health crisis like Covid-19 can influence different segments of the energy market, underscoring the varying degrees of sensitivity and resilience among these segments. The study's insights are crucial for understanding the dynamics of energy markets in the face of unprecedented global challenges.

In their 2023 study, Roy et al. investigated the comparative economic impacts of the Covid-19 pandemic and the Russia-Ukraine conflict on energy markets. Their research involved analyzing and contrasting the crude oil markets with other markets—both energy-related and non-energy—in terms of their efficiency and interconnectedness during these two major crises.

The results of this comparative analysis revealed that both crises had a more pronounced impact on the energy sector than on the non-energy sector. However, the nature and extent of this impact varied across different energy markets. Specifically, the study found that Brent crude oil was more significantly affected during the Russia-Ukraine war compared to the Covid-19 pandemic. In contrast, natural gas experienced a greater impact during the Covid-19 crisis than during the war. Meanwhile, WTI (West Texas Intermediate) crude oil was equally affected by both the pandemic and the war.

Additionally, the researchers noted an increase in the interconnection between markets during both the Covid-19 pandemic and the Russia-Ukraine conflict. This observation suggests that these crises led to greater linkages and dependencies among different markets, reflecting a complex web of economic interactions and reactions to global events.

Roy et al.'s study provides valuable insights into the differential impacts of global crises on various segments of the energy market, highlighting the nuanced ways in which these markets respond to external shocks and their interconnected nature.

In their 2023 research, Shaik et al. delved into the impact of geopolitical risk on stock, oil, and gold returns during three major events: the global financial crisis (GFC), the Covid-19 pandemic, and the Russia-Ukraine war. The study utilized monthly data series for crude oil (WTI) and gold prices, covering the period from January 2007 to April 2022, thereby encompassing significant disruptions in the financial markets such as the GFC (2008–2009), Covid-19 (2020–2021), and the Russia-Ukraine war (2022).

To assess the performance of global stock markets, the study used the Dow Jones Global Index (DJGI), which serves as an equity proxy aimed at providing capitalization coverage of 95% of equities worldwide. The authors noted that the Geopolitical Risk Index (GPR) experienced high fluctuations during the Russia-Ukraine war, in contrast to the lower fluctuations during the Covid-19 period and even lower during the GFC.

The study's findings revealed that during the Covid-19 and Russia-Ukraine war periods, there was a strong correlation between the GPR and both WTI and DJGI. Additionally, it was observed that GPR leads WTI during these periods. Conversely, the DJGI index was found to lead geopolitical risk during the GFC, the Covid-19 pandemic, and the Russia-Ukraine war.

The study also highlighted the role of gold, noting that it offers better diversification opportunities compared to WTI and DJGI. Gold was found to lead movements against WTI and DJGI during times of disruption in the financial markets. This suggests that gold could be a more stable investment during periods of high geopolitical risk and market volatility. Shaik et al.'s research provides valuable insights into the complex interactions between geopolitical risks and different asset classes during periods of global crises.

Umar et al.'s 2022 study focused on assessing the impact of the Russia-Ukraine war on metals, conventional energy, and renewable energy markets. The research utilized statistical tests and standard event study techniques as part of a fact-finding approach. The data analyzed spanned from September 2, 2021, to March 25, 2022, encompassing the period around the onset of the conflict.

The findings from the study revealed several key insights:1. Impact on Clean Energy Market: There was a significant increase in abnormal returns in the clean energy market on the day the war started. This suggests that the conflict had an immediate and noticeable effect on this market. 2. Conventional Energy and Metals Markets: Except for the gas oil index, none of the conventional energy or metals markets exhibited significant abnormal returns on the day of the event. This indicates a varied response among different energy and metals markets to the onset of the war. 3. Aggregate Abnormal Returns (AARs): At the aggregate level encompassing all markets, AARs were found to be significant both on the day of the event and in the post-event period. This highlights the broader market impact of the Russia-Ukraine war. 4. Individual

Market Analysis: When analyzing each market separately, abnormal returns were significant at the 5% level on the day of the event, especially for clean energy markets. This underlines the particular sensitivity of clean energy markets to the conflict. 5. Cumulative Aggregate Abnormal Returns (CAAR): The CAAR of the clean energy market was significant in the later period. For conventional energy and metal markets, CAARs became significant after a brief period (t+3 days). 6. European Clean Energy Markets: These markets began experiencing effects 5 days before the event, with larger impacts observed on day t+1 compared to other markets. This could indicate a heightened sensitivity or anticipation in these markets. 7. Conventional Energy Market - Gasoline: In the conventional energy market, gasoline experienced an impact in the period leading up to the event, suggesting anticipatory market movements in response to the brewing conflict.

Umar et al.'s study provides a comprehensive analysis of the diverse impacts of the Russia-Ukraine war across different market segments, highlighting the varying degrees of sensitivity and response timing to geopolitical events.

In their 2019 study, Garzón Gordón et al. delved into the short-term effects of the Russia-Ukraine war on oil prices. The primary objective of the research was to enhance understanding of how the conflict in Ukraine indirectly influenced oil prices by examining the impact of key events during the war on daily oil prices. To achieve this, they employed an event study model, which is designed to ascertain the significance of specific events on market variables.

The key findings from the study are insightful: 1. Selective Impact of Events: The study found that the events which affected daily oil prices were not widespread but occurred in very specific phases of the conflict. This suggests a selective sensitivity of the oil market to certain developments within the war. 2. Differential Impact on Oil Types: Interestingly, the price of WTI (West Texas Intermediate) was more significantly impacted by these events compared to Brent prices, despite the geographical location of the war in Europe. This indicates a nuanced and complex relationship between geopolitical events and different types of crude oil markets. 3. Rapid Market Response: The researchers observed no noticeable lag in the market's response to the events they considered. This implies that the oil market assimilated and reacted to the impacts of

relevant events very quickly, reflecting a high degree of market efficiency in processing new information.

The research by Garzón Gordón et al. provides valuable insights into the dynamics of the oil market in response to geopolitical conflicts. It highlights the intricacies of market reactions to global events and underscores the importance of understanding these dynamics for stakeholders in the energy sector.

In 2023, Ha conducted a study to explore the dynamic relationships between crude oil, gold, and stock markets during the Russia-Ukraine war. The primary objective was to understand the factors driving the erratic behavior of the oil market, especially following the shock induced by the outbreak of the Russia-Ukraine conflict on February 24, 2022. To achieve this, Ha employed a time-varying parametric vector autoregression (TVP-VAR) model, combined with an extended co-connectivity approach. This methodology was used to analyze the interrelations between crude oil, gold, and the stock market, focusing on the connectivity of these four markets from January 1, 2018, to April 8, 2022, with particular emphasis on the period of Russia's invasion of Ukraine.

The key findings from Ha's study are as follows: 1. Interrelation of Markets: The research demonstrates that the markets analyzed (crude oil, gold, and stocks) are interrelated both under normal conditions and during wartime scenarios. This indicates a complex web of interdependencies among these financial markets. 2. Impact of War Crises on Market Interconnection: The study reveals that war crises, such as the Russia-Ukraine conflict, seem to significantly affect the interconnections between different markets. This suggests that geopolitical conflicts can alter the typical dynamics and correlations observed among these markets. 3. Volatility of Oil Market During Wartime: Among the markets analyzed, the oil market was found to be the most volatile during wartime. The study notes that in times of uncertainty, such as during war, the oil market frequently transmits volatility shocks to other markets, highlighting its central role in global market dynamics. 4. Fluctuating Oil Prices: Ha's findings show that oil prices have been particularly fluctuant recently, with the Russia-Ukraine conflict exacerbating this trend. The fluctuations in oil prices became more pronounced and challenging to predict during the conflict.

Ha's research provides valuable insights into the behavior of key financial markets during times of geopolitical unrest, particularly highlighting the central role of the oil market in transmitting shocks and influencing other markets. The study underscores the importance of understanding these dynamics for market participants and policymakers, especially in times of global conflicts.

Appiah-Otoo's 2023 research critically investigated the ramifications of the Russia-Ukraine conflict on oil prices within the United States. This scholarly inquiry aimed to determine if there was a consequential impact of the Russia-Ukraine war on oil prices, particularly seeking to establish a causal linkage between the two. In this context, Appiah-Otoo (2023) selected the United States as the focal point for analysis, meticulously examining daily oil price data spanning from January 24, 2022, to April 18, 2022. The research predominantly utilized West Texas Intermediate (WTI) oil price data as the benchmark for assessing oil price fluctuations.

To conduct this empirical investigation, Appiah-Otoo (2023) employed advanced methodological approaches, including quantile regression and wavelet coherency analysis. These techniques were instrumental in quantifying the impact of the war on oil prices. The study's outcomes indicated a significant elevation in US oil prices attributable to the Russia-Ukraine war. This notable finding underscores a unidirectional causal relationship from the Russia-Ukraine conflict to long-term oil price movements in the United States, offering pivotal insights into the geopolitical dimensions of energy economics.

In their 2023 study, Pan & Sun delved into the dynamics of forward/inverse leverage and spillover effects in three key crude oil futures markets—WTI, Brent, and Oman—focusing on the periods before and after the onset of the Russia-Ukraine conflict in 2022. The research was grounded in the application of various time-varying parameter models, including GJR-GARCH, ADCC, DCC, and ECCC. These models were instrumental in analyzing changes in volatility, ordinal/inverse leverage, and spillover effects within the WTI, Brent, and Oman crude oil futures markets, particularly in relation to the influence of the Russia-Ukraine conflict.

The study's findings indicated that the geopolitical conflict significantly altered the leverage effect in all three markets. Furthermore, it led to a slight increase and stabilization in the dynamic conditional correlation, while simultaneously diminishing

the volatility spillover effect between each pair of the markets. Notably, the normal leverage effect persisted as the primary factor influencing oil prices, maintaining its dominance throughout both the secondary and the entire sample periods analyzed.

Pan & Sun's (2023) research provides critical insights into the complex interplay of market dynamics in the face of geopolitical tensions, specifically highlighting how such conflicts can reshape financial interactions and correlations in significant global commodity markets like crude oil.

In their 2023 research, Enescu & Szeles conducted a thorough examination of the volatility in energy prices following the outbreak of the Russia-Ukraine conflict. Their empirical analysis primarily utilized generalized autoregressive conditional heteroskedasticity (GARCH) models, a sophisticated statistical approach designed to effectively capture and quantify volatility. The study focused on several key energy commodities, including Brent crude oil, TTF (Title Transfer Facility) natural gas, and UK natural gas.

The empirical results from Enescu & Szeles's study revealed significant implications of the Russia-Ukraine war on the energy markets, impacting both the economy and society in multifarious ways. Notably, there was a marked increase in the volatility of energy prices, particularly for natural gas. This heightened volatility was indicative of the European energy market's vulnerability during this specific period, emphasizing its dependence on Russian gas supplies.

Among the energy commodities analyzed, TTF natural gas exhibited the most pronounced fluctuations and the highest range of conditional variance. This finding is particularly telling of the European Union's reliance on Russian gas supplies. The research by Enescu & Szeles (2023) thus sheds light on the critical vulnerabilities and dependencies in the European energy market, especially in the context of geopolitical conflicts that can disrupt energy supply chains and market dynamics.

In 2022, Nerlinger & Utz embarked on a study to explore the impact of the Russia-Ukraine conflict on the share prices of energy companies. They employed a fact study methodology, using a standard approach typically applied in financial research to assess the effects of specific events on stock returns.

The findings from their research indicated that energy firms, in general, experienced positive cumulative average abnormal returns around the event date of the Russia-Ukraine conflict. This positive financial performance suggests that investors anticipated beneficial outcomes for these companies amidst the geopolitical turmoil.

Delving deeper, the study also analyzed results within various industry subgroups. It was found that market participants held optimistic expectations particularly for the conventional energy segments, such as those involved in uranium technology. This expectation of profitability in the future for these segments underscores a significant market sentiment, suggesting that investors see potential for growth and higher returns in specific areas of the energy sector in light of the Russia-Ukraine conflict.

Nerlinger & Utz's (2022) study provides insightful analysis into the financial market's response to geopolitical events, particularly highlighting the nuanced impacts on different segments within the energy industry.

In their 2023 research, Huang et al. undertook a comprehensive analysis of the ramifications of the Russia-Ukraine conflict on the crude oil market and its subsequent effects on the stock markets of countries that import and export crude oil. To assess the efficiency of the crude oil market in the context of the conflict, they utilized a Multiple Fractional Variance Draining Analysis (MF-DFA). Additionally, they employed the Multiple Fractional Drain Cross-Correlation Analysis (MF-DCCA) method to compare the cross-correlations between the crude oil market and the stock markets of importing and exporting countries, both before and after the onset of the conflict.

The study's findings revealed several key insights: 1. Crude Oil Market Efficiency: There was a notable decrease in the efficiency of the crude oil market following the Russia-Ukraine conflict. This indicates a disruption in the market's ability to process information and reflect it in oil prices. 2. Cross-Correlations with Stock Markets: The research discovered that, post-conflict, cross-correlations between the crude oil market and the stock markets of crude oil importing countries strengthened. However, for crude oil exporting countries, these cross-correlations did not exhibit a significant change. 3. Persistence of Cross-Correlations: Further investigation into the persistence of these cross-correlations showed a divergence between importing and exporting countries. Specifically, the cross-correlations between the capital markets of importing countries

and the crude oil market were weaker compared to those of exporting countries around the time of the conflict.

Huang et al.'s (2023) study provides a nuanced understanding of the complex interdependencies between crude oil and stock markets in the wake of geopolitical disturbances. The findings highlight how such conflicts can differentially impact market dynamics and efficiency, depending on a country's position as a crude oil importer or exporter.

Inacio et al.'s 2023 research was focused on evaluating the impact of the Russia-Ukraine conflict on global crude oil and refined product prices. To achieve this, they employed both bivariate and multivariate different cross-correlation methods, aiming to dissect and understand the price relationships across three distinct time periods: Period 0 (pre-Covid-19 pandemic and pre-Russia-Ukraine war, February 2019 - February 2020), Period 1 (during the Covid-19 pandemic and before the Russia-Ukraine war, February 2021 - February 2022), and Period 2 (concurrent with the Covid-19 pandemic and the Russia-Ukraine war, February 2022 - February 2023).

The study's findings reveal notable distinctions in market dynamics across these periods. A significant difference was observed between Period 0 and the subsequent periods (1 and 2), indicating that both the Covid-19 pandemic and the Russia-Ukraine war had a marked impact on crude oil and refined product prices.

When comparing Periods 1 and 2, the research found no significant difference in the price relationship between Heating Oil and Brent Crude Oil. However, a significant difference was noted for the Gasoil - Brent Crude Oil pair, suggesting that the war had a more pronounced impact on diesel oil prices in Europe compared to those in the US.

Furthermore, the methodologies employed in the study underscored the differential and spillover effects observed across different energy commodities. This highlights the complexity and unique dynamics inherent in each market, influenced by a range of factors including geopolitical events, global crises, and regional market structures.

Inacio et al.'s research contributes to a deeper understanding of the intricate interplay between global events and energy markets, demonstrating how external shocks can lead to varied impacts across different segments of the energy sector.

Basdekis et al.'s 2022 empirical study delved into the interdependencies among specific stock market indices, exchange rates, and crude oil prices over the period from January 2021 to July 2022. The selected variables for this investigation included the Russian Trading System Index (RTSI), Eurostoxx, S&P 500, EUR/USD and RUB/USD exchange rates, along with crude oil prices. The objective was to ascertain whether there exists a simultaneous coherence between these variables across different times and scales throughout the examined period.

To achieve this, the researchers employed a wavelet coherence approach. This method is adept at uncovering relationships between time series data in both the time and frequency domains, providing a nuanced understanding of how these relationships evolve over time and across different scales.

The study's findings indicated significant correlations between all the variables, varying across different time periods and frequencies within the timeframe under study. One of the key observations was the interdependence between the RTSI and crude oil prices, which seemed to be influenced by capital constraints in the Russian stock market coupled with an escalated demand for crude oil.

Additionally, the study identified a negative correlation between the US stock index (S&P 500) and crude oil in the low-frequency bands. Similar negative correlations were observed between the RTSI and Eurostoxx with crude oil during the post-Covid-19 and pre-Russia-Ukraine war periods.

The research by Basdekis et al. provides valuable insights into the complex interrelations among global financial markets and commodity prices, highlighting how these connections can vary across different economic conditions and time scales. This understanding is crucial for investors and policymakers in navigating the intricacies of global financial markets.

5. Discussion

Summarizing the results of this research, it is found that uncertainty caused by supply and demand shocks due to Covid-19, combined with investor anxiety, has significant implications for oil price volatility. Despite the temporary nature of supply and demand shocks, their effects are persistent in many sectors and countries. In the US, the price of crude oil is negatively affected, while in Japan, only a short-term effect is observed. The Brent futures price plays a key role in the WTI and INE futures markets. Uncertainty indicators, caused by the pandemic, negatively affect the historical volatility of energy markets, especially in the WTI crude oil market, causing even more intense volatility. The static and dynamic linkages between the price of oil and clean energy businesses have undergone significant change with the outbreak of the pandemic. Uncertainty in oil supply due to the pandemic is driving the market towards natural gas, increasing its price as the main substitute for oil. The relationships between oil, gas and other factors are affected at various time scales and post-pandemic period.

During the Russia-Ukraine conflict, the renewable energy industry experienced a notable surge in abnormal returns, with European markets demonstrating a quicker response to the war compared to others. The conflict's impact on oil prices was more nuanced. While the overall oil prices did not see significant disruption due to events occurring during the conflict, there were differences in how the two major benchmarks, WTI and Brent, responded. WTI exhibited a greater sensitivity to the conflict than Brent.

Interestingly, Brent crude's response to the Russia-Ukraine war differed from its behavior during the Covid-19 pandemic. On the other hand, natural gas prices were more significantly impacted by the pandemic than by the war. WTI, in contrast, faced challenges during both these crises.

The efficiency of the crude oil market, in general, appeared to weaken following the onset of the Russia-Ukraine conflict. This suggests a shift in the market dynamics and a potential increase in unpredictability or volatility.

Furthermore, the Geopolitical Risk Index (GPR), an indicator measuring global tensions and conflicts, showed heightened fluctuations during the war compared to the pandemic period. There was a discernible correlation between the GPR and crude oil prices, with the GPR leading during these periods. This finding indicates a strong link between geopolitical tensions and crude oil market dynamics, underscoring the sensitivity of commodity markets to global political events.

The war raises US oil prices and affects prices in the long run. Changes in leverage are seen in crude oil futures markets and increased volatility for natural gas in Europe due to its reliance on Russian gas. During the period before the Covid-19 pandemic and the Russia-Ukraine war (2019-2020), there was a significant difference in the prices of crude oil and refined products compared to the period after (2020-2023). The important difference for Gasoil - Brent Crude Oil observed between the periods 2021-2022 (during the Covid-19 pandemic and before the Russia-Ukraine war) and the period 2022-2023 (during the Covid-19 pandemic and the Russia-Ukraine war), suggests a higher impact of the war on diesel oil prices in Europe compared to US diesel.

The findings of the present research are in agreement with the results of other related studies. Xing et al. (2023) examining the impact of COVID-19 and the war in Ukraine on oil and gas energy prices found that these events greatly affected energy supply and demand, causing energy price volatility and disrupting global economic order with profound long-term implications. They pointed out that the year 2020 saw the lowest energy prices, both for oil and natural gas, as energy demand fell due to the shock of the Covid-19 pandemic. Furthermore, it was found that energy price fluctuations mainly affected European countries without a resilient economy. However, it appears that the impact of Covid-19 on energy price volatility is diminishing over time. The results of Xing's study et al. (2023) also reveal that crude oil and natural gas prices were strongly shocked by the Covid-19 pandemic and the subsequent war in Ukraine. In particular, the price of Brent crude oil is more volatile and fragile than that of TTF natural gas during the period 2006–2023. Finally, researchers point to a positive correlation between oil and natural gas prices and the Covid-19 pandemic. Investigating the short-term impact of the pandemic on the energy market over the period 2020–2022, it is found that it has had a declining impact since the beginning of 2023. In contrast, the impact from the ongoing war in Ukraine has become a new reality, affecting the global energy market and causing far-reaching effects in the long term.

Kalogiannidis et al. (2022) also studied the economic effects of the Russia-Ukraine war on the European fuel market. The results of this review showed that a direct effect of the war on the global economy was a disruption of the global supply chain. This came in the form of shocks to energy and trade supplies. It caused energy costs, commodity prices, and food prices to rise, resulting in rising inflation in many nations around the world. The authors conclude that geopolitical conflicts are seriously damaging the economy worldwide.

However, even from such a difficult and complicated situation that has been created after the Covid -19 pandemic and after the Russia-Ukraine war, some positive elements can emerge. In particular, some important perspectives are emerging for the energy sector globally.

The above events promoted the reshaping of the energy industry, promoting the transition from traditional to green energy (Xing et al., 2023). The need to reform the energy industry and transition to renewable energy sources is urgently emerging as a consequence of the impact of the Covid-19 pandemic and the Russia-Ukraine war on the energy market. The need for change and adaptation in the energy sector is highlighted mainly by the significant reduction in energy demand due to the pandemic, which caused serious problems in the traditional energy industry (Zakeri et al., 2022). Energy supply chain producers are already under pressure to switch to renewables. The observed drop in oil prices during the pandemic and war has highlighted the vulnerability of dependence on conventional energy sources, highlighting the need to seek alternative, sustainable options. Considering the current trend of greener transitions as well as global environmental challenges, it is vital to build a sustainable world by creating an ecological energy system with reduced carbon emissions and environmentally friendly practices (Allam et al., 2022). Changing the energy model requires a fundamental restructuring of the energy infrastructure to support energy storage, distribution from renewable sources and its efficient use. It is necessary to rebuild production systems, with an emphasis on renewable energy sources, as well as upgrade and strengthen distribution networks to support greater production from renewable sources (Hoang et al., 2021).

Based on the above, some suggestions emerge for future research. In particular, a key issue that needs further investigation is the protection of energy security in critical

conditions, such as pandemic and war. In this context, it is necessary to examine the reaction of the energy market to these conditions and how different countries can protect themselves from the inevitable fluctuations. It also needs to be considered how energy security is affected by the degree of dependence on specific sources (such as Russian gas). The diversity of sources and the diversification of suppliers need to be considered, as well as how countries can strengthen their energy independence and develop domestic sources, minimizing the risk of international crises (Liwang, 2023). Another aspect of this issue for future investigation is how countries can work together to enhance energy security at the global level by looking at international agreements (Zakeri et al., 2022). Future research on these issues can help prepare energy agencies and countries in general to cope with possible future critical situations affecting energy security.

In addition, future research should also focus on innovation and research in the energy sector, following critical events. Critical events, such as war and pandemic, highlight the importance of sustainability (Allam et al., 2022). Future research should focus on innovative solutions that promote sustainability and protect the environment, the development of new technologies to improve energy efficiency and the more efficient use of renewable energy sources. Innovative solutions that contribute to economic growth while promoting sustainable development must also be explored and promoted (Heffron et al., 2021). Overall, research in this area should focus on practical solutions that can be implemented in practice, thus promoting the transition to a more sustainable and resilient energy future.

6. Conclusion

In conclusion, the completion of this paper reveals complex dynamics in the global energy market. Both the Covid-19 pandemic and the Russia-Ukraine war have created significant disruptions and concerns in global energy markets, causing severe fluctuations in energy prices worldwide (Xing et al., 2023).

In general, the pandemic has had an impact on demand and supply, due to restrictive measures and a slowdown in economic activity, while the war in Ukraine has caused geopolitical concerns and uncertainty. The coexistence of pandemic and war caused complex fluctuations in energy prices, with different price reactions among different types of oil and derivatives, indicating the importance of geopolitical circumstances and specific characteristics of markets (Kalogiannidis et al., 2022).

This analysis highlights the complex nature of the factors affecting energy prices, underscoring the importance of continuous monitoring and adaptation to these dynamic conditions. Moreover, it highlights the need for careful management and strategic adaptation of energy systems in the presence of global challenges (Allam et al., 2022). Finally, the influence of geopolitical instability on energy prices highlights the need for further research and analysis on energy supply security and alternative energy sources that can contribute to ensuring energy security in times of crisis.

BIBLIOGRAPHY

Albulescu, C. (2020). Coronavirus and oil price crash. *arXiv preprint arXiv:2003.06184* https://arxiv.org/ftp/arxiv/papers/2003/2003.06184.pdf

Allam, Z., Bibri, S. E., & Sharpe, S. A. (2022). The rising impacts of the COVID-19 pandemic and the Russia–Ukraine war: energy transition, climate justice, global inequality, and supply chain disruption. *Resources*, *11*(11), 99.

Alsagr, N., & van Hemmen, S. (2021). The impact of financial development and geopolitical risk on renewable energy consumption: evidence from emerging markets. *Environmental Science and Pollution Research*, *28*, 25906-25919.

Appiah-Otoo, I. (2023). Russia–Ukraine War and US oil prices. *Energy Research Letters*, *4*(1).

Asianto, A. (2019). The price determinants of West Texas Intermediate crude oil. *Jurnal Aplikasi Bisnis dan Manajemen (JABM)*, *5*(1), 153-153.

Ayanoğlu, A., & Yumrutaş, R. (2016). Production of gasoline and diesel like fuels from waste tire oil by using catalytic pyrolysis. *Energy*, *103*, 456-468.

Basdekis, C., Christopoulos, A., Katsampoxakis, I., & Nastas, V. (2022). The impact of the Ukrainian war on stock and energy markets: A wavelet coherence analysis. *Energies*, *15*(21), 8174.

Bencivenga, C., D'Ecclesia, R. L., & Triulzi, U. (2012). Oil prices and the financial crisis. *Review of Managerial Science*, *6*, 227-238.

Bhar, R., & Malliaris, A. G. (2011). Oil prices and the impact of the financial crisis of 2007–2009. *Energy Economics*, *33*(6), 1049-1054.

Bildirici, M., Guler Bayazit, N., & Ucan, Y. (2020). Analyzing crude oil prices under the impact of covid-19 by using lstargarchlstm. *Energies*, *13*(11), 2980.

Bourghelle, D., Jawadi, F., & Rozin, P. (2021). Oil price volatility in the context of Covid-19. *International Economics*, *167*, 39-49.

Bradshaw, M. J. (2009). The geopolitics of global energy security. *Geography Compass*, *3*(5), 1920-1937.

Campos, A., & Fernandes, C. (2017). The geopolitics of energy. *Geopolitics of energy and energy security*, *24*, 23-40.

Chang, C. L., McAleer, M., & Wang, Y. A. (2020). Herding behaviour in energy stock markets during the Global Financial Crisis, SARS, and ongoing COVID-19. *Renewable and Sustainable Energy Reviews*, *134*, 110349.

Cheng, A., Chen, T., Jiang, G., & Han, X. (2021). Can Major Public Health Emergencies Affect Changes in International Oil Prices?. *International Journal of Environmental Research and Public Health*, *18*(24), 12955.

Coburn, T. C. (2020). Oil and Gas Infrastructure. *The Oxford Handbook of Energy Politics*, 99.

Devold, H. (2013). *Oil and gas production handbook. An introduction to oil and gas production, transport, refining and petrochemical industry*. Recovery from: https://library.e.abb.com/public/34d5b70e18f7d6c8c1257be500438ac3/Oil%20and%20gas%20production%20handbook%20ed3x0_web.pdf

Dutta, A., Bouri, E., Uddin, G. S., & Yahya, M. (2020). Impact of COVID-19 on global energy markets. In *IAEE Energy Forum Covid-19 Issue* (Vol. 2020, pp. 26-29). IAEE Cleveland, OH, USA.

Echaust, K., & Just, M. (2021). Tail dependence between crude oil volatility index and WTI oil price movements during the COVID-19 pandemic. *Energies*, *14*(14), 4147.

Eia, Independent Statistics and Analysis. U.S. Energy Information Administration. (2023). *Gasoline explained, where our gasoline comes from.* https://www.eia.gov/energyexplained/gasoline/where-our-gasoline-comes-from.php

El-Gamal, M. A., & Jaffe, A. M. (2018). The coupled cycles of geopolitics and oil prices. *Economics of Energy & Environmental Policy*, *7*(2), 1-14.

Enerdata. World Energy & Climate Statistics – Yearbook (2023). Crude oil production. https://yearbook.enerdata.net/crude-oil/world-production-statistics.html

Enerdata. World Energy & Climate Statistics – Yearbook (2023b). Natural gas production. https://yearbook.enerdata.net/natural-gas/world-natural-gas-production-statistics.html

Enescu, A. G., & Szeles, M. R. (2023). Discussing energy volatility and policy in the aftermath of the Russia–Ukraine conflict. Frontiers in Environmental Science, Vol.11. https://doi.org/10.3389/fenvs.2023.1225753

Erias, A. F., & Iglesias, E. M. (2022). Price and income elasticity of natural gas demand in Europe and the effects of lockdowns due to Covid-19. *Energy Strategy Reviews*, *44*, 100945.

Faramawy, S., Zaki, T., & Sakr, A. E. (2016). Natural gas origin, composition, and processing: A review. *Journal of Natural Gas Science and Engineering*, *34*, 34-54.

FocusEconomics (2016). What is the Difference between WTI and Brent Crude Oil? https://www.focus-economics.com/blog/difference-between-wti-and-brent/

Foglia, M., & Angelini, E. (2020). Volatility connectedness between clean energy firms and crude oil in the COVID-19 era. *Sustainability*, *12*(23), 9863.

Garzón Gordón, A. J., & Hierro Recio, L. Á. (2019). External Effects of the War in Ukraine: The Impact on the Price of Oil in the Short-term. *International Journal of Energy Economics and Policy, 9 (2), 267-276.*

Gong, X. (2022). Energy security through a financial lens: Rethinking geopolitics, strategic investment, and governance in China's global energy expansion. *Energy Research & Social Science*, *83*, 102341.

Gong, X. L., Feng, Y. K., Liu, J. M., & Xiong, X. (2023). Study on international energy market and geopolitical risk contagion based on complex network. *Resources Policy*, *82*, 103495.

Ha, L. T. (2023). Dynamic interlinkages between the crude oil and gold and stock during Russia-Ukraine War: evidence from an extended TVP-VAR analysis. *Environmental Science and Pollution Research*, *30*(9), 23110-23123.

Heffron, R. J., Körner, M. F., Schöpf, M., Wagner, J., & Weibelzahl, M. (2021). The role of flexibility in the light of the COVID-19 pandemic and beyond: Contributing to a sustainable and resilient energy future in Europe. *Renewable and Sustainable Energy Reviews*, *140*, 110743.

Hoang, A. T., Nižetić, S., Olcer, A. I., Ong, H. C., Chen, W. H., Chong, C. T., ... & Nguyen, X. P. (2021). Impacts of COVID-19 pandemic on the global energy system and the shift progress to renewable energy: Opportunities, challenges, and policy implications. *Energy Policy*, *154*, 112322.

Huang, M., Shao, W., & Wang, J. (2023). Correlations between the crude oil market and capital markets under the Russia–Ukraine conflict: A perspective of crude oil importing and exporting countries. *Resources Policy*, *80*, 103233.

Inacio Jr, C. M. C., Kristoufek, L., & David, S. A. (2023). Assessing the impact of the Russia–Ukraine war on energy prices: A dynamic cross-correlation analysis. *Physica A: Statistical Mechanics and its Applications*, *626*, 129084.

Investing News Network (2023). Top 10 Countries for Natural Gas Production. https://investingnews.com/top-natural-gas-producers/

Kalogiannidis, S., Chatzitheodoridis, F., Kalfas, D., Kontsas, S., & Toska, E. (2022). The economic impact of Russia's Ukraine conflict on the EU fuel markets. *International Journal of Energy Economics and Policy, 12*(6), 37.

Katyukha, P., & Mottaeva, A. (2021). Evolution of global oil benchmarks: new trends in pricing in the international oil market. In *E3S Web of Conferences* (Vol. 284, p. 01008). EDP Sciences.

Khan, M. H., Ahmed, J., Mughal, M., & Khan, I. H. (2023). Oil price volatility and stock returns: Evidence from three oil-price wars. *International Journal of Finance & Economics*, *28*(3), 3162-3182.

Kolb, R. W. (2011). Geopolitical threats to world energy markets. *The Journal of Social, Political and Economic Studies*, *36*(2), 154-196.

Liu, H., Ferreira, S., & Karali, B. (2021). Hurricanes as news? Assessing the impact of hurricanes on the stock market returns of energy companies. *International Journal of Disaster Risk Reduction*, *66*, 102572.

Liwang, H. (2023). Future National Energy Systems, Energy Security and Comprehensive National Defence. *Energies*, *16*(18), 6627.

Mansson, A. (2014). Energy, conflict and war: towards a conceptual framework. *Energy Research & Social Science*, *4*, 106-116.

Mochizuki, J., & Chang, S. E. (2017). Disasters as opportunity for change: Tsunami recovery and energy transition in Japan. *International journal of disaster risk reduction*, *21*, 331-339.

Monge, M., Gil-Alana, L. A., & de Gracia, F. P. (2017). US shale oil production and WTI prices behaviour. *Energy*, *141*, 12-19.

Morgan, B. (2015). QER Report: Energy Transmission, Storage, and Distribution Infrastructure. https://www.energy.gov/sites/prod/files/2015/09/f26/QER_AppendixB_NaturalGas.pdf

Nerlinger, M., & Utz, S. (2022). The impact of the Russia-Ukraine conflict on energy firms: A capital market perspective. *Finance Research Letters*, *50*, 103243.

Noguera-Santaella, J. (2016). Geopolitics and the oil price. *Economic Modelling*, *52*, 301-309.

Nyga-Łukaszewska, H., & Aruga, K. (2020). Energy prices and COVID-immunity: The case of crude oil and natural gas prices in the US and Japan. *Energies*, *13*(23), 6300.

OEC. Crude Petroleum (2023). https://oec.world/en/profile/hs/crude-petroleum?latestTrendsScaleSelector=Trade+Value+Growth#exporters-importers

Otsuka, A. (2019). Natural disasters and electricity consumption behavior: a case study of the 2011 Great East Japan Earthquake. *Asia-Pacific Journal of Regional Science*, *3*(3), 887-910.

Pan, Q., & Sun, Y. (2023). Changes in volatility leverage and spillover effects of crude oil futures markets affected by the 2022 Russia-Ukraine conflict. *Finance Research Letters*, 104442.

Pascual, C., & Zambetakis, E. (2010). The geopolitics of energy. *Energy Security: Economics, Politics, Strategies, and Implications*, 9-35.

Peng, J., Li, Z., & Drakeford, B. M. (2020). Dynamic characteristics of crude oil price fluctuation—from the perspective of crude oil price influence mechanism. *Energies*, *13*(17), 4465.

Quintino, D., Ogino, C., Haq, I. U., Ferreira, P., & Oliveira, M. (2023). An Analysis of Dynamic Correlations among Oil, Natural Gas and Ethanol Markets: New Evidence from the Pre-and Post-COVID-19 Crisis. *Energies*, *16*(5), 2349.

Radovanović, M., Filipović, S., & Golušin, V. (2018). Geo-economic approach to energy security measurement–principal component analysis. *Renewable and Sustainable Energy Reviews*, *82*, 1691-1700.

Rakshit, B. (2021). Impact of natural disasters on energy consumption: evidence from Indian states. *Energy research letters*, *2*(3).

Roy, A., Soni, A., & Deb, S. (2023). A wavelet-based methodology to compare the impact of pandemic versus Russia–Ukraine conflict on crude oil sector and its interconnectedness with other energy and non-energy markets. *Energy Economics*, *124*, 106830.

Setiawan, E. B., Agusinta, L., Suryawan, R. F., Ricardianto, P., Saria, M., Mulyono, S., & Sakti, R. F. J. (2021). Changes in demand and supply of the crude oil market during the COVID-19 pandemic and its effects on the natural gas market. *International Journal of Energy Economics and Policy*.

Shahbaz, M., Trabelsi, N., Tiwari, A. K., Abakah, E. J. A., & Jiao, Z. (2021). Relationship between green investments, energy markets, and stock markets in the aftermath of the global financial crisis. *Energy Economics*, *104*, 105655.

Shaikh, I. (2022). Impact of COVID-19 pandemic on the energy markets. *Economic Change and Restructuring, 55*(1), 433-484.

Shaik, M., Jamil, S. A., Hawaldar, I. T., Sahabuddin, M., Rabbani, M. R., & Atif, M. (2023). Impact of geo-political risk on stocks, oil, and gold returns during GFC, COVID-19, and Russian–Ukraine War. *Cogent Economics & Finance*, *11*(1), 2190213.

Timma, L., Zoss, T., & Blumberga, D. (2016). Life after the financial crisis. Energy intensity and energy use decomposition on sectorial level in Latvia. *Applied Energy*, *162*, 1586-1592.

Umar, M., Riaz, Y., & Yousaf, I. (2022). Impact of Russian-Ukraine war on clean energy, conventional energy, and metal markets: Evidence from event study approach. *Resources Policy*, *79*, 102966.

Vatsa, P., & Miljkovic, D. (2022). Energy and crop price cycles before and after the global financial crisis: A new approach. *Journal of Agricultural Economics*, *73*(1), 220-233.

Wang, K. H., & Su, C. W. (2021). Asymmetric link between COVID-19 and fossil energy prices. *Asian Economics Letters*, *1*(4).

Wen, J., Zhao, X. X., & Chang, C. P. (2021). The impact of extreme events on energy price risk. *Energy Economics*, *99*, 105308.

Xing, X., Cong, Y., Wang, Y., & Wang, X. (2023). The Impact of COVID-19 and War in Ukraine on Energy Prices of Oil and Natural Gas. *Sustainability, 15*(19), 14208.

Yang, Y. T., Yang, T. Y., Chen, S. H., & Tong, C. V. (2022). Exploring the non-linearity of West Texas Intermediate crude oil price from exchange rate of US dollar and West Texas Intermediate crude oil production. *Energy Strategy Reviews*, *41*, 100854.

Zakeri, B., Paulavets, K., Barreto-Gomez, L., Echeverri, L. G., Pachauri, S., Boza-Kiss, B., ... & Pouya, S. (2022). Pandemic, war, and global energy transitions. *Energies*, *15*(17), 6114.

Zhang, D., Farnoosh, A., & Lantz, F. (2022). Does something change in the oil market with the COVID-19 crisis?. *International Economics*, *169*, 252-268.