LUISS

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Chair of Empirical Finance

Impact of recent economic shocks on the energy sector : analysis of the conditional volatility of Natural Gas and Crude Oil

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Contents

Abstract

This thesis investigates the conditional volatility of Title Transfer Facility (TTF) natural gas and Brent crude oil prices, amidst an era marked by unprecedented economic, geopolitical, and health challenges. Utilizing GARCH models, the study aims to gain a deeper understanding of volatility dynamics in response to external shocks such as the COVID-19 pandemic and geopolitical tensions, with a particular focus on Russia's invasion of Ukraine. By examining the relationship between volatility, commodity prices, and economic policies, the research seeks to provide insights for risk management and the formulation of more informed investment strategies within the global energy markets.

Chapter 1 sets the foundation with a macroeconomic analysis, examining the impact of inflation and central bank policies on global economic stability. Chapter 2 focuses on the commodities and energy sectors, exploring price dynamics and the repercussions of geopolitical conflicts on energy markets. Chapter 3, through a quantitative approach, applies GARCH models to analyze the conditional volatility of TTF and Brent, offering a perspectives on the predictability of commodity returns and the effects of political-economic uncertainty and investor sentiment.

The thesis concludes that a thorough understanding of conditional volatility in the commodities market is essential for navigating the uncertainties of global markets, providing significant contributions to academic debate and practical implications for policymakers and market participants.

Introduction

In recent years, the global economy has been subjected to a series of unprecedented challenges that have tested the resilience of markets, policy frameworks, and economic theories alike. From the shockwaves sent through global markets by the Covid-19 pandemic to the geopolitical tensions exemplified by Russia's invasion of Ukraine, the landscape of international finance and economics has been marked by volatility and uncertainty. This thesis aims to dissect these multifaceted challenges, providing a comprehensive analysis of their implications for the global economy, with a particular focus on the commodities and energy sectors.

The opening chapter establishes the basis for this inquiry, offering a macroeconomic snapshot of the recent international milieu. It ventures into the economic narratives of the European Union and the United States, conducting a comparative exploration of their strategic economic maneuvers and outcomes amidst prevailing global uncertainties. This segment further addresses the market turbulences triggered by external perturbations, including the Covid-19 pandemic and geopolitical skirmishes, with an acute focus on Russia's aggressive posture. A detailed scrutiny of inflationary pressures—tracing their origins, manifestations, and impacts on wealth distribution and economic expansion—paves the way for a discourse on the strategic responses by monetary authorities, emphasizing the intricate act of balancing inflation containment with the promotion of economic resurgence.

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Finally, in chapter 3 an analytical deep dive into the conditional volatility of natural gas and crude oil is performed, leveraging a quantitative methodology to decode market tendencies. A review of contemporary literature on the predictability of commodities returns and the sway of investor mood and macroeconomic policy uncertainty sets the stage for a detailed application of GARCH models.

Integrating diverse innovations within these models aims to shed light on the subtleties of market volatility and its precursors, with a concentrated examination of TTF and BRENT as exemplar case studies. The findings from these analyses are deliberated, with the validation of outcomes furnishing pivotal insights into risk governance and strategic investment decision-making in flux markets.

In summary, this dissertation endeavors to intertwine macroeconomic overviews with granular analyses of commodities and energy market dynamics, offering a panoramic view of the prevailing global economic scenario. By dissecting the interactions between economic strategies, market responses, and geopolitical developments, it intends to furnish valuable foresights into the emerging challenges and prospects for worldwide economies and market actors.

CHAPTER 1

1. Global context and the macroeconomic situation

To understand the context and the object of the thesis study and in order to offer a detailed and in-depth answer to the research question and the objectives of the work, it is necessary to understand and analyze the dynamics and economic scenarios that are influencing the performance of global economy .

In this paragraph we intend to delve deeper into the current economic panorama of the EU and US economies, analyzing the causes and implications that have contributed to bringing uncertainty and volatility[1] to the markets. Particular attention will be paid to the impact of the pandemic, war and the energy crisis.

1.1. Global scenario of EU and US

It is easy to understand that economic entities are closely interconnected with each other, therefore, there is a significant correlation between the economic performance of the European Union (EU) and that of the United States (USA).

To evaluate the economic performance of a country, macroeconomic measurements are essential to obtain a comprehensive overview. Among these measures, the most relevant are the GDP which represents the total value of goods and services produced within a country over the course of a year, we also find the unemployment rate which indicates the percentage of the total number of individuals in the workforce who are unemployed. Another crucial indicator is inflation which calculates the annual percentage change in a price index, usually the consumer price index.[1]

In addition to the previous indicators, there are other macroeconomic tools such as the long-term interest rate, i.e. the yield or cost of money borrowed for a prolonged period of time, a tool that is used by central banks to influence the economy by defining their monetary policy. Finally, the exchange rate which represents the relative value of one currency compared to another and therefore evaluates the stability of the national currency compared to others.

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[1] Wells, R., Graddy, K., & Krugman, P. R. (2012). L'essenziale di economia (2° edizione, pag. 293cap.11).

1.1.1. European Union: general overview

The European Union (EU) is an economic and political union, an integrated financial system made up of 27 member countries that share a common set of policies and institutions. The EU was created with the aim of intensifying cooperation between members and promoting growth and stability in the region, ensuring more than half a century of peace and prosperity. [2]

The single market is the backbone that allows sustainable growth in Europe, as it aims to remove trade barriers between member countries, and is based on four fundamental freedoms: the free movement of goods, services, people and of capital, in order to create economic opportunities and promote the competitiveness and cohesion of members.[3]

The EU is one of the world's largest players in international trade and plays a significant role in the global economy as an exporter and importer of goods and services. The main partners for total trade in goods and services are the United States (21% of total non-EU trade), China (12%) and Switzerland (8%).[4]

To understand the economic situation of the union, we make use of the macroeconomic projections carried out by Eurosistema and ECB experts, which contribute to the assessment conducted by the Governing Council of the ECB on economic trends and risks to price stability. They are published four times a year: in March, June, September and December.

Economic activity in the euro area declined slightly in the third quarter of 2023; this reflected the negative contribution to growth provided by the destocking of inventories, which was partly counterbalanced by the positive contribution of domestic demand. (Figure 1**).**

In the third quarter, growth in the euro area amounted to -0.1%, a level slightly lower than the zero expected in the projections last September (table 1). Value added in the manufacturing and construction sectors continued to decline, while in the services sector it increased.

As regards the components of demand, private consumption grew in the third quarter; the increase concerned in particular the consumption of services, probably supported by the segment with a high intensity of interpersonal contacts during the summer season, and of durable goods. Conversely, losses in competitiveness due to exchange rate and energy price developments have led to a decline in exports.

The current inflationary trend continues to be a cause for concern, while for 2023 the average inflation rate was 5.4%, it is expected to decrease to 3.0% in 2024. This expected reduction in

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[2] L'Ue - Che cos'è e che cosa fa. - https://op.europa.eu/webpub/com/eu-what-it-is/it/

[3] L'Ue - Che cos'è e che cosa fa. - Cit,

[4] L'Ue - Che cos'è e che cosa fa. - Cit,

inflation reflects the decrease in all main components, influenced both by fiscal policy measures and by forecasts relating to raw material prices.

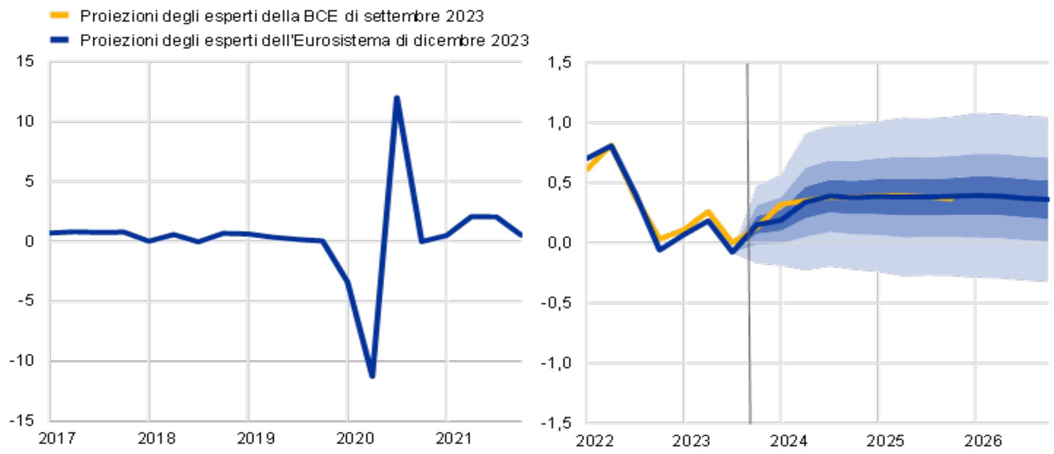
In an economic context where turbulence has put the system to the test, the labor market has proven solid. In 2023, the euro area unemployment rate was 6.5%, and down from 6.6% in 2022. (table 2) This data is published by Eurostat, the statistical office of the European Union.

Over the past decades, policy rates have remained at historically low levels, reflecting the need to provide substantial stimulus to the economy.

In this context, it was notable to see the ECB reference rate rise to 4.25%, an unusual value compared to previous trends, indicative of the current direction of monetary policy. This increases paralleled movements in other market segments. For example, the yield on ten-year bonds saw an increase, reaching 3.1%, while the STR rate, which represents the cost of unsecured overnight loans in euros that the main euro area banks contract among themselves, also increased. averaged 3.20% in 2023.

Figure 1: Euro area real GDP growth

(percentage changes on the previous quarter, quarterly data seasonally adjusted and corrected for number of working days)



Source:

https://www.ecb.europa.eu/pub/projections/html/ecb.projections202312_eurosystemstaff~9a39ab5088.it.html

Table 1: Projections for growth and inflation in the euro area

	December 2023 (annual percentage changes)					**September 2023**(annual percentage changes)			
	2022	**2023**	**2024**	**2025**	**2026**	**2022**	**2023**	**2024**	**2025**
GDP in real terms	3,4	0.6	0.8	1.5	1.5	3,4	0.7	1.0	1.5
HICP	8.4	5.4	2.7	2.1	1.9	8.4	5,6	3.2	2.1

Source:
https://www.ecb.europa.eu/pub/projections/html/ecb.projections202312_eurosystemstaff~9a39ab5088.it.html

Table 2: Projections for real GDP, labor markets and trade

	December 2023(annual percentage changes)					**September 2023** (annual percentage changes)			
	2022	**2023**	**2024**	**2025**	**2026**	**2022**	**2023**	**2024**	**2025**
GDP in real terms	3,4	0.6	0.8	1.5	1.5	3,4	0.7	1.0	1.5
Private consumption	4.2	0.5	1.4	1.6	1.4	4.1	0.3	1.6	1.6
Collective consumption	1.5	0.1	1.1	1.3	1,2	1.5	-0.1	1.1	1.4
Gross fixed investments	2.8	1.3	0.4	1.8	2.1	2.9	1.7	-0.4	1.4
Exports[1)]	7.4	-0.4	1.1	2.9	3.0	7.3	1.3	2.5	3.1
Imports[1)]	8.1	-0.9	1.7	3.1	3.0	8.1	0.3	2.5	3.1

	December 2023(annual percentage changes)					September 2023 (annual percentage changes)			
	2022	2023	2024	2025	2026	2022	2023	2024	2025
Employment	2,3	1.4	0.4	0.4	0.4	2,3	1,2	0.2	0.2
Unemployment rate (% of labor force)	6.7	6.5	6.6	6.5	6.4	6.7	6.5	6.7	6.7
Current account balance (% of GDP)	-0.7	1,2	1.0	1.0	1.1	-0.8	1.1	1.4	1.6

Note: Projections regarding real GDP and its components are based on seasonally adjusted data adjusted for the number of working days. Historical statistics may diverge from the most recent Eurostat publications due to data dissemination beyond the cut-off date of the projections. It is possible to download statistics, even on a quarterly basis, from database of macroeconomic projections available on the ECB website.

1.1.2 Overview of United States economy

The USA is a federal constitutional republic, composed of a central government and 50 individual states with their own powers and authorities. Economically they adopt a capitalist model, in which most businesses and resources are privately owned and operated with the primary motivation of profit. This system has led them to represent the largest economy in the world and therefore a colossus that profoundly influences the performance of the world economy. They are leaders in several sectors, including technology, finance, healthcare and have risen to second place as the most innovative country in the world.[5]

Thanks to the success and central role of the USA in the world economy, the US dollar (USD) has also acquired a fundamental position on the international scene, this currency has become the main point of reference in trade and finance. Important commodities, such as oil, gas, gold and many other natural resources, are valued in dollars in the world's major financial markets. This dominance is further highlighted by the fact that some countries have chosen to adopt the dollar as their official currency.[6]

The American economy has its roots in the primary sector, subsequently seeing enormous industrial growth in the 20th century, becoming a world leader in many industries, from automotive (General Motors) to consumer electronics (Apple), from aerospace (Boeing) to sports clothing (Nike) and

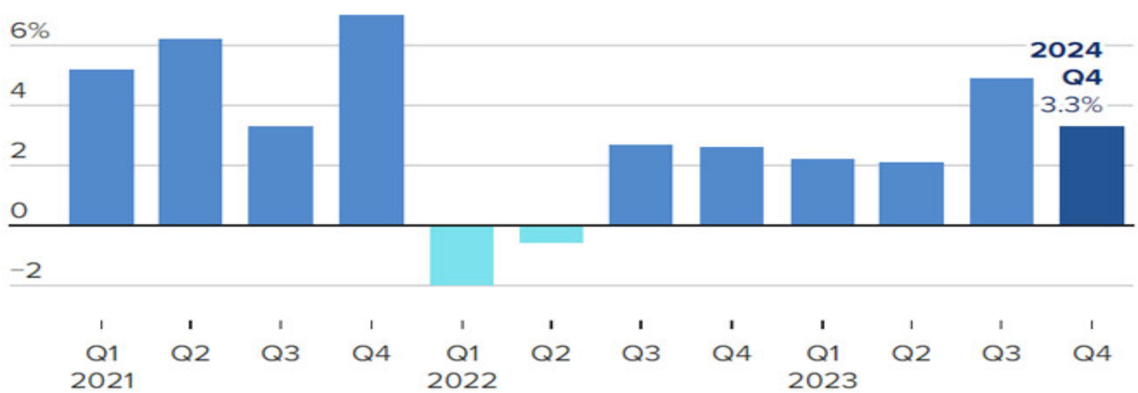
[5] UNITED STATES. -https://www.anpit.it/sportelli/sportello-internazionaliizzazione/stati-uniti/

[6] UNITED STATES. - Cit.

much more, the secondary sector still accounting for 25% of GDP. The most developed sector with the greatest impact on US economic growth (73%) is the tertiary sector, where great importance is given to the transport network, but also to banking, insurance, international trade and entertainment. The stars and stripes economy continues to reserve surprises for the markets. The US GDP also closed the last quarter of 2023 with an unexpected result: +3.3%, slowing down from the previous +4.9% but well above the 2%, analysts had bet on. A figure that brings growth for the whole of 2023 to 2.5% and gives the Federal Reserve (Fed) more margins for postpone the rate cut of interest. Hypothesis which, according to the managers, is now not only more probable but also desirable from an inflation perspective. Consumption and work also held up more than expected. (figure 2)

According to the report drawn up by the Department of Commerce, what determined the slowest quarterly growth rate of the last two years was the slowdown to 2.8% of consumption expenses**.** Precisely this magnitude, combined with public spending increasing by 3.7% and private investments growing by 2.1%, however, was worth a performance on an annual basis that no one could have expected. A reconfirmation of two phenomena that have now become a constant for the economic performances achieved by Washington: liquidity reserves accumulated by citizens during the pandemic are far from exhausted and the labor market is resisting the Fed's monetary tightening in terms of both wages and new jobs. With similar numbers, a scenario of soft landing which once again fuels doubts about the moves of Jerome Powell and colleagues on the cost of money.

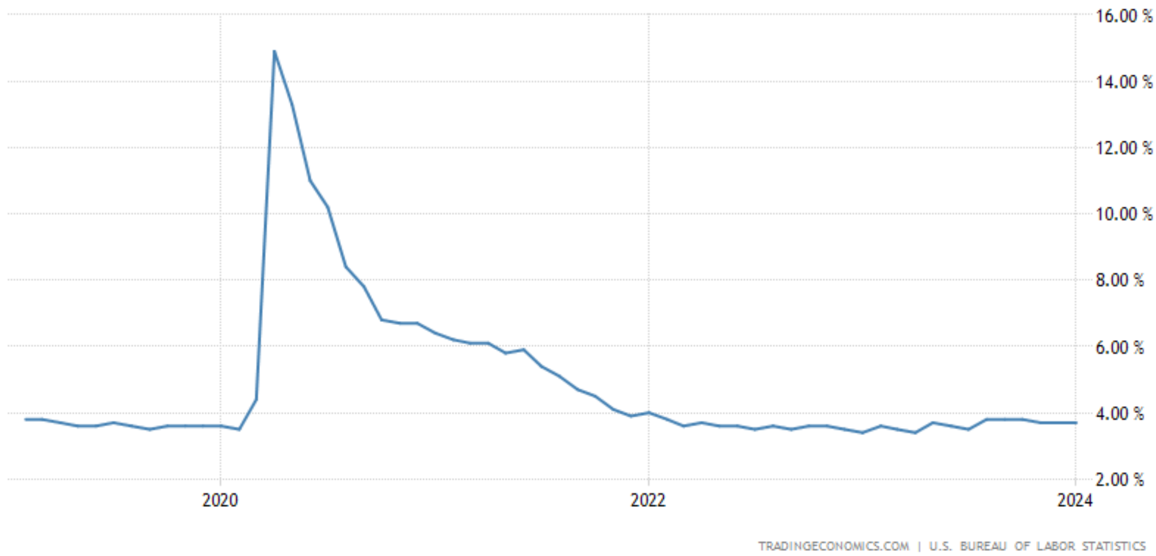
Figure 2: Real gross GDP of the United States



Seasonally adjusted annual growth rate of the US economy. Data as of January 25, 2024. Source: US Bureau of Economic Analysis

During the pandemic, the labor market suffered a major crisis, with the unemployment rate jumping to 14.7% (from 3.67% in 2019) during the lockdown. Since March 2022, it has varied between 3.4% and 3.7%, a labor market that confirms its solidity and stability also in 2023 even if some increases have come from the data of recent months, the creation of new jobs it fell short of expectations.

Figure 3: US unemployment rate 2020-2023



Source: https://it.tradingeconomics.com/united-states/unemployment-rate

Table 3: US unemployment rate (August 23-January 24)

Release date	Now	Current	Expected	Previous
02.02.2024 (Jan)	2.30pm	3.7%	3.8%	3.7%
05.01.2024 (Dec)	2.30pm	3.7%	3.8%	3.7%
08.12.2023 (Nov)	2.30pm	3.7%	3.9%	3.9%
03.11.2023 (Oct)	1.30pm	3.9%	3.8%	3.8%
06.10.2023 (Sep)	1.30pm	3.8%	3.7%	3.8%
01.09.2023 (Aug)	1.30pm	3.8%	3.5%	3.5%

Source: https://it.investing.com/economic-calendar/unemployment-rate-300

During the previous year inflation in the USA Annual core inflation rate eased to 3.9%, below 4% in the previous period but above expectations of 3.8%. The trend remains consistent with forecasts and has not shown significant peaks, indicating a situation that is coming back under control, for this reason forecasts expect inflation to fall below 3% in 2024.[7]

Although the USD is one of the main protagonists on the global financial stage, the political uncertainties and economic tensions it is facing have led the currency to depreciate in recent months, in particular it has seen a decrease in value against the EUR of 1.99% in the previous year and 5.90% in the last 5 years.

The Fed's reference rate, the "Federal Funds Rate", is currently set at a decidedly high level, equal to 5.50%. This aggressive rate clearly indicates a proactive strategy of the central bank, wanting to influence the economic and monetary trend. Likewise, the effective rate for short-term loans (EFFR) follows at 5.33 as well as 10-year sovereign bonds raised their work 4.11.

The US economy, having anticipated the implementation of anti-inflationary measures, now seems more balanced than Europe. The U.S. labor market is robust, with consistent new job creation and a historically low unemployment rate. Yet, inflation represents a threat to the growth and stability of the economy which is why the interest rate continues to rise. For the dollar the year 2023 was not exciting losing value from all major currencies.[8]

Figure 4: euro/dollar exchange rate 2019-2024

Source: https://www.xe.com/it/currencycharts/?from=EUR&to=USD&view=5Y

7 https://tradingeconomics.com/united-states/forecast

8 An Update to the Economic Outlook: 2023 to 2025. -https://www.cbo.gov/system/files/2023-07/59258-econ-outlook.pdf

1.2. Uncertainty and volatility in the markets

The dynamics of uncertainty and instability of the financial markets has represented a topic of growing interest, reaching its peak in recent years as global events such as the pandemic and then the war in Ukraine have amplified the complexity of economic and financial variables.

Uncertainty according to economist John Maynard Keynes is linked to the inability of economic agents to make reliable predictions about future events, and this is due to the limited ability of economic agents to draw on complete or definitive knowledge, arguing that most decisions are based on "conventions" rather than on objective probabilistic calculations, underlining the vulnerability of the economic system to prevailing sentiments. Uncertainty could lead to periods of excessive pessimism or optimism among investors, helping to influence and amplify the volatility of the markets and the entire economic landscape.[9]

In the markets, volatility, on the other hand, refers to the instrument that measures the change in a price in a given period, serving as a risk indicator. A high degree of volatility is associated with greater risks but with higher profit potential, while a low risk indicates greater stability with returns that tend to be more modest given the limited fluctuation.[10]

Factors that can influence uncertainty and volatility in the markets can be multiple and interconnected. Some examples could be Central Bank decisions, financial crises or macroeconomic news. In particular, the most relevant factors in this historical period will be explored in depth.

The "Volatility Index (VIX)" is one of the most popular financial instruments on the market as it is used as a measure of volatility expectations on the stock market in the United States. Through its oscillations it allows us to predict the volatility expected in the next 30 days by detecting what the feelings of investors may be, highlighting their relative nervousness (periods of uncertainty or fear on the market) or on the contrary, periods of relative calm that indicate stability.[11]

Expressed in percentage terms, in Figure 7 a value of 10% represents an expected volatility of 10% for the following month. The reading takes place following the reference levels which therefore when the value is 20%, suggests a certain stability of the market, however, when it exceeds the threshold of 30% we are faced with periods of uncertainty (high volatility).[12]

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[9] Harmstone, TO. A history of the risk. Page 1-2 - https://www.morganstanley.com/im/publication/insights/macro-insights/mi_ataleofrisk_it.pdf

[10]CWhat is the Volatility Index (VIX) and how do you trade it? | FP Markets Italy. - Cit.

[10] Harmstone, A. A history of risk. Page 6 – Cit.

[11] What is the Volatility Index (VIX) and how do you trade it? | FP Markets Italy. - https://www.fpmarkets.com/it/education/forex-trading/understanding-volatility-index-in-forex/

[12] What is the Volatility Index (VIX) and how do you trade it? | FP Markets Italy. - Cit.

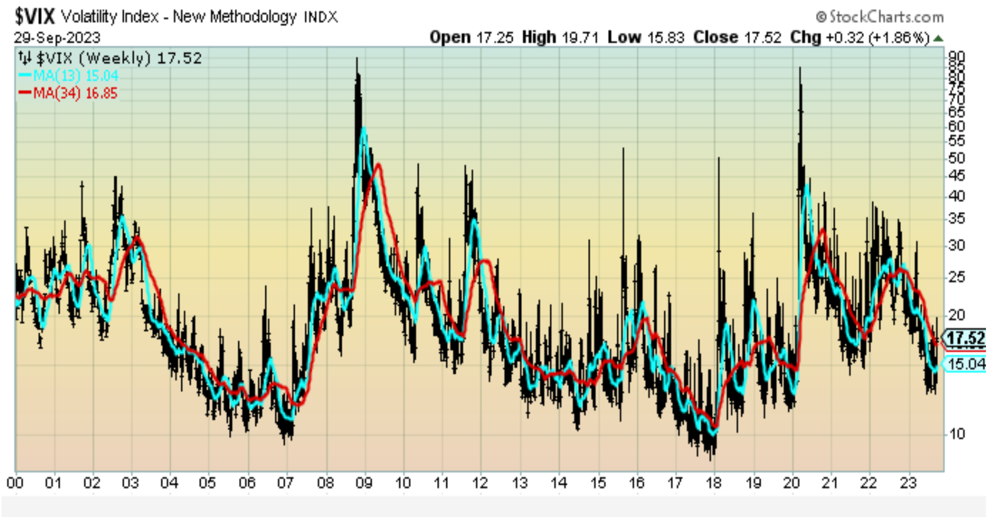
Figure 5 highlights the moments of economic instability from 2000 onwards, in particular we can see how the first surges in volatility were recorded at the beginning of the 2000s during the explosion of the dot-com bubble (speculative bubble) and by terrorist attacks of September 11, 2001 causing waves of panic among investors, leading to a sudden flight from risk.

The 2008 financial crisis also represented a historic moment for the VIX indicator as it reached levels so high that they have never been repeated, reflecting the uncertainty and lack of confidence in the global financial system and suggesting unprecedented volatility and a pervasive atmosphere of fear.

The trend following the crisis shows a gradual return to moderate levels with sporadic upward declines particularly in moments of uncertainty linked to Brexit or Donald Trump's presidential elections between 2016 and 2017 as well as trade tensions between the USA and China relating to duties.

The period 2021-2023 saw a further series of fluctuations in the VIX index linked mainly to three events: the Covid-19 pandemic and its economic repercussions, geopolitical instability, in particular linked to the war in Ukraine and vulnerability of the banking sector which in just a few months saw the sudden collapse in the United States of Silicon Valley Bank (SVB) and Signature Bank (SBNY) as well as the forced takeover of Credit Suisse by the government in Switzerland.

Figure 5 Volatility Index (VIX)



Source: https://www.economicgreenfield.com/2023/10/02/vix-weekly-and-monthly-charts-since-the-year-2000-october-2-2023-update/

The VIX index therefore allows us to interpret the mood and expectations of investors who in recent years have shown how delicate the balance of the financial markets is, with a series of events that have tested the resilience and adaptability of the world economy. Knowledge of market uncertainty and volatility offers economic actors the tools to prevent or mitigate financial instability phenomena or investors the possibility of seizing opportunities and protecting their interests.

1.3 Covid-19 pandemic and Russia invasion

The introduction of the next elements is of fundamental importance for the success of an accurate essay since these topics represent extraordinary events and situations that have had a significant impact on the global economy

Covid-19 pandemic

The Covid-19 (SARS-CoV-2) pandemic has been a health crisis that has shaken the entire world. This phenomenon originated in Wuhan, Hubei Province, China, in late 2019. The virus spread rapidly globally, with first outbreaks outside China reported in other parts of Asia, but Covid-19 soon reached all continents. Within a few months, the WHO declared the situation a full-blown pandemic, underlining its scale and impact on a global scale.

The economic consequences have been devastating, with numerous nations implementing lockdowns and curfews to contain the spread of the virus. These restrictions began in March 2020 and triggered a significant contraction in economic activity, causing numerous job losses and triggering financial crises. Unprecedented efforts have been made to develop and distribute effective vaccines globally in an effort to contain the pandemic and protect public health.[13]

Vaccination campaigns kicked off in early 2021, laying the first foundation for subsequent easing that spurred an economic recovery. Although by the second half of 2022 almost all states have lifted restrictions and the Covid-19 pandemic is under control, it remains one of the most significant obstacles ever faced by humanity. It has tested the tenacity of society, healthcare systems and world governments.[14]

War in Ukraine

Russia's invasion of Ukraine began on February 24, 2022 and continues to evolve. This complex

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[13] WHO Director-General's Opening Remarks at the Media Briefing on COVID-19 - 11 March 2020 - https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the- media-briefing-on-covid-19March 11, 2020

[14] Floor national Of vaccination COVID-19. Epicentro.iss.it. -https://www.epicentro.iss.it/vaccini/covid-19-piano-vaccinazione

war situation is the result of an intricate mix of political, historical and economic events. The ethnic and cultural differences between Ukraine and Russia, together with the dispute for the dominion of resources and regions of strategic importance, are at the center of this conflict.[15] Over time, the clashes have worsened, causing a notable number of victims, the flight of many citizens, serious damage to infrastructure and entire cities razed to the ground. The humanitarian crisis, however, represents only one of the many consequences of this conflict.[16]

The economic sanctions undertaken by Europe and the world against Russia have caused a sharp reduction in supplies of Russian gas, energy and raw materials, influencing prices towards a sharp rise.[17] As of August 2022, the price in Europe has reached historic highs of 340 euros per megawatt hour. In the United States, prices also surpassed their highest levels since 2008. Additionally, the costs of food items, such as wheat, saw a sharp increase due to Ukraine, which was one of the world's leading exporters of corn, wheat and oil. of sunflower.[18]25 The continuation of the conflict has generated significant inflation, sharp increases in bills, fuel costs and raw materials, placing the West faced with important economic challenges.[19]

1.4 Surge in inflation

Price stability is one of the essential aspects in assessing the health of an economy. Over the years, it has become the priority of central banks as economic studies have highlighted that in the long run, economies with lower inflation are generally characterized by higher growth in production and income.[20]

The causes of current inflation are rooted in the measures introduced to counter the two important crises that shook the world: the health crisis at the beginning of 2020 and the geopolitical one in 2022 which further complicated the global economic panorama. The repercussions of these events

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15 UN General Assembly calls for immediate end to war in Ukraine -https://unric.org/it/lassociazione-generale-delle-nazioni-unite-chiede-la-fine-immediata-della-guerra-in- Ukraine/

16 Message from the Secretary General on the war in Ukraine. - https://unric.org/it/messaggio-del- segretario-generale-sulla-guerra-in-ucraina/

17 Gas Market Report, Q4-2022 -https://www.iea.org/reports/gas-market-report-q4-2022

18 Global impact of the war in Ukraine on food, energy and financial systems. -https://unric.org/it/globale-impact-of-war-in-ukraine-on-food-energetici-and-financial systems

19 EU restrictive measures against Russia in relation to Ukraine (since 2014). - https://wwww.cornsilium.europa.eu/it/policies/sanctions/restrictive-measures-against-russia-over-ukraine/

20 Bank Central European. Why And important That the prices they are stable? - https://www.ecb.europa.eu/ecb/educational/explainers/tell-me-more/html/stableprices.it.html

were having a negative impact on the economy and therefore urgent stimulus measures were needed.[21]

There are many factors that have influenced the destabilization of prices, in particular the increase in energy prices that began in 2021, and worsened in 2022 with the outbreak of the war in Ukraine. The issue related to energy supply represents the main reason why Ukraine assumes fundamental strategic importance for Europe. In fact, over 26% of the natural gas coming from Russia passes through Kiev and Europe has proved to be very vulnerable towards the West and has therefore had to face a drastic decrease in gas supplies and an increase in energy costs, as 50% of non-European gas was imported from Russia.[22]

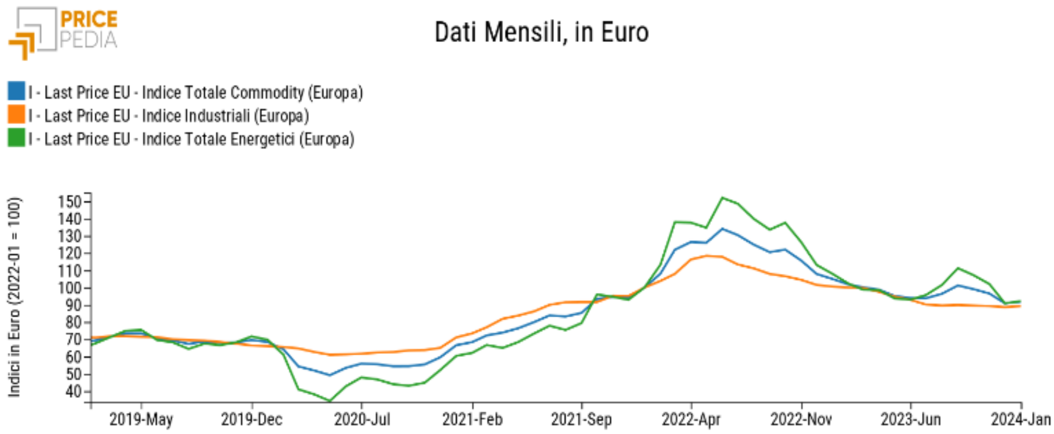
Figure 6 : Raw material prices (2019 – 2023)

[21] Inflation and war in Ukraine: the Swiss economy is moving with the handbrake on. https://economiesuisse.ch/it/articles/inflation-and-war-ukraine-swiss-economics-travels-with-the-handbrake-on

[39] Energy: 5 maps to understand the gas crisis. ISPI. -https://www.ispionline.it/it/pubblicazione/energia-5-maps-understanding-the-gas-crisis-33342#:~:text=But%20da%20where%20passes%20everything

[22] Energy: 5 maps to understand the gas crisis. ISPI. -https://www.ispionline.it/it/pubblicazione/energia-5-maps-understanding-the-gas-crisis-33342#:~:text=But%20da%20where%20passes%20everything

Figure 7: Raw material prices (2019 – 2023)



Source:https://www.pricepedia.it/it/magazine/

The onset of the war between Russia and Ukraine has contributed to creating instability in the markets and led to a considerable increase in the price of raw materials, triggering uncertainties and concerns regarding energy supplies, in particular regarding oil and natural gas, which are fundamental to the economy. Volatility in energy prices has emerged as one of the main factors contributing to higher prices.

Moreover, the countries in which the expansion of the money supply has been notable, driven by government stimulus policies, abundant bank loans and very low interest rates, have seen high inflation rates such as, for example, in the United States where they have reached almost 10%. This phenomenon confirms the validity of one of the key theories of economics: the quantity theory of money.

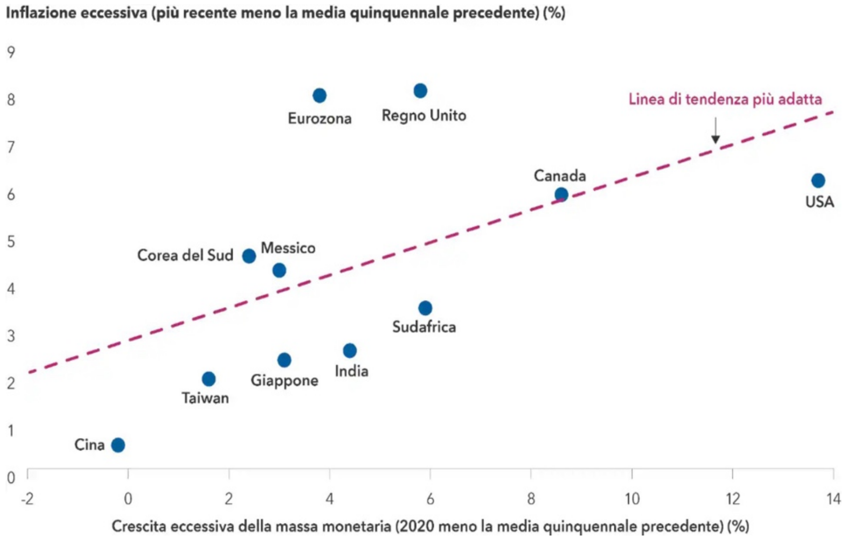
The quantity theory of money is a key concept in economics, it was developed by the monetarist school which argues that an increase in the quantity of money in circulation, other variables being equal, will lead to an increase in the prices of goods and services and therefore central banks, which manage the money supply, are responsible for the long-term price trend[23].

It can be seen from the graph how the measures taken by the United States and the EU led to a significant increase in the quantity of money in circulation during the crisis from Covid-19. Above all the United States has conducted an unprecedented stimulus policy to limit the negative effects of the pandemic on the economy. The approach of the ECB is also similar, providing subsidized financing to banks by implementing securities purchase policies to guarantee liquidity to the

[23] ECB The stability of the prices: Why And important For you. Page 47. - https://www.ecb.europa.eu/pub/pdf/other/whypricestabilityit.pdf

financial system. Furthermore, the same effects can also be seen in the United Kingdom and Canada.

Figure 8: The growth of the money supply that contributed to high inflatio



Source: capitalgroup.com, inflation data is updated in August or July 2022 and reflects the latest data available as of 14.09.2022

Another cause can be traced back to the difficulties of supply, caused by the continuation of "zero covid" policies in China, which represents a key point in the industrial supply chain, this has created a significant "bottleneck". The lack of supplies caused by the measures taken such as border blockades and mobility restrictions, which have hindered the international transport of goods by creating logistical problems, have contributed to slowing down production, slowing down the activity of many companies and creating difficulties in meeting the consumer demand.[24]4

1.5 High inflation effects on the economy

A high rate of change in prices is considered harmful as it can generate a series of consequences on multiple sectors of a country's economic system. The authorities become agitated when the inflation rate begins to rise as economists believe that this phenomenon produces high economic costs.42

1.5.1 Effects on income distribution

In a climate of uncertainty and mistrust in the future, those who suffer most from inflation are those who earn fixed incomes, including employees and pensioners. While the costs of goods and services

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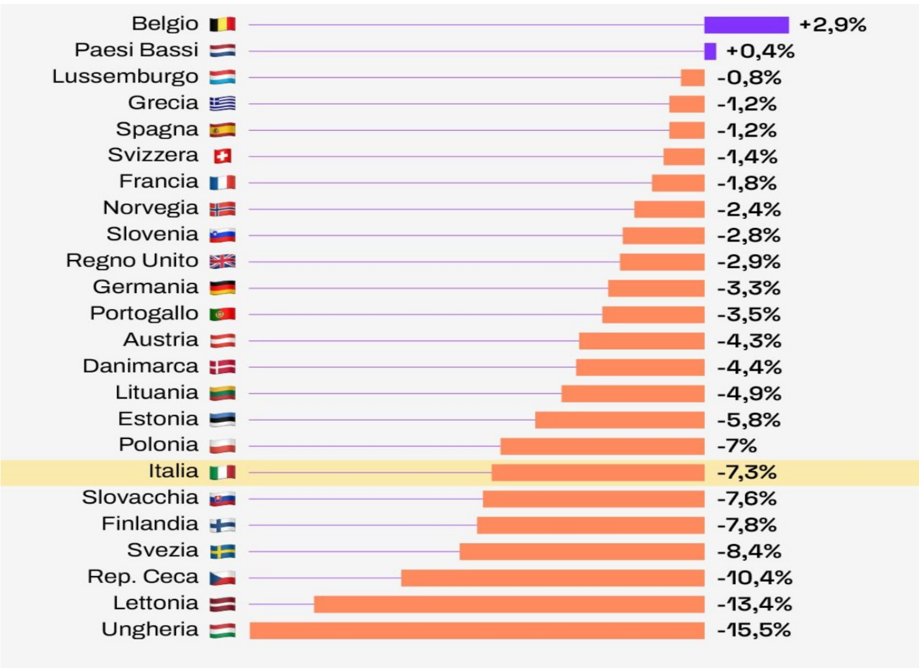
[24] [41] Rees, D. Three reasons why inflation is back... to stay. -https://www.schroders.com/it- it/en/private-investors/view/three-reasons-why-inflation-is-back...-to-stay

continue to increase, nominal wages are usually adjusted only periodically through contract renewals. As a result, there is a decrease in the real value of wages.

Those who depend on variable incomes, such as professionals, artisans and traders, are more inclined to adjust their compensation or the prices of goods based on changes in the purchasing power of money. This adaptation allows them to preserve their real income even in an inflationary environment.

From the analysis of figure 9, it is clear how the current context of general inflation observed in OECD countries has a tangible impact on real wages, progressively eroding purchasing power in economies. Although nominal wages have shown some recovery, it has not been nearly as rapid as the cost of living, leading to a decline in real wages in 30 of the 34 countries for which data is available (-3.8%).

Figure 9: Change in real wages between the first quarter of 2022 and 2023



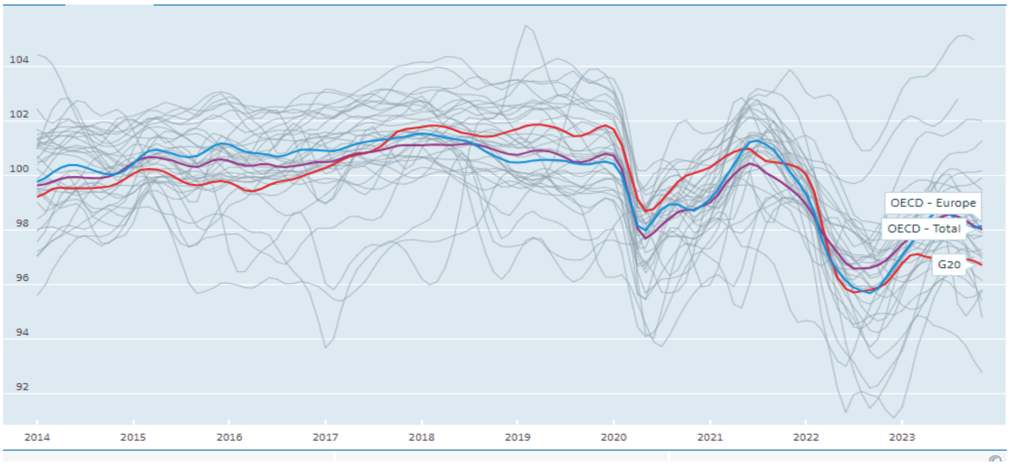
Source: oecd.org

1.5.2 Slowdown in economic growth

The decrease in purchasing power leads to changes in consumption habits. When the prices of goods and services constantly increase, families tend to anticipate their spending, for fear of having to pay too much for goods in the future. This implies a reduction in liquidity and consequently also in savings. Banks will have to increase interest rates on deposits to compensate for the loss of purchasing power and convince families to maintain liquidity. In the absence of savings, investor confidence will tend to decrease, slowing down investments and this will have negative effects on economic development.

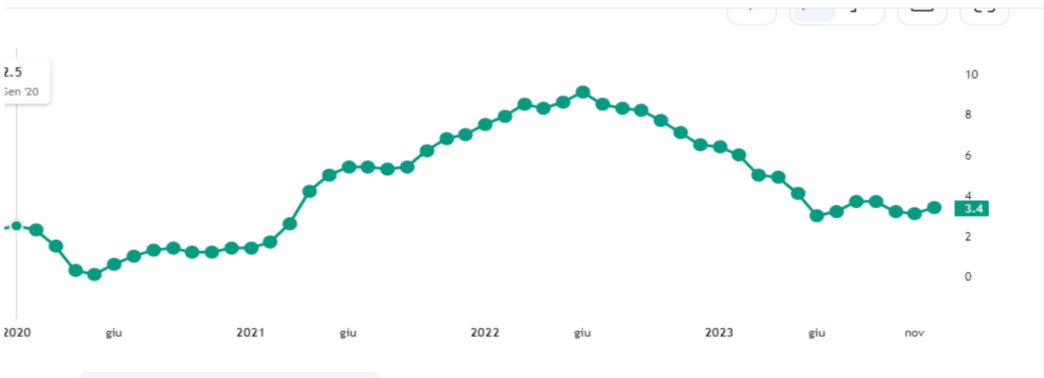
In Figure 10 we can see how the lows in terms of economic growth and consumer confidence were ultimately reached in 2022. The first part of 2023 shows how confidence plays a key role in the performance of an economy, when the confidence has started to improve, business indicators have also recorded a recovery. In February, the number of firms reporting an increase in production was higher than the number of those experiencing a decline, with substantial increases in the United States, the eurozone, China and the United Kingdom.Accurately forecasting inflation is critically important as central banks use these forecasts to make monetary policy decisions. It also affects the financial planning of investors and savers who tend to protect their investments and wealth. They can be a valid stimulus for unions when they request wage adjustments, which take into account the erosion of purchasing power. In the economic system, actors use forecasts to manage and plan their strategies, this allows them to contribute to economic stability.The Fed's projections regarding price trends highlight the effectiveness of the measures implemented in order to re-establish price stability in the country. Figure 11 clearly illustrates how the peak of inflation was reached in mid-2022 and now experts expect it to return to more moderate levels, (after ending 2023 at 3.2%), 2.5% in 2024 and 2.1% in 2025.

Figure 10: Consumer confidence index (CCI) https://data.oecd.org/



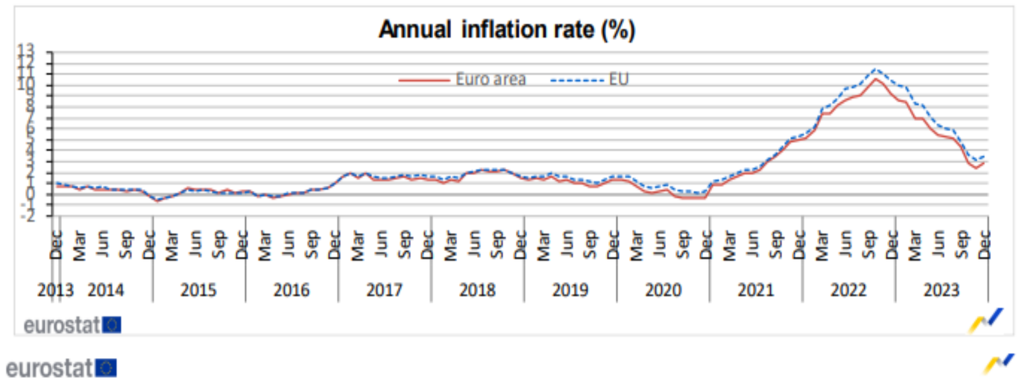
Source: oecd-ilibrary.org

Figure:11: US inflation



Source: https://it.tradingview.com/symbols/ECONOMICS-USIRYY/

Figure 12



Source: https://formatresearch.com/2024/01/17/eurostat-inflazione-annua-area-euro/

Even in Europe, the peak of inflation was reached in the third quarter of 2022 and during 2023 we saw a notable deceleration in prices. In line with the measures undertaken, a continuous reduction in prices is anticipated, forecasting that inflation will reach 2.7% in 2024 and reach 2.1% in 2025.[25]

1.6 Central banks response

Central banks are normally public law entities responsible for regulating and supervising the banking system, as well as controlling the monetary base, pursuing various macroeconomic objectives such as price stability, economic growth and full employment. At a time of particular global economic instability, when prices are out of control, their actions and decisions have a significant impact, influencing various aspects of citizens' daily lives and the overall health of financial systems.

[25] europa.eu/pub/projections/html/ecb.projections202312_eurosystemstaff~9a39ab5088.it.html

The Federal Reserve System, commonly known as the Federal Reserve or simply the Fed, represents the central bank of the United States of America. It is recognized globally as the most important central bank, given its significant influence on the national and global economy.[26] The hyper-expansionary policies implemented by the Fed to counteract the economic contraction due to the health measures implemented to cope pandemic needs are the main cause of the inflation that hit the United States in 2021. This decisive intervention, which saw a combination of burdensome fiscal and monetary policy interventions, allowed the US economy to restore production levels prior to the pandemic already in the first months of 2021. In particular, the interest rate on Fed Funds was immediately lowered to 0.25% (decrease of 100 basis points) and government bonds and bonds were purchased on a large scale (the so-called Quantitative Easing) which led the US central bank to provide liquidity of at least 120 billion dollars per month[27].

At the beginning of 2021, some worrying signs of a potential inflationary wave could already be seen in the United States, despite these first signs the Fed decided to maintain an accommodative monetary policy. The authorities argued that inflation would be temporary and non-structural in nature. This increase in prices was perceived as a direct consequence of the phenomena of resource dislocation and the distorting effect caused by the direct comparison with the price levels of the previous year in which significant negative variations had been recorded. These phenomena occurred due to a recovery in economic activity that was neither complete nor uniform across all sectors. The dislocation arose from the difficulty of reallocating resources in an economic environment trying to quickly adapt to post-pandemic changes. While some industries thrived, others struggled to return to pre-pandemic levels, leading to imbalances in prices and supplies. In this context, the Fed tried to reassure the market by suggesting that inflation would be a temporary phenomenon and not a persistent trend.[28] Expansionary monetary policy choices played a crucial role in the manifestation of inflation in the US, although they were necessary in that context.

Figure 11 illustrates how from the second half of 2021 the price increase consistently exceeded 5%, culminating in a peak of 9% in June 2022. The energy market played a marginal role, while the market's reaction to the restart post-covid has led to a growth in the prices of food, industrial goods and services. In the first half of 2023, inflation decreased from 6.41% to 2.97%.

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[26] Federal Reserve Board - Structure of the Federal Reserve System - https://www.federalreserve.gov/aboutthefed/structure-federal-reserve-system.htm

[27] La politica monetaria USA e gli effetti sulle economie emergenti. - https://osservatoriocpi.unicatt.it/ocpi-pubblicazioni-la-politica-monetaria-usa-e-gli-effetti-sulleeconomie-emergenti

[28] Board of Governors of the Federal Reserve System Monetary Policy Reports - https://www.federalreserve.gov/monetarypolicy/files/20220225_mprfullreport.pdf Board of Governors

From this analysis it emerges that US inflation can be understood as the result of a combination of effects resulting from expansionary monetary policies, repercussions minor external issues such as the crisis in Ukraine, and above all by strong internal demand triggered by the economic reopening and accentuated by the significant fiscal and monetary stimulus measures adopted by the government and the Fed.

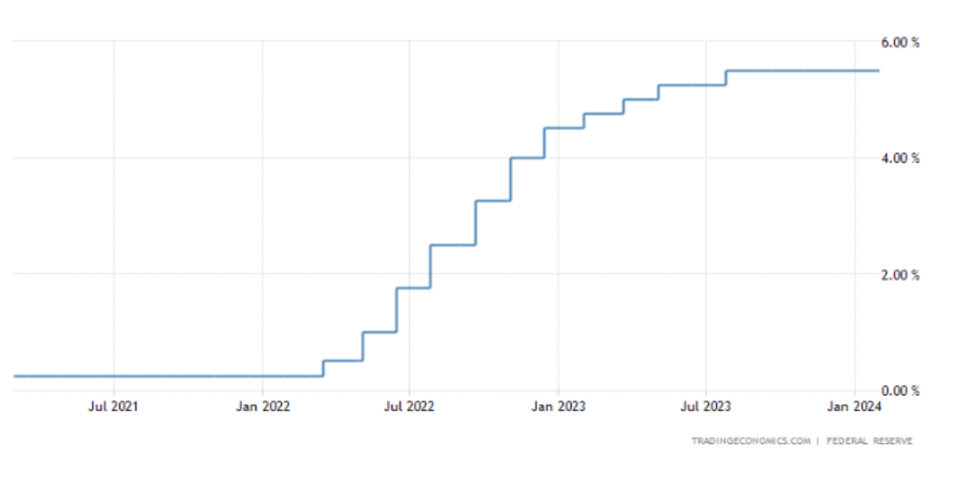
Following the onset of the conflict in Ukraine, the markets recorded a marked growth in the prices of various raw materials, this trend fueled an atmosphere of uncertainty in the financial markets, inducing the Fed to make a decisive change in its monetary policy. This change, in reality, had already been discreetly initiated a few weeks earlier through the progressive reduction of the size of its balance sheet. The most important strategic intervention implemented to avoid consolidation by inflation was the increase in interest rates which aims to reduce the demand for credit and spending since higher rates make investments and loans less attractive. [29]

Interest rates are the key tool used by central banks to regulate inflation and guarantee stable prices in the long term. Examining figure number 13 we note that the interest rate has been adjusted upwards 11 times starting from March 2022, when the target federal funds reference rate was effectively equal to 0%, it is now set in a band that varies between 5.25% and 5.50% (highest level since 2001). The effectiveness of this strategy emerges from the analysis relating to inflation, highlighting a sharp decline from 9.1% in June 2022 to 3.2% for the month of July 2023. The current rate policy represents a clear departure from the "easy money" strategy ” adopted following the 2008 financial crisis. Projections suggest that the Fed could further raise the rate in the coming sessions[30]

[29] Board of Governors of the Federal Reserve System Monetary Policy Report – Cit.

[30] [52] Federal Reserve to Taper Bond Purchases and Raise Interest Rates | US Bank. - https://www.usbank.com/investing/financial-perspectives/market-news/federal-reserve-tapering-asset-purchases.htmL

Figure 13: US interest rate

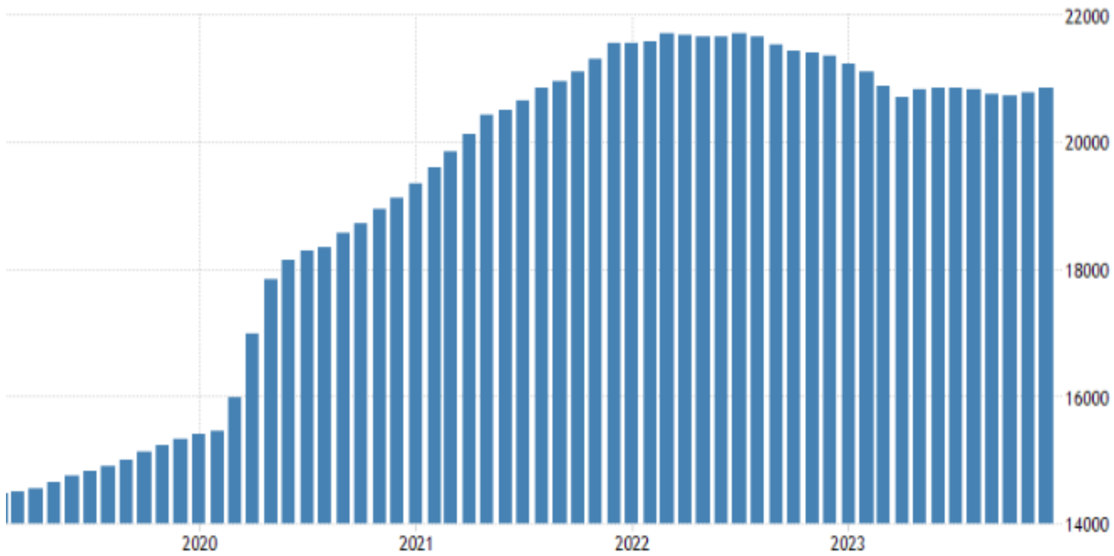


An alternative to stimulate the economy are open market operations "OMO", these operations involve the purchase of government bonds from commercial banks and institutions with the main aim of increasing liquidity in the banking system, thus increasing the amount of money in circulation. This can, in turn, boost employment and promote economic growth. The strategy implemented by the Fed led to the expansion of its balance sheet which reached almost 9000 billion, doubling the value compared to the beginning of the pandemic crisis, this once again demonstrates the proactive approach in relaunching the economy through monetary policies aggressive.

At the same time as the decision to raise interest rates, the Fed embarked on a process of reducing the securities held in its portfolio. From the analysis of the figure it emerges that the maximum accumulation of these securities was reached in April 2022, after which we can evidently notice a decreasing trend, culminating in a reduction of approximately 720 billion dollars in securities. Decision which is part of a restrictive monetary strategy aimed at controlling inflation and stabilizing the economy.

Figure 14 provides a clear direct correlation between the increase in the M2 money supply and the expansion of Quantitative Easing (QE) operations. This report highlights how every time the Fed has implemented or intensified its QE operations, there has been a subsequent growth in the volume of M2. This increased liquidity is then reflected in the increase in M2, a broad indicator of the money supply that includes both physical money and short-term deposits. The close correlation between these two factors indicates the responsiveness of the money supply to the Fed's monetary policy decisions.

Figure 14 - M2 coin in circulation in the USA



Source: https://it.tradingeconomics.com/united-states/money-supply-m2

The start of the interest rate increases and the decrease in the money supply implemented at the end of the first quarter of 2022 indicate how the Fed has begun to pursue a more restrictive and conservative approach in its monetary policy, distancing itself from the expansionary measures adopted for a decade. Due to the dominant role of the dollar in financial markets and the size of the US economy, decisions have a direct impact on other world economies regardless of their domestic situation, these nations are often pressured to raise their interest rates to prevent outflows of capital and excessive devaluations of their currencies. A scenario that proves particularly problematic for developing economies as they have large dollar liabilities.

After the decision of the latest rate increase of interest at the end of July 2023, the US economy shows signs of resilience and stability. This can largely be attributed to a well-calibrated combination of strategies, on the one hand, a more restrictive monetary policy, aimed at containing inflation and stabilizing prices, and on the other, an expansionary fiscal policy, aimed at stimulating demand and to support economic growth. This synthesis of interventions is creating a balance, keeping the economy away from the risks of a recession while ensuring a smooth and controlled transition, without significant shocks to the labor market or employment.[31]

The strategies implemented are proving their effectiveness in steering the economy towards price stability. Even if the objective of an inflation rate of no more than 2% has not yet been achieved and

[31] The Fed raises interest rates by 25 basis points. -https://www.ilsole24ore.com/art/la-fed-alza-rates-25-basis-points-AFoI8XM

therefore remains a priority, recent trends over the last three months offer positive signs. This suggests that only minor adjustments to the interest rate may be necessary and that the peak may be near.[32]

The European Central Bank (ECB), founded in 1998 with the aim of maintaining price stability and preserving confidence in the single currency, the euro, the institution responsible for implementing monetary policy for the twenty countries of the Union European countries that have adopted the single currency, forming the so-called euro zone.

In particular, it supervises banks in the euro area in order to contribute to the security of the system, with the aim of protecting savings and making banks more solid. The ECB also ensures the good financing of the financial infrastructures necessary for the proper functioning of the payment network and digital transfers. It develops and produces banknotes, coordinating their production and issuance in the countries where the euro is used. Provides recommendations to reduce risks so that financial stability in the system is preserved.

In line with other global central banks, the European one pursues its objective of maintaining inflation around 2%. To achieve this, it uses a series of tools to direct price movements that are designed to influence both the amount of money in circulation and the cost of loans available to citizens and businesses. The main monetary policy tool available is represented by the set of three interest rates on operations: main refinancing, marginal refinancing and "overnight" deposits with central banks.[33]

European inflation has different characteristics compared to US inflation. In Europe the predominant factor was the shock in the energy market which occurred in parallel with the war crisis in Ukraine, a crucial region for energy supply routes to Europe, especially gas. While in the United States the increase in prices derives more from a strong demand for goods and services not satisfied by supply. The following graph number 24 illustrates how the combination of various factors has led to an atmosphere of instability and price volatility, in particular the cost of energy has had a greater impact on the European level.[34]

The inflationary trend initially followed the trend of reduced demand in the pandemic context with energy prices collapsing also due to disruptions in supply chains. As the economy began to recover and restrictions were eased, energy prices quickly rebounded, fueling inflation. Food and services that had remained stable during the pandemic also showed steady growth and despite a significant

[32] [54] The Fed raises interest rates by 25 basis points. - Cit.

[33] [55] The EU - What it is and what it does. - Cit.

[34] ECB rate: why it increases and what it means. -https://n26.com/it-it/blog/increase-tassi-bce

reduction in energy prices in the last quarter of 2022 and the first half of 2023, they showed signs of growth. This is due to the fact that the industry, while benefiting from lower energy costs but facing high raw material prices, has maintained or increased its prices in order to recover from the crises following the Covid pandemic. This dynamic impacts a wide range of other products and services.

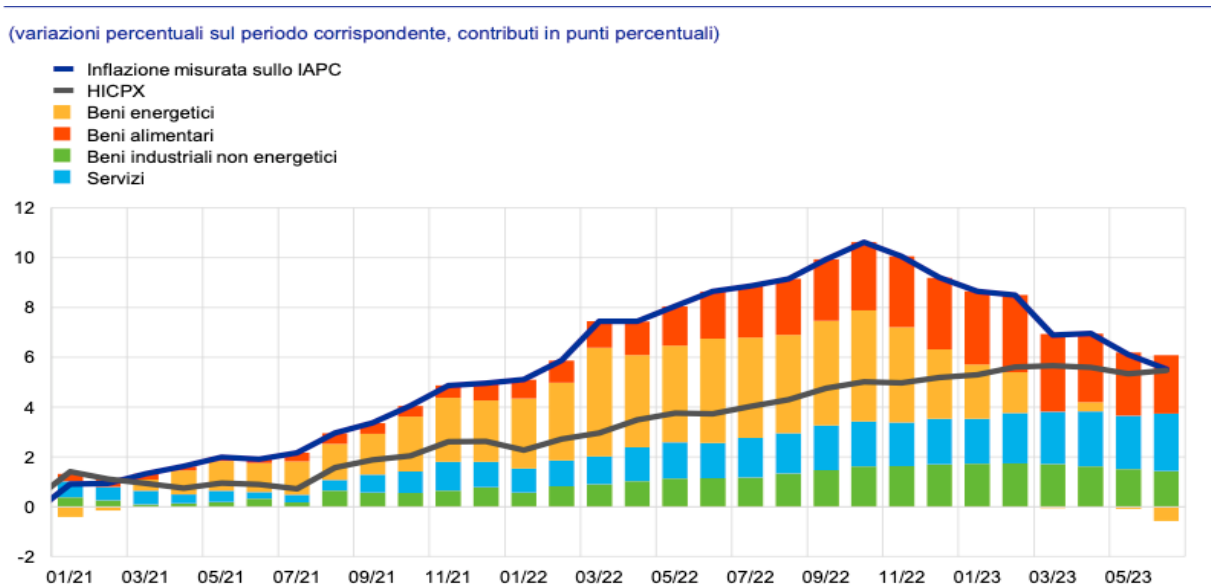


Figure 15:Overall inflation and related components

Source: ECB Economic Bulletin, number 5 / 2023 - update on economic, financial and monetary developments, pg. 22

Like the Fed, the ECB also responded to the pandemic crisis by adopting new initiatives to ensure an effective implementation of monetary policy in all euro area countries. It has launched new long-term financing programs at particularly favorable conditions and strengthened existing ones. "Lagging" by about a quarter compared to the USA, the EU area was also faced with a significant increase in prices, exceeding 10% in October and November 2022. This strong acceleration has sparked growing concern among economic actors.

The interest rate on refinancing operations is essential to understand the direction of the monetary policy implemented. The economic strategy adopted by the ECB presents similarities with that of the Fed, highlighting how they are adopting similar approaches. In the course of just 12 months, the ECB increased the interest rate 9 times, a decisive and forceful move. These consecutive increases demonstrate the determination to try to anchor inflation expectations and ensure price stability within the eurozone. An obvious change in strategy, since since the 2008 financial crisis and even more evident during the 2020 pandemic crisis, the ECB has pursued a highly accommodating monetary policy while keeping interest rates intentionally low.

The frequency in monetary policy decisions and the basis points that were increased in the second half of 2022 make the ECB's strategic change clear. In particular, we were faced with four hikes and an increase of 250 basis points (2.5%), a clear signal of the institute's intention to respond with determination to the rise in inflation, while at the same time trying to balance the needs of economic growth and of price stability in the euro area.

Figure 16

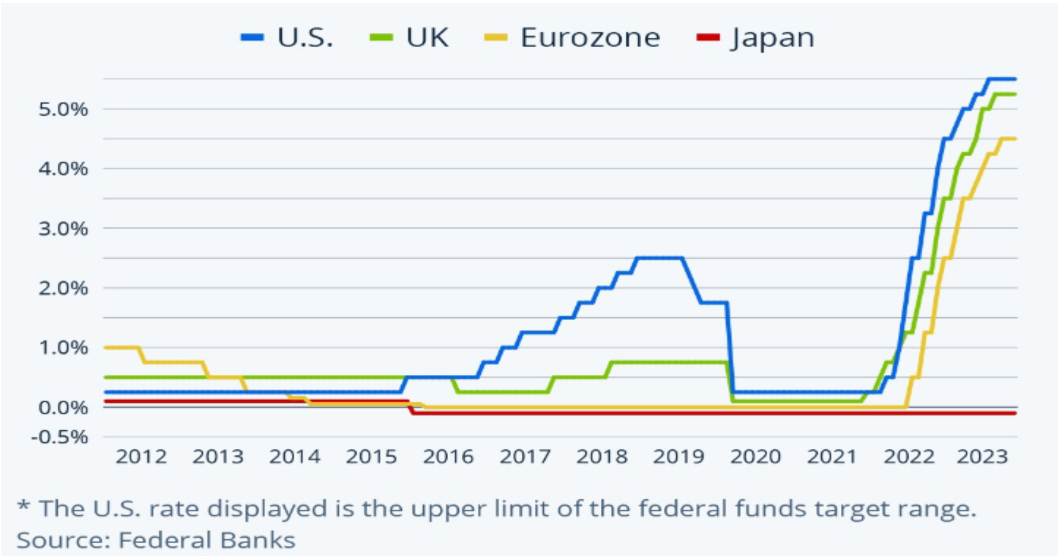
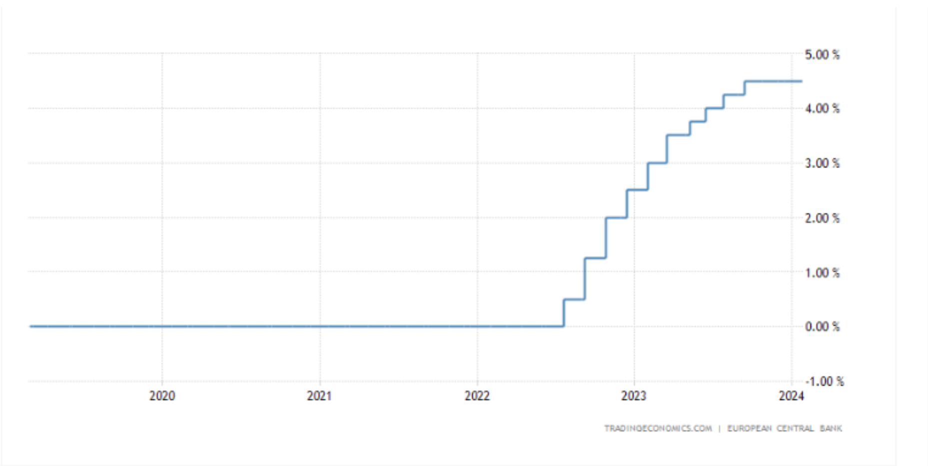


Figure 17: ECB interest rate



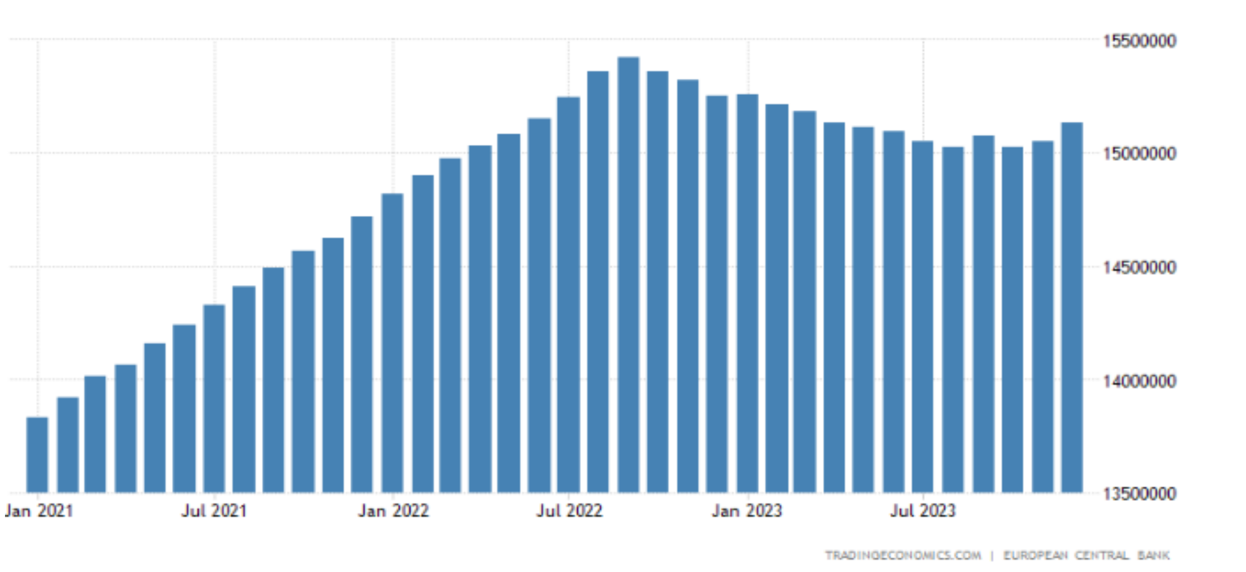
Source: https://it.tradingeconomics.com/euro-area/interest-rate

In February 2023, the Governing Council clearly outlined the monetary strategy for the first half of the year, indicating a strong direction towards continued increases in interest rates. From figure number 18 it can be seen how this decision is confirmed by the increases made subsequently which brought the rate to the current 4.50%. In addition to setting interest rates, the ECB regulates the provision of liquidity in the market through the use of repurchase agreements in the open market context. This instrument represents one of the most used and consists in the purchase or sale of liquidity to banks, under certain conditions with established deadlines, allowing the central bank to regulate the general liquidity in the system.[35]

The adjustment of monetary policy strategies has highlighted the intention to reduce securities positions in the Eurosystem. This decision represents a reversal from past actions taken in response to previous economic crises. During those difficult times, the predominant approach had been to inject large amounts of liquidity into the financial system, with the aim of stimulating economic activity and offsetting the risks of a prolonged recession. From the beginning of 2023, with a view to the following years, the ECB has clearly expressed its intention to gradually but decisively reduce the size of its balance sheet[36].

The implementation of a more rigid policy is highlighted not only by the increase in the interest rate but also by the contraction of the M2 currency, consistent with the choices decided by the ECB to control the rise in prices. Analyzing the figure number 29 below, it can be observed how the quantity of money present in the euro area continued to increase until October 2022, the period in which inflation reached its peak, subsequently, especially from the first quarter of 2023, a constant reduction of the currency in circulation indicating the change of direction in the monetary strategy, in order to strengthen its response against inflationary pressures.

Figure 18: M2 Coin Zone EUR



[35] The EU - What it is and what it does. - Cit.

[36] Monetary policy decisions.
https://www.ecb.europa.eu/press/pr/date/2023/html/ecb.mp230202~08a972ac76.it.html

The increase in interest rates, together with the contraction of the monetary base and the attenuation of the energy shock has had a direct impact in containing and reducing inflation. Raising interest rates not only makes borrowing more expensive, but thus discourages excessive investments and consumption. At the same time, by reducing the quantity of money in circulation, the quantity of liquidity available is limited, putting a brake on the excessive growth of prices. These measures demonstrate the importance of a balanced and timely approach in managing monetary policies.[37]

At the same time, the restrictive measures have brought uncertainty to the growth prospects for the economy and inflation in the euro area and have also caused a sharp decrease in the demand for credit in the second quarter, as highlighted by the survey carried out by the ECB on the July 2023 bank credit. In addition, banks have adopted more stringent criteria when disbursing loans to both households and businesses, due to growing concerns regarding potential risks related to customer creditworthiness and a lower appetite for risk.

In the ECB's opinion, it is no longer appropriate to focus solely on inflationary risks to avoid the most negative consequences. It is e

ssential to balance the fear that too restrictive a monetary policy may prove excessive, with the concern that the measures taken may not be up to the circumstances. Rising interest rates and reduced public debt acquisition have raised concerns, given the possible impact on the debt sustainability of certain particularly vulnerable countries[38].

[37]. -https://www.ecb.europa.eu/press/key/date/2023/html/ecb.sp230216~a297a41feb.it.htmL

[38] Bank, AND. C. (2023). There politics monetary the next day of the shock energetic -https://www.ecb.europa.eu/press/key/date/2023/html/ecb.sp230216~a297a41feb.it.htmL

CHAPTER 2

Commodities and energy sector dynamics under global uncertainties

2.1 The growing importance of commodities in financial markets

In the financial marketplace, commodities are in demand for their fungibility and lack of qualitative differences, which renders them interchangeable regardless of the producer's identity. These commodities fall into two broad macro-categories: Soft and Hard. Soft commodities, hailing from agricultural and livestock sectors, include a variety of goods ranging from agricultural staples such as oats and wheat to meats like cattle and pork belly. On the other hand, hard commodities encompass those from the energy sector including gasoline and electric energy, precious metals such as gold and platinum, as well as a suite of industrial metals.
Electricity stands out within the hard commodities for its unique characteristics—it is derivative of other primary energy sources, must be utilized immediately upon production, and its storage and transportation are associated with high costs and potential waste.

When we consider the major commodities markets globally, we observe a dynamic landscape. In North America, the Chicago Mercantile Exchange (CME) operates as a hub for a wide array of products including futures on indices, currencies, and commodities, alongside derivatives on economic indicators like inflation. The New York Mercantile Exchange (NYMEX) is integrated within the CME group since 2006 and is a pivotal market for trading commodities such as WTI Crude Oil and various metals. Similarly, the COMEX focuses on industrial and precious metals trading, and the Chicago Board of Trade (CBOT) has been renowned since 1848 for its trade in agricultural commodities. Meanwhile, the Toronto Stock Exchange (TSX) in Canada is known for trading mainly in mining and energy stocks.
In Asia, the Dalian Commodity Exchange (DCE) stands as a prominent market for agricultural futures, while the Multi Commodity Exchange (MCX) in India specializes in a variety of commodities including oil and natural gas. Europe's landscape is marked by the Intercontinental Exchange (ICE), known for trading commodities such as cocoa and coffee, the London Metal Exchange (LME) which deals with a range of metals, and the European Energy Exchange (EEX), a regulated platform operating within the Eurex group controlled by Deutsche Boerse.

The commodity trading industry has enjoyed an upward trend over the past five years. While all industries go through multiyear cycles of peaks and troughs, the industry’s prospects look excellent for the years ahead.Indeed, commodity trading is on the cusp of the next normal. The energy transition now under way is an economic and physical transformation that cuts across and integrates the various global food, energy, and materials systems. From a commodity trading standpoint, this transformation will increase structural volatility, disrupt trade flows to open new arbitrages, redefine what it means to be a commodity, and fundamentally alter commercial relationships. All these developments will create unique opportunities and challenges for new and incumbent players alike.

Below, we outline the primary modes of commodity investment:

✓ Direct Ownership of Physical Goods: This method involves acquiring the actual physical commodities themselves. However, it is the least favored among financial investors due to issues like perishability and the need for suitable storage facilities.

✓ Investing in Stocks of Commodity-Producing Companies: Investors can purchase shares of companies engaged in the production of commodities. This approach exposes investors to specific risks associated with a particular commodity, alongside general market risks. Share prices may also reflect corporate management performance.

✓ Creating a Portfolio of Shares in Commodity-Related Companies: In contrast to the previous method, this strategy involves relying on specialized investors or commodities trading advisors (CTAs) to manage a diversified portfolio of stocks in companies operating within the commodities market.

✓ Trading Commodity Futures: Futures contracts for commodities are actively traded on exchanges. These financial instruments are often utilized by companies producing commodities to hedge against price uncertainties. This is a widely used method among financial investors. Essentially, two parties enter into a contract to exchange an underlying asset at a predetermined future date. In practice, only a small fraction of these contracts result in the actual exchange of the underlying asset, with most contracts either being renegotiated or closed with opposing positions.

✓ Passive Investment in Exchange Traded Commodities (ETCs): ETCs are financial instruments issued based on direct investments made by the issuer in commodities or commodity derivatives. These instruments passively replicate the performance of a single commodity or commodity indices.

2.2 Commodity price drivers

Commodity prices are predominantly influenced by the interplay of supply and demand dynamics, with inventory levels serving as a significant determinant. The decision of a nation to either immediately consume a commodity or reserve it for future use plays a crucial role in shaping its price trajectory.

Moreover, commodities exhibit negative correlations with traditional assets such as stocks and bonds, while displaying positive correlations with inflationary changes. This phenomenon underscores the heightened returns observed in the commodity markets during the period spanning 2021 to 2022.

Trading in commodities typically occurs through futures contracts on exchanges or in spot markets, with derivatives such as options, swaps, and forwards also being utilized, albeit to a lesser extent. Among these instruments, futures contracts hold particular prominence.

The commodities market stands out as one of the most information-sensitive , characterized by numerous informational constraints. Obtaining comprehensive information regarding the supply, demand, and inventory levels of commodities poses significant challenges to market participants. These informational frictions have been instrumental in explaining market fluctuations, as evidenced by events such as those observed in the early 2008 period (Hamilton, 2009) and the volatility witnessed in 2022.

For instance, in 2008, Brent crude oil futures surged to an all-time high of $137 per barrel before experiencing a sharp decline to below $70 per barrel within a few months. Similarly, in 2022, prices soared to a peak of $111 per barrel before stabilizing thereafter.

Similar patterns of volatility are observed in natural gas prices, with peaks occurring in the early 21st century, notably in September 2005 and June 2008. In August 2022, natural gas prices reached a ten-year high. The scholarly discourse has primarily focused on elucidating the underlying shocks driving such price fluctuations.

In recent years, the burgeoning demand emanating from emerging markets, particularly China, has continued to outpace relatively stagnant supply levels. Notably, fluctuations in oil prices are closely intertwined with Chinese economic conditions, given China's status as the world's largest crude oil importer.

Oil holds immense significance for the global economy, with its correlation to emerging markets witnessing a pronounced uptrend over the first decades of the 21st century. Moreover, commodities have increasingly garnered attention as viable assets for portfolio diversification, with futures contracts serving as popular tools for risk mitigation. The influx of investments into this market, particularly from commodity index traders (CITs), has surged, with these investors treating commodity futures as a standalone asset class akin to traditional stocks and bonds. Their investment vehicles typically involve swap contracts and exchange-traded notes offered by fund companies (Cheng & Xiong, 2014).

The influx of investments has indeed spurred significant market volatility, thereby posing formidable challenges to long-term economic stability. Scholarly studies delineate various economic mechanisms through which futures market trading exerts influence on commodity prices.

Commodity Storage**:** The concept of commodity storage, encapsulated within the "theory of storage" of H.Working arises when individuals opt to defer consumption. According to this theory, the price of a commodity equals the sum of its current consumption value and the anticipated value derived from consuming it at a future date when its supply is scarce. Delaying commodity utilization incurs a cost, resulting in elevated commodity prices as supplies diminish—a phenomenon commonly referred to as the "convenience yield." However, the convenience yield is inherently constrained by the nonnegativity of commodity inventory. Moreover, the spread between futures and spot prices is intricately linked to the cost of storing the commodity. It is noteworthy that financing costs directly influence the cost of storing commodities, particularly in carry trade scenarios, thus rendering interest rates pivotal. Additionally, commodity storage serves to mitigate the risks stemming from demand or supply shocks.

Risk Sharing**:** Risk sharing mechanisms have emerged as a means to attenuate risk exposure among producers, such as oil producers susceptible to price fluctuations. Commodity futures markets, often centralized and accessible, facilitate the utilization of hedging strategies by both consumers and producers to mitigate commodity price risk, thereby enhancing risk sharing efficiency. Producers can offload commodity futures contracts to speculators, thus diversifying their commodity risk. Commercial hedgers are intermingled with speculators, as empirical evidence suggests that hedgers frequently engage in trading activities surpassing their risk hedging requirements.

Information Discovery**:** The complexity inherent in commodity markets lies in information discovery, as obtaining comprehensive information remains arduous. Futures market trading can be construed as an amalgamation of dispersed information gleaned from various market participants. Singleton (2012) contends that divergent beliefs among market participants can spur speculation against one another. Moreover, the lack of readily available information contributes to inefficiencies within commodity markets, as evidenced by disparate commodity prices across global exchanges to accommodate transportation costs. Consequently, inefficiencies persist, as higher commodity prices do not necessarily correlate with diminished consumer demand due to the dearth of information.

2.3 Relationship between spot and futures

Spot returns are derived from the instantaneous transaction of a physical asset at a specific date, while commodity futures represent financial instruments that compel buyers and sellers to deliver a specific asset at a predetermined price at a future date.

As the expiration date approaches, the price of commodity futures tends to converge towards the spot price, impacting the financial position's performance.

The arbitrage mechanism moves the agreed-upon price in the futures contracts to the spot price as the contract's expiration nears. If the futures price exceeds the spot price, arbitrageurs may sell the futures contract, purchase the underlying asset in the spot market, and deliver it to the futures contract holder. Conversely, if the futures price is lower than the spot price, arbitrageurs may purchase the futures contract, receive the underlying asset, and sell it in the spot market. This arbitrage process continues until the forces of demand and supply on futures and/or spot prices eliminate the discrepancy, accounting for transaction costs associated with buying and selling operations.

Speculation on futures can lead to paradoxical situations where long-term contracts are entered into for quantities far exceeding the actual availability for delivery. Investors with long positions are disinclined to close contracts at expiration to put pressure on those holding short positions. The latter, to avoid insolvency, may be compelled to pay very high prices to close their positions, resulting in a significant increase in futures and spot prices.

The difference between spot and futures prices determines the slope of the futures curve. The structure of the commodity futures curve can exhibit both negative and positive slopes depending on the dynamics of supply and demand for the commodity in question.

An increasing slope of the futures curve implies that buyers, i.e., investors, will pay a higher premium for futures compared to the price of the physical asset itself. If the spot price of the commodity remains unchanged until the futures expiration, the buyer will incur a loss proportional to the initial slope of the futures curve. Consequently, depending on market movements, gains or losses can arise from the evolution of futures prices.

Most investors, who have no direct interest in physically owning the commodity, use futures for speculation and renew their positions a few days before expiration, purchasing futures with longer-term maturities.

As mentioned earlier, financial derivatives obligate the seller to deliver a specific quantity of the underlying asset to the buyer on a predetermined date (maturity date), establishing the purchase price (strike price) in advance. Once acquired, the derivative can be traded with other investors at market price.

Basis

The equation below illustrates the return generated from purchasing a futures contract on a specific commodity with maturity at time T, held until its expiration, assuming that the spot price of the commodity remains unchanged

$$\boxed{Basis = \frac{S(t) - F(t,T)}{F(t,T)} \times \frac{365}{T - t}}$$

Where $S(t)$ represents the spot price of the commodity at time t, and $F(t,T)$ represents the futures price at time t that expires after T time periods. The factor 365 is an annualization factor.

The technical term for this return is the basis or roll yield.

The basis quantifies the loss of the investor in case market prices remain unchanged. If the term is positive, the market for that commodity will have a term structure curve with a negative slope. In this case, the market is in a state of Backwardation. In the opposite case, the market will be in a Contango state, and thus the curve will have a positive slope.

Consequently, the index is positive in a "backwarded" market and negative in a "contangoed" market.

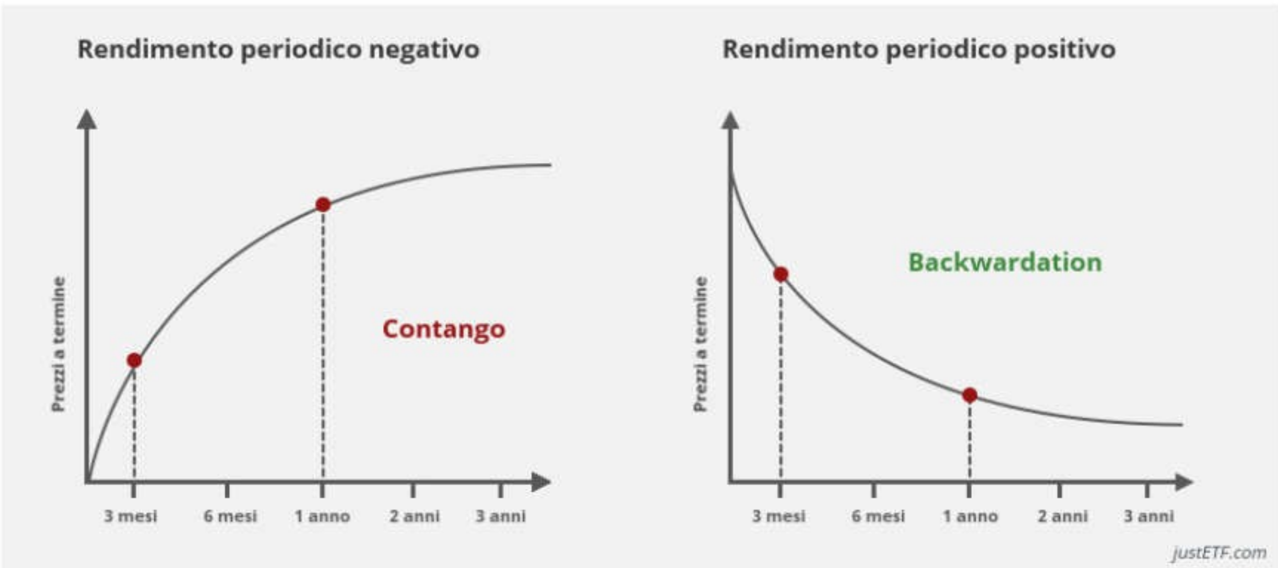


Figure 19: Contango vs Backwardation

Source: justetf.com

Producers of commodities may benefit from fixing future prices in advance. Fixing a futures price lower than the spot price leads risk-averse financial operators to purchase these derivative instruments. In this case, the slope of the futures term structure will be negative.

When there is an accumulation of a commodity by producers, it means that they have taken a long position on that commodity. By becoming part of the futures contracts, producers reduce their long position, bringing futures prices to a value lower than current prices. In this case, it is referred to as "normal backwardation" and suggests a negative futures price term structure. This phenomenon is influenced by the stock levels of the commodity under consideration.

If inventory levels are low, the futures price will converge to the spot price. Conversely, high inventory levels lead producers to prefer demand for futures contracts to hedge against risk, resulting in a negative difference between futures and spot prices.

In this latter case, futures are used to build hedging operations to protect against market risks: long or short positions are taken in futures to neutralize latent risks on assets to be bought or sold.

However, empirically it has been demonstrated that for the majority of commodities, a state of permanent backwardation cannot be achieved.

2.4. **Implication of the Ukrainian conflict on energy trades**

The geopolitical landscape has been dramatically reshaped by the Russian invasion of Ukraine, with significant implications for global energy markets. The incursion not only accentuates Ukraine's pivotal role in the energy domain, with its extensive gas production capabilities and nuclear power infrastructure, but also highlights the geopolitical risks that have far-reaching effects on trade and commodity prices.

Amidst the conflict, China has maintained a neutral stance, influenced by its strategic interests, including its lengthy border with Russia and the economic benefits of discounted energy imports. Similarly, the BRICS nations have avoided denouncing the invasion, striving to establish a new world order and affirm their global influence.

The Zaporizzja nuclear power plant in Ukraine, responsible for a significant portion of the country's electricity, has become a critical concern. Its potential destruction poses environmental threats not only to Ukraine but also to Russia and adjacent countries. Such risks extend beyond energy to the semiconductor supply chains, given their integral role across multiple industries.

This geopolitical turmoil has triggered global repercussions, with the EU and the US implementing sanctions against Russia, while many emerging countries adopt a neutral stance, potentially benefitting from shifts in global power dynamics. Despite Western support for Ukraine, Russia has found a formidable ally in China. Facing EU energy sanctions, Russia has sought new commercial partners, strengthening trade ties with emerging economies and redirecting energy flows eastward.

Geopolitical risk plays a significant role in energy trade dynamics, with diplomatic relations often dictating trade volumes between nations. A pertinent example is the relationship between China and the USA, where despite being the world's two leading economies, tensions frequently impact trade and commodity prices. For instance, the US's attempts to restrict China's access to semiconductor technology have escalated tensions, prompting retaliatory measures from China, such as restrictions on crucial chip production metals.

This geopolitical landscape, particularly the conflict between Ukraine and Russia, underscores the interplay between macroeconomics and commodity markets. Sanctions imposed by the EU and subsequent retaliatory measures from Russia have upended global dynamics, affecting energy trade and the broader world order.

In parallel, the EU's energy relationship with Russia has come under scrutiny. With the EU heavily reliant on energy imports due to its meager reserves, Russia's abundant resources have made it a crucial energy partner. However, geopolitical tensions have heightened fears of energy shortages in the EU, prompting efforts to diversify energy sources and reduce reliance on Russian imports.

Prior to sanctions, the EU had been transitioning towards sustainable energy sources, with Russian natural gas playing a significant role. However, the Ukraine invasion prompted some EU countries to reduce their reliance on Russian energy, with Germany achieving self-sufficiency and others diversifying their energy sources. This marked a significant departure from the EU's previous energy strategy, necessitating increased imports from alternative suppliers like Azerbaijan and Norway.

2.4.1 Analytical perspective on EU-Russia energy trades

In the broader context of global economic standings in 2021, the European Union emerged as the world's third-largest economy, following the United States and China. The EU's economic vitality is intrinsically linked to substantial energy requirements underpinning its myriad activities. Nevertheless, the EU's own energy reserves are notably limited, comprising a mere 0.1% of the world's oil and 0.2% of its natural gas reserves. This scarcity starkly contrasts with Russia's energy landscape. As the globe's eleventh-largest economy, Russia exhibits modest domestic energy consumption relative to its abundant reserves. Indeed, Russia holds a significant 6% of the world's oil reserves and a substantial 20% of its natural gas reserves.

Russia's strategic significance in the global energy supply chain is thus underscored, with the European Union having become the primary importer of Russian energy commodities by 2020. The symbiotic trade relationship between the EU and Russia was cultivated on the pillars of Russia's resource-richness, competitive pricing, and the logistical efficiencies afforded by a network of direct pipelines. This geographical proximity, despite objections from the US regarding potential over-reliance, facilitated a robust energy trade framework between the two regions.

However, the geopolitical discord that has recently materialized between the EU and Russia has amplified concerns regarding energy security within the Union. The unforeseen demand fluctuations due to the COVID-19 pandemic, paired with Russia's scaled-back production, did little to alter the overall composition of Russia's foreign trade, which remained predominated by energy exports to Europe. For instance, the Netherlands and Germany were significant importers of Russian crude oil, accounting for 12.4% and 8.6% of Russia's crude oil exports, respectively. Moreover, European markets continued to dominate the Russian export trade structure, with crude oil products alone constituting over 60% of Russia's total export value.

In anticipation of sanctions, the European Union had initiated a strategic pivot towards sustainable energy consumption, intensifying efforts to integrate renewable energy sources while phasing out conventional fossil fuels. Russian natural gas, perceived as a relatively less polluting energy source, was central to the EU's energy transformation agenda. Notably, EU countries imported 155 billion cubic meters of Russian natural gas in 2021. However, the landscape underwent a drastic transformation following the Ukrainian crisis, compelling EU member states to reassess their energy dependencies. Germany's move towards energy self-sufficiency exemplified this shift, while other nations like Spain and the Netherlands diversified their energy procurement strategies. This paradigm shift in the EU's energy strategy was further evidenced by the marked reduction of Russian oil imports by 90% in 2023 relative to the previous year's figures—a testament to the EU's adaptability and the fortuitous impact of milder temperatures and sustainable policy initiatives during the 2022-23 winter season.

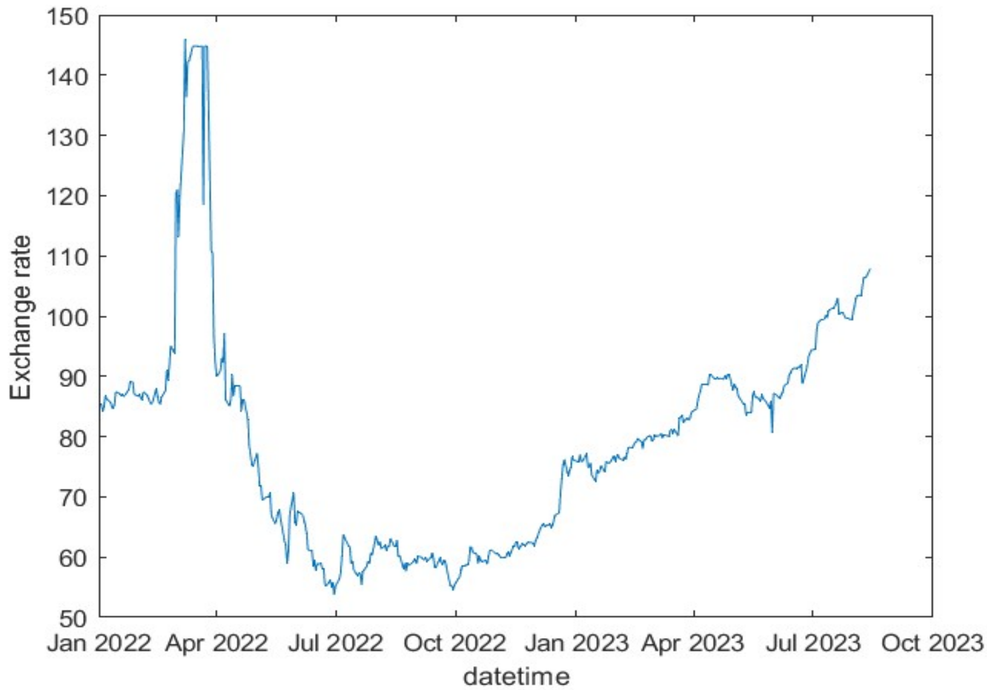
To attain complete autonomy from Russian energy resources, it is imperative for the European Union to adopt a harmonized and strategic approach to energy acquisition. This necessitates a commitment to a progressive energy transition that encompasses renewable energy sources and hydrogen technologies, thereby ensuring long-term energy independence and reinforcing resilience against external geopolitical upheavals.

In a decisive response to the Russian incursion into Ukraine, European nations collectively imposed a series of unprecedented sanctions aimed at halting the aggression or at least destabilizing the Russian economy. The European Central Bank (ECB), traditionally autonomous and politically independent, played an instrumental role in this economic countermeasure by freezing Russian foreign reserves. This move signaled a significant departure from the ECB's routine operations and a prioritization of European cohesion and geopolitical objectives over its fundamental mandate of ensuring price stability.

The imposition of sanctions, while serving a political and diplomatic purpose, had inadvertent economic repercussions, notably exacerbating already rising inflationary pressures—a phenomenon highlighted by Mulder in 2022. The ECB's actions also raised questions about the dynamics of the Principal-Agent relationship between the central bank and the political structures of the member states, appearing to contravene Article 130 of the Treaty on the Functioning of the European Union, which mandates the ECB's operational independence from Union institutions.

On the 26th of February, the G7 leaders issued a unified denouncement of the Russian military actions, which was followed by the European Commission's formalization of sanctions that included blocking the international reserves of the Russian central bank, excluding Russian banks from the SWIFT financial messaging system, and freezing the assets of numerous Russian corporations and nationals. These measures were significant for challenging the notion of sovereign immunity typically afforded to central banks and targeted the world's eleventh-largest economy at the time

Figure 20: Euro/Ruble Exchange rate



Data Source: Yahoo finance

In the early months of 2022, the Euro's value against the Ruble experienced a significant fluctuation. Commencing the year at approximately 90 Rubles to the Euro, the onset of conflict precipitated a sharp devaluation in the Ruble. As the war escalated and sanctions were enforced, the exchange rate surged, peaking at 150 Rubles to the Euro. The financial markets in Moscow and Saint Petersburg saw a period of closure from March 14th to the 18th, contributing to a stabilization of the exchange rate during that time.

In a swift reaction to the invasion, the Russian Central Bank took drastic action, escalating its interest rates from 10% to an unprecedented 20%, bracing for an economic downturn and surging inflation, which at the time soared to 23%. By April, in a retrograde step reminiscent of the Bretton Woods system, the Central Bank's head, Elvira Nabiullina, restored the Ruble's gold convertibility and slashed interest rates by 300 basis points in an attempt to mitigate financial instability risks, inaugurating a period of Quantitative Easing. These monetary measures, coupled with a reduction in production, saw inflation slow to 17%, the economic contraction soften, and the Ruble's value increase beyond its pre-invasion level.

Russia's economy in the first quarter showed a surprising vigor, posting a commercial surplus attributed to a substitution of domestic goods and services for imports. The Ruble's robust recovery was in part a response to countermeasures which included restrictions on currency exchange and mandates for businesses to convert the majority of their foreign revenue into Rubles. Despite a substantial decrease in imports, the elevated prices of exports sustained the Ruble's circulation within Russia. The summer of 2022 marked a period of significant appreciation for the Ruble, achieving its strongest valuation in seven years.

The immediate aftermath of the sanctions saw a dramatic impact on the Ruble and Russian bonds, with the Central Bank adopting a forceful monetary policy stance. However, the full weight of the sanctions on the Russian economy seemed to diminish over time. Partial adherence to the sanctions by G20 nations allowed Russia some latitude, particularly in its dealings with China, which held a considerable portion of Russia's foreign reserves. The currency earned from fossil fuel sales to European nations played a role in supporting the Ruble's value, as detailed by Davies in 2022.

Yet, the Ruble's initial strength was not indicative of the underlying economic health. Towards the end of 2022, the currency began to falter once more, and by the following year, it had become one of the most depreciated currencies, plunging by 40%. Analysts point to the Western sanctions, especially the price cap on oil that took effect in December 2022, as a primary factor for this decline. The disparity between Russia's budgetary oil price assumptions and the capped price has been costly, with estimations of daily losses reaching 170 million Euros, as reported by DW. Additionally, the withdrawal or divestment of foreign businesses from Russia, estimated at a value of $20 billion, has further strained the Russian economy.

By mid-2023, the implementation of energy sanctions had yielded a degree of stabilization in oil supply, reducing Russia's oil and gas tax revenues. The ECB maintained vigilant oversight of European financial institutions to ensure adherence to the sanctions, in line with EU policy. According to Quaglia and Verdun, the ECB's alignment with the political consensus among EU member states facilitated the sanctioning process, despite the central bank's historical focus on price stability. The prevailing economic situation, marked by high inflation and the necessity of energy realignment, led to a recalibration of priorities within the EU's financial governance, positioning geopolitical stability as a paramount concern over price stability in the context of wartime exigencies. This stance by the ECB represents an alignment with the principal-agent framework, whereby it adhered to the directive of political authorities in sanctioning Russia, deviating from its conventional focus on price stability.

2.5 Energy sanctions effects on exchange rates

Significant geopolitical events, particularly conflicts, tend to precipitate commodity supply shocks that are often reflected in the currency exchange rates. These fluctuations have implications for both investors and policymakers in countries engaged in the export or import of commodities. The conflict involving Russia and Ukraine, both substantial energy exporters, unsurprisingly triggered an increase in commodity prices, as observed by Wang in 2022. The international sanctions aimed at severing Russia from the global financial system suggest that we may continue to witness heightened commodity price volatility.

In the immediate aftermath of such events, a rise in commodity prices typically results in an influx of foreign currency in the exporting countries due to augmented export revenues, potentially leading to the currency's appreciation, as evidenced by the Ruble's trajectory in 2022.

Taking Canada as a case study, given its status as a major exporter of commodities such as gas, oil, and wheat—similar to Ukraine and Russia—one would expect an increase in revenue and a corresponding appreciation of the Canadian dollar (CAD). The OECD reports that Canada is a significant player in the global oil, natural gas, and wheat markets, suggesting that the Ukrainian crisis would likely bolster profits and fortify the CAD against the Euro. However, this expected outcome only partially unfolded. While the EUR/CAD exchange rate did drop from 1.43 in February 2022 to around 1.30 in September 2022, it reverted to pre-sanctions levels by July 2023, supporting the findings of Chinese economists that the wider global impacts were relatively muted.

Understanding the relationship between commodity shocks and exchange rates is vital for traders seeking to optimize investment strategies and asset allocation for robust returns during turbulent times. Krugman's 1983 model sheds light on how exchange rates respond to shifts in commodity prices, suggesting that an increase in energy prices is typically followed by the depreciation of the importing countries' currencies. The extent of this depreciation is contingent upon the demand elasticity for energy in importing countries and the expenditure elasticity in exporting countries.

In contrast to Canada, the European Union, as a net energy importer, faces a different set of challenges. The literature extensively explores the impact of energy prices on exchange rates because they serve as reliable indicators of economic conditions and gauges of war-related uncertainties. In this context, the price of natural gas has been posited as an indicator of the European Union's economic trajectory, while crude oil prices are considered reflective of the global economic potential.

The macroeconomic effects of commodity shocks, particularly the inverse relationship between high oil prices and future economic growth, have been highlighted by scholars such as Hamilton in

2003. Given the EU's reliance on natural gas for its energy transition, natural gas prices emerge as a significant economic growth indicator for the Eurozone.

The direct impact of commodity shocks on exchange rates is also well-documented, with exchange rates acting as conduits through which commodity prices influence various economic aspects, as noted by Quiang in 2019.

The dimension of uncertainty in this nexus has garnered scholarly attention. Baker's introduction of the 'economic policy uncertainty' index in 2016 provides a tool to measure the uncertainty that influences traders' expectations regarding the exchange rate and the broader economy. This index, which incorporates major events like elections or wars, was utilized by Kang, an ING senior economist, in 2017 to establish that policy uncertainty and oil shocks exert tangible effects on both the Consumer Price Index (CPI) and exchange rates.

2.6 Energy shocks effects on Euro

In January 2023, economists A. Sokhanvar and E. Nouri from the Borsa Istanbul Review embarked on a study to explore the effects of commodity price fluctuations on the exchange rates of nations that either export or import these commodities. Their analysis utilized two sophisticated modeling techniques: quantile autoregressive distributed lags (QARDL) and dynamic simulated autoregressive distributed lags (DSARDL), both of which are advanced iterations of the traditional Autoregressive Distributed Lag (ARDL) model. Unlike ARDL, which predicts future values based on a combination of a variable's own past values, seasonal effects, trend effects, and the lagged values of other variables, QARDL and DSARDL introduce additional complexity and nuance, allowing for a more detailed examination of the relationship between commodity prices and exchange rates.

The study analyzed hourly price data for wheat, oil, and natural gas, alongside the EUR/CAD exchange rate, from February 1 to April 30, 2022, a period marked by significant geopolitical tension. Canada was specifically chosen for the analysis due to its role as a major exporter of these commodities, akin to Russia. The QARDL model is particularly effective in identifying both immediate and delayed effects of commodity price changes, highlighting the nonlinear dynamics at play. Conversely, the DSARDL model facilitates the simulation of exchange rate reactions to variations in the prices of gas, oil, and wheat, offering insights in a graphical format that simplifies the understanding of complex lagged relationships.

QUARDL:

Equation

$$\mathbf{Q_{ER}} = \beta(t) + \sum_{j=1}^{p} \phi_j(t) * ER_{t-j} + \sum_{j=0}^{q} \theta_j(t) * CP_{t-j} + \sum_{j=0}^{r} \eta_j(t) * VIX_{t-j} + \varepsilon_t(t)$$

DSARDL:

Equation

$$\boldsymbol{ER_t} = \sum_{j=1}^{p} \phi_j * ER_{t-j} + \sum_{j=0}^{q} \theta_j * CP_{t-j} + \sum_{j=0}^{r} \eta_j(t) * VIX_{t-j} + \varepsilon_t(t)$$

Both methodologies regress on the natural logarithm of the exchange rate (ER), the natural logarithm of the commodity price (CP), and the implied volatility of the S&P 500 (VIX), allowing for a detailed assessment of the impact of each commodity on exchange rates. The QARDL model's results, especially regarding natural gas, reveal a significant impact on the EUR/CAD exchange rate, most notably at higher quantiles, whereas the effects of oil and wheat are more pronounced at lower quantiles. This analysis indicates that commodity price changes tend to negatively affect the EUR/CAD exchange rate across the board, with the long-term implications being particularly stark. The persistence of negative coefficients across all quantiles suggests a trend towards long-term equilibrium, with the Canadian dollar appreciating against the euro following increases in gas and oil prices.

Table 4: QARDL ESTIMATION ON THE IMPACT OF GAS ON EUR/CAD

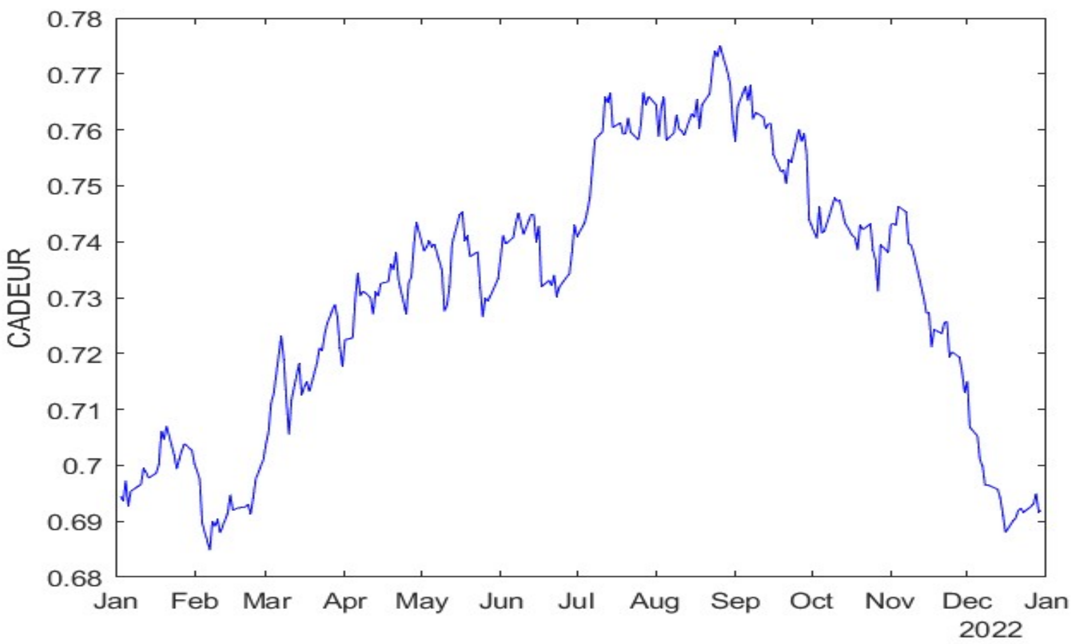
Quantile	ρ	ω^{Gas}	ω^{Vix}	φ	β^{Gas}	β^{Vix}
0.1	−0.072*** (0.000)	−0.113*** (0.000)	0.004 (0.565)	0.238* (0.075)	−0.017 (0.231)	−0.017** (0.032)
0.2	−0.083*** (0.000)	−0.117*** (0.000)	0.009 (0.208)	0.221 (0.229)	−0.011 (0.534)	−0.017* (0.086)
0.3	−0.095*** (0.000)	−0.115*** (0.000)	0.010 (0.204)	0.209 (0.326)	0.003 (0.882)	−0.008 (0.481)
0.4	−0.099*** (0.000)	−0.111*** (0.000)	0.008 (0.331)	0.214 (0.347)	0.004 (0.852)	−0.008 (0.519)
0.5	−0.092*** (0.000)	−0.110*** (0.000)	0.006 (0.475)	0.210 (0.368)	0.005 (0.813)	−0.007 (0.590)
0.6	−0.082*** (0.000)	−0.103*** (0.000)	0.005 (0.596)	0.206 (0.369)	0.014 (0.500)	−0.003 (0.827)
0.7	−0.068** (0.013)	−0.073 (0.212)	0.009 (0.600)	0.206 (0.333)	0.014 (0.466)	−0.003 (0.814)
0.8	−0.081** (0.049)	−0.062 (0.212)	−0.006 (0.755)	0.053 (0.771)	0.018 (0.308)	0.003 (0.805)
0.9	−0.102* (0.087)	−0.045 (0.269)	0.006 (0.751)	0.053 (0.710)	0.018 (0.189)	0.003 (0.742)

Source: Results from Borsa Istanbul Review (Sokhanvar Bouri, 2022)

Further reinforcing the QARDL findings, the DSARDL analysis elucidates the immediate depreciation of the EUR/CAD rate following geopolitical shocks. This phenomenon is attributed to the increased costs faced by importing countries, necessitating the acquisition of more of the exporting country's currency, thus depreciating their own. This effect also sheds light on the quick recovery of the ruble post-sanctions. The study also notes the minimal impact of these geopolitical events on Canada, which, conversely, saw economic benefits and was positioned to enter new trade agreements with Eurozone nations.

The consensus within the academic community is that energy shocks typically lead to an appreciation of the currencies of exporting nations. This research offers valuable insights for forex and commodity traders, highlighting the rapid transmission of commodity price shocks to exchange rates and the potential for traders to capitalize on short-term opportunities by adjusting their portfolios in response to geopolitical developments. Additionally, the study corroborates the long-term association between commodity prices and exchange rates, which realign with fundamental values through the actions of central banks. The findings also document the disruptive effect of Western sanctions on Russian commodity exports, leading to price increases and inflationary pressures, from which commodity-rich countries like Canada have benefited. The correlation between energy prices and exchange rate movements, demonstrated by the QARDL and DSARDL analyses, underscores the significant impact of geopolitical events on financial markets.

Figure 21. CAD/EUR Exchange rate



Source: Data from Yahoo Finance

Figure 21 illustrates the trajectory of the EUR/CAD exchange rate throughout 2022. The year commenced with the exchange rate at approximately 0.7, subsequently descending to its nadir in early February, where the Euro demonstrated considerable strength at around 0.685. The onset of conflict precipitated a series of sanctions and embargoes on Russian commodities, catalyzing an appreciation of the Canadian dollar. This appreciation saw the EUR/CAD exchange rate escalate to 0.73 by early April, with a continued ascension peaking at 0.77 on August 24, 2022.

The initial months of the confrontation, and more broadly, the first half of the year, saw European nations grappling with not only a shortfall in Russian commodities necessitating alternative supply sources but also an economic maelstrom. This storm manifested in a tangible recession within financial markets — exemplified by the FTSE MIB index shedding close to 20% in the first six months — and a devaluation of the Euro. The Euro's depreciation was not limited to its Canadian counterpart but also saw it equate to the US dollar, marking a nadir unseen in over a decade.

However, the subsequent period from September 2022 witnessed a resurgence of the Euro, attributable to the fortified cohesion among European states and NATO, as well as a unified European Union response to the conflict, propelling the Euro to pre-invasion valuations.

In a concerted effort to bolster the European economy and attenuate Russian export revenues, the European Council enacted an emergency regulation on October 6, 2022. This regulation encompassed three pivotal measures:

1. The reduction of electricity consumption.
2. The imposition of a revenue cap on electricity producers.
3. The procurement of a solidarity contribution from fossil fuel enterprises.

Furthermore, on December 19, 2022, EU energy ministers introduced a novel market correction mechanism designed to curtail episodes of exorbitant gas prices within the EU that are discordant with current market rates. This mechanism is poised for automatic activation when the month-ahead price on the Title Transfer Facility (TTF) surpasses 180 €/MWh for a duration of three working days or if the month-ahead TTF price exceeds a reference price for Liquefied Natural Gas (LNG) on global markets by 35 €. Once activated, transactions involving natural gas futures above the ‘dynamic bidding limit’ of 180 € are prohibited. This mechanism is slated for a minimum activation period of 20 working days and is subject to automatic deactivation should the dynamic bidding limit recede below 180 €.

These strategic measures, coupled with price caps, have been efficacious in curbing price surges, achieving the dual objectives of reducing Russian revenues and indirectly fortifying the Eurozone and its currency. Observers note that the conflict has served as an inflection point for the European Union, prompting a 'Geopolitical Awakening' and spurring a coordinated response in alignment with the Treaty of Maastricht's principles.

The Russian incursion into Ukraine dealt a formidable blow to the Euro in the short term. Nonetheless, the European Central Bank (ECB)'s solidarity with Ukraine and steadfast position helped mitigate the economic shockwaves, revitalizing the Euro. The Eurozone's economic fortitude exceeded anticipations: it recorded a 3.5% increase in real GDP for 2022 and saw unemployment rates plummet to 6.6% by December 2022. The robust labor market not only sustained the EU economy during Russia's prolonged engagement in the conflict but also extended employment opportunities to a multitude of Ukrainian refugees.

CHAPTER 3

Natural Gas and Crude Oil conditional volatility analysis

3.1 Recent literature on commodities return predictability

In the initial chapters, the discussion transitioned from examining the economical context in which driving inflation to a more focused examination of commodities' influence. Historical patterns indicate that significant inflationary surges are often accompanied by energy crises, which exacerbate these spikes. The period following the crisis in Ukraine, specifically the years 2022 to 2023, witnessed a tumultuous commodity market characterized by steep escalations in both pricing and volatility. This turbulence has been a major contributor to inflation, casting a shadow of uncertainty over the economic prospects of individuals and businesses alike.

The geopolitical complexities of recent times have reshaped trade alliances globally, igniting tensions reminiscent of the Cold War era. Particularly in the Eurozone, the reliance on fundamental resources such as oil and natural gas is at the heart of both economic and societal dialogues. Given the EU's commitment to sustainable transition, natural gas assumes unprecedented significance. Accordingly, this thesis aims to explore the feasibility of forecasting the trajectory of commodity prices, with a special emphasis on natural gas an oil. Accurate predictions of commodity yields and market fluctuations are instrumental for evaluating inflationary trends, currency valuation, and strategic monetary policy decisions, offering substantial benefits to both investors and corporate entities.

Over time, the body of literature dedicated to forecasting commodity returns has expanded, integrating diverse elements and analytical techniques to enhance our grasp of the interplay between economic indicators, market sentiments, and commodity performance. This thesis will examine whether policy uncertainty and investor sentiments are reliable predictors of commodity returns, drawing on the foundational work by Shazad, Raza, Balcilar, and Ali from 2017, and will survey the progression of scholarly methods in forecasting commodity returns to date

- Before delving into sentiment analysis and the implications of economic policy uncertainty, the academic community concentrated on the effects of financialization and macroeconomic factors on commodity returns. Research by Büyükşahin and Robe (2014), Gilbert (2010), and Hamilton and Wu (2015) delved into the impact of speculative activity, index-linked investments, and broader macroeconomic indicators on the pricing of commodities. Their collective objective was to identify the determinants that could forecast commodity market movements.

- A separate avenue of inquiry has been the prediction of commodity returns through the lens of price volatility and risk management. Scholars have applied various predictive models, such as GARCH-type models (Beckmann and Czudaj, 2013; Reboredo, 2013) and nonlinear autoregressive distributed lag models (Pukthuanthong and Roll, 2011), aiming to dissect and understand the volatility patterns and their association with different economic and financial indicators. These contributions have significantly advanced our understanding of how market uncertainties impact commodity returns and the formulation of risk mitigation tactics.
- Furthering the discourse on market uncertainties, some investigators have probed the influence of economic policy uncertainty (EPU) on the performance of commodities. The studies by Wang et al. (2015) and Reboredo and Wen (2015) demonstrated a predictable interrelation between EPU and commodity returns, suggesting that policy announcements and political developments bear considerable weight on commodity markets. Notably, EPU is known to affect economic activity at the inception of recessions (Baker, 2015), with the surge in natural gas prices post-invasion being a manifestation of this phenomenon.

3.2 Impact of investor sentiment and economic policy uncertainty on commodities return

The scholarly contribution of Shazad, Raza, Balcilar, and Ali to the scientific literature advances the foundational underpinnings of commodity returns prediction by integrating economic policy uncertainty and investor sentiment. Their pioneering utilization of the nonparametric causality-in-quantiles technique introduces a novel dimension to the analysis, facilitating a more nuanced exploration of the interrelationships. Through the introduction of these variables and methodologies, their research enriches the analytical toolkit for comprehending commodity returns and enriches the ongoing discourse in financial econometric inquiry. Particularly notable is their innovative incorporation of investor sentiment, a novel aspect that distinguishes their work as the inaugural endeavor in this line of research.

The economists employed the "nonparametric causality-in-quantiles" methodology proposed by Balcilar et al. (2016), a statistical approach employed to investigate causal linkages between two variables, especially across diverse performance levels or "quantiles." This technique enables researchers to discern how alterations in one variable may influence the behavior of another variable across various levels of performance or risk.

In essence, the "nonparametric causality-in-quantiles" methodology delves into how one variable exerts influence on another variable under disparate conditions, such as contrasting high or low performance levels. Such analysis facilitates the observation of how variables mutually influence each other contingent on specific circumstances, as evident in financial markets where market conditions fluctuate, thereby influencing variable dynamics.

The researchers amassed weekly data spanning from July 8, 1996, to June 27, 2016, encompassing economic policy uncertainty, bullish and bearish investor sentiments, and six major commodities including gold, oil, palladium, platinum, silver, and titanium. Economic policy uncertainty is quantified utilizing a news-based index compiled from over 1000 newspapers, focusing on terms pertaining to legislation, deficit, regulation, and related aspects. Bullish and bearish investor sentiments are derived from the American Association of Individual Investors (AAII) investor sentiment survey, reflecting participants' anticipations regarding the stock market's trajectory.

The authors acknowledge the intricacies inherent in delineating precise measures of market sentiment and recognize the array of proxies available in empirical literature. They contend that while these proxies may not universally escape contention, they offer valuable insights notwithstanding their context-specific nature.

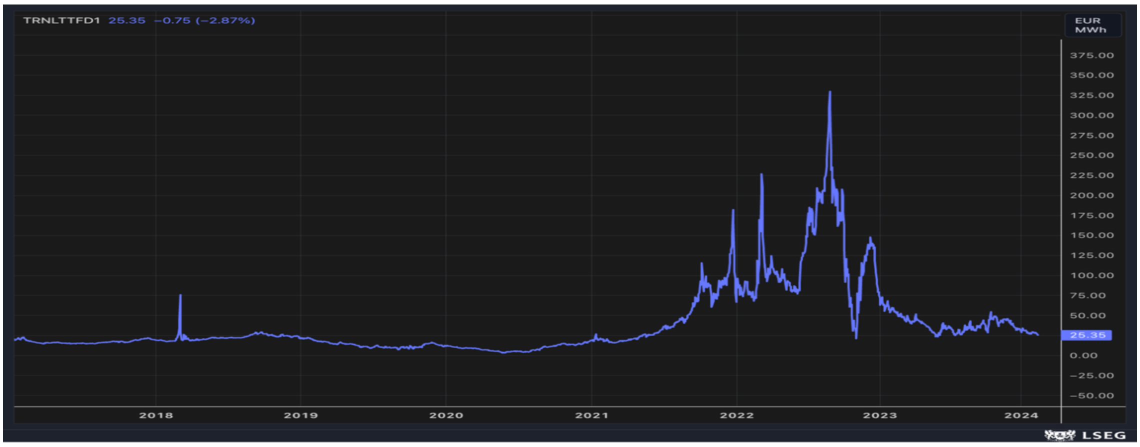
Their study entails multiple stages and statistical methodologies. Initially, the researchers scrutinize the data's distributional characteristics, encompassing skewness, kurtosis, and normality assessments, confirming the non-normal distribution and temporal dependence of the data. To ascertain the aptness of the nonparametric approach, they examine nonlinearity between commodity returns and the chosen predictive indicators utilizing the BDS (Broock et al., 1996) test, revealing evidence of nonlinearity.

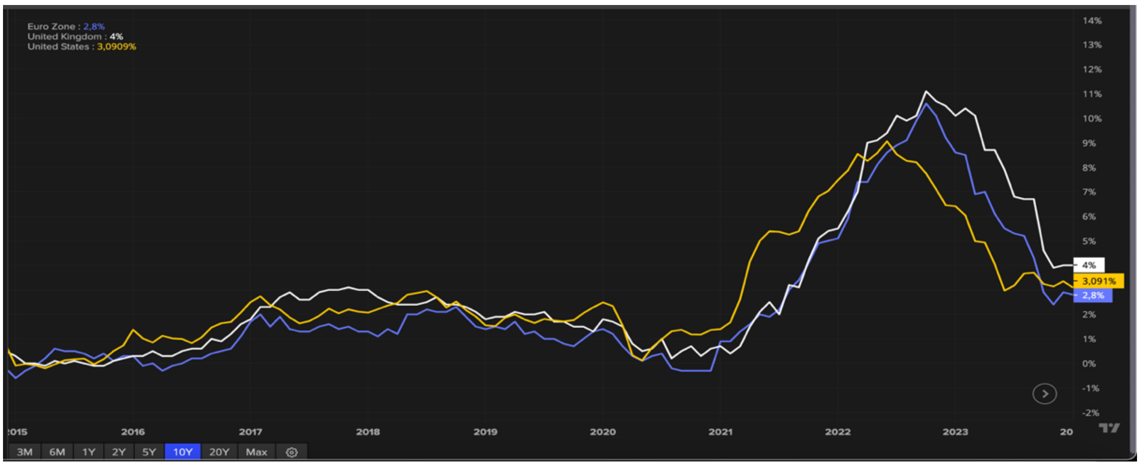
The crux of the analysis revolves around the "nonparametric causality-in-quantiles" methodology. Overall, the study's findings unveil substantial causal connections between economic policy uncertainty, investor sentiments, and commodity returns and volatility across diverse quantiles. The results underscore the potency of investor sentiments as determinants of commodity returns and volatility patterns, suggesting their pertinence for investment decisions in commodity markets. Notably, they identify significant causal linkages from economic policy uncertainty and investor sentiments to commodity returns and volatilities. In line with prior scholarship, they furnish supplementary evidence of shocks' pivotal role as primary drivers of economic activity; indeed, there is indication that financial agents have heightened awareness but also heightened sensitivity to shocks in the aftermath of financial tumult. Furthermore, they ascertain that investor sentiment surpasses economic policy uncertainty in prognosticating commodity returns, notwithstanding contrasting assertions in extant scientific literature such as Bethke (2017).

3.3.1 Natural Gas data

The analysis primarily focuses on the Title Transfer Facility (TTF), recognized as the preeminent reference market for natural gas traded on the Amsterdam exchange. The TTF is a hub that consolidates offers from both domestic and international producers, establishing it as the benchmark for the European market. The dataset includes daily observations recorded from January 3, 2017, to February 1, 2024. This period encompasses a stretch of comparative market stability and also captures the volatility induced by the post-pandemic economic rebound and the subsequent conflict in Ukraine. The TTF price, quoted in euros per megawatt-hour (€/MWh), is determined by the daily average of trading prices. Participants in this market have the flexibility to purchase natural gas through the platform under two types of pricing agreements: spot prices or futures contracts.

Figure 22 : TTF Time Series, Figure 22.1: CPI in Eurozone





Data source: from LSEG

Initially, we observe a period of relative stability with low price levels, suggesting a market in balance with supply and demand closely matched.

As we embarked on 2021, an examination of the TTF (Title Transfer Facility) chart revealed a period of low and stable prices. This tranquility in the gas market was consistent up until the latter part of the year. Coinciding with the gradual resurgence of global economic activities and a subsequent uptick in demand, there was an observed escalation in TTF prices towards the year's end, aligning with the initial swell in inflationary pressures.

In the comparative analysis between this graph and the Consumer Price Index (CPI) for the European Union, a parallelism emerges, showcasing a closely tracked trajectory between the two datasets. As depicted in the initial graph, the inflation apex in 2021 synchronizes with the initial price surge of TTF, suggesting that the enduring high inflation may partly stem from the amplified volatility and resulting spikes in gas prices, which were further exacerbated by supply disruptions.

Entering 2022, a secondary surge in TTF prices materialized, in tandem with the onset of the Ukraine conflict, injecting a wave of uncertainty into the market. Prices climaxed at €200 before receding to the €100 mark. The relative stability in prices during the war's early days could be ascribed to the uninterrupted fulfillment of existing contracts between the EU and Russia, despite mounting apprehensions among European leadership and the yet-to-be-felt brunt of sanctions on the energy sector.

The latter half of 2022 saw a marked upsurge in TTF prices as the EU's sanctions against Russia took effect amid an intensifying conflict. By August, prices had reached an unprecedented peak of €300. This surge was attributed to the growing uncertainty and the fact that many European countries were still in the throes of transitioning away from Russian gas dependency.

As we look towards the latter part of 2022 and beyond, European endeavors to secure gas alternatives to Russian supplies have contributed to a moderated pricing landscape. The TTF scaled a historic €340/MWh in August 2022, a stark contrast to the more temperate €23/MWh observed in June 2023, offering a reprieve from the earlier price frenzy. Nevertheless, despite the precipitous price drop, volatility within the market remains unabated. The recent apprehensions regarding supply and demand imbalances have been reignited, this time due to potential labor strikes in Australia. Notably, the considerable price disparity observed between August 2022 and August 2023 can largely be attributed to a softening in gas demand, rather than a decline in market volatility or to the earlier-than-anticipated filling of storage facilities in 2023. This empirical analysis underscores the persistent nature of volatility in the TTF market.

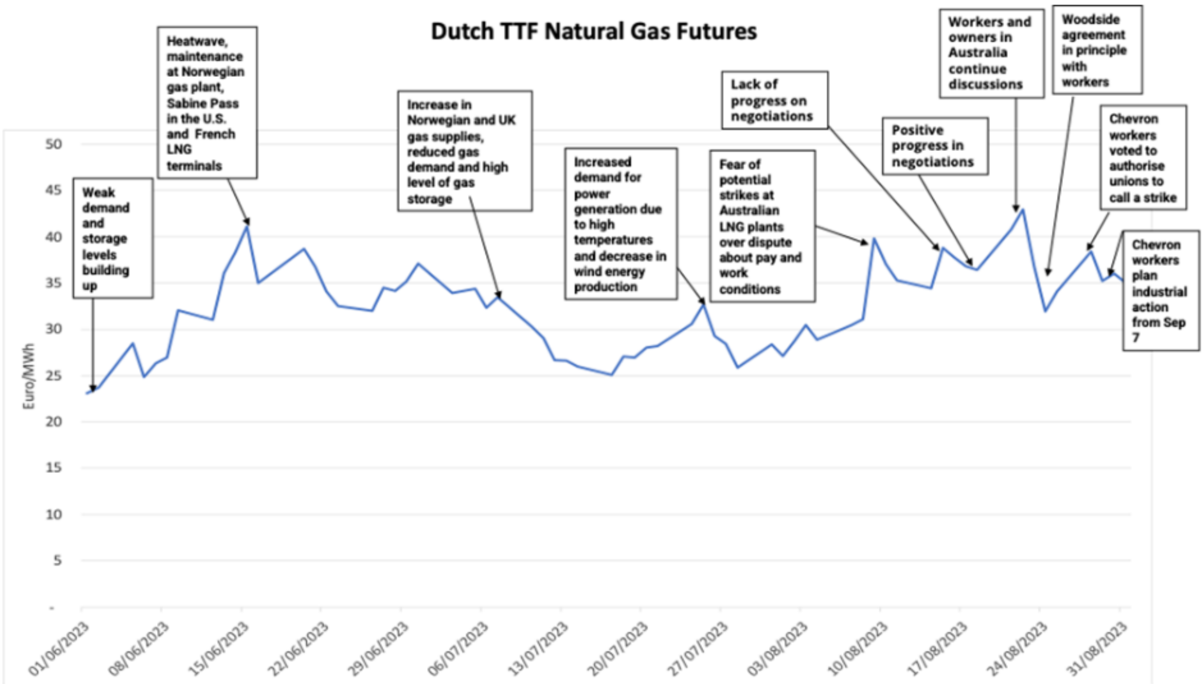


Figure 23: 2023 3vents affecting TTF Futures

3.3.2 Crude Oil data

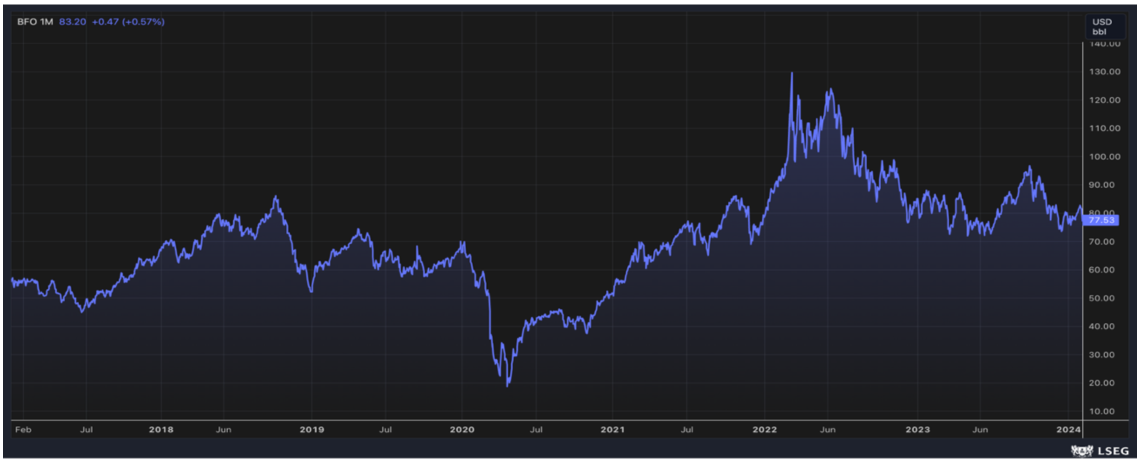
The second dataset in our analysis is centered on the Brent Blend, which is sourced from the Brent oil field in the North Sea. This benchmark has become the cornerstone for crude oil pricing within Europe. Originating from a combination of 15 different oil fields across the North Sea, the Brent Blend offers a comprehensive and diversified reflection of the region's oil production. The strategic location of the Brent oil field, northeast of the Shetland Islands, affords it a significant position in serving the European market. Similar to the TTF dataset, the Brent dataset comprises observations from the same period, starting January 3, 2017, and extending to February 2, 2024. This period selection allows for an examination of market dynamics over a span that includes both stability and volatility, thus providing a robust framework for analysis. Since 1988, the Brent Blend has been the standard for ICE crude oil utures contracts, becoming the most utilized benchmark for European, African, and Middle Eastern oil. The blend is characterized by its high quality and suitability for production into gasoline and middle distillates, both highly demanded products, contributing to its benchmark status.

The future of Brent Blend continues to be significant in crude oil pricing, even as the oil market evolves. New blends and shifting production patterns may challenge its position, but its current role remains strong.

Comparatively, Brent Blend is often set against West Texas Intermediate (WTI), another major benchmark. While both are light, sweet crude oils, they are distinct in their production locations and market influences. WTI, being landlocked, often trades at a different price due to its transportation and storage dynamics in contrast to the waterborne Brent.

Figure 24 illustrates the historical price movements of Brent Blend crude oil from January 2, 2017, to February 2, 2024. The chart provides a clear depiction of how Brent, as a leading benchmark for oil prices in Europe, Africa, and the Middle East, has responded to various global economic and geopolitical events through its price volatility.

Figure 24: Brent Time series



Data Source:from LSEG

In the beginning phase, from early 2017 to mid-2018, we observe a gradual uptrend in prices, which can be attributed to the coordinated production cuts by OPEC and its allies to curb the supply glut that had led to lower prices. This phase shows the market's response to these macroeconomic efforts to stabilize the oil market.

Moving into 2019, there is a slight decline and then a period of stability, which is typical for commodity markets as they go through cycles of correction after a significant rally. During this period, the market might have been assessing the sustainability of the price recovery amid fluctuating global demand and the potential for increased shale oil production from the United States.

The dramatic drop in early 2020 is a direct consequence of the COVID-19 pandemic outbreak, which led to a historic plunge in demand as countries worldwide imposed lockdowns. This was further exacerbated by a short-term price war between some of the major oil-producing nations, leading to a temporary oversupply.

Post the initial shock, we see a sharp recovery in the latter half of 2020 as demand began to normalize, and producers agreed to cut supply to support the market. The price rise into 2021 reflects the recovery optimism and the gradual reopening of economies.

However, in 2022, the chart shows significant price volatility, with a steep increase in prices, likely in response to the geopolitical tensions arising from the war in Ukraine, which raised serious concerns about supply disruptions from a major producing region. This led to increased prices as the market grappled with the potential for a supply shock.

As we progress into 2023 and early 2024, the price shows a downward correction, potentially due to a combination of factors such as increased production from other regions, advancements in renewable energy reducing the reliance on fossil fuels and the stabilization of geopolitical tensions that previously disrupted the market.

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3.4 Methodology

Before delving into the modeling framework for estimating volatility, it is imperative to delineate several fundamental constructs integral to financial time series analysis. Chief among these is the concept of conditional volatility, which refers to the expected variability of a financial instrument's return at a future time, given the information available at present. This contrasts with unconditional volatility, which considers the overall variability without conditioning on current information. Mathematically, conditional volatility at time *t* is given by the square root of the expected value of the squared deviation from the mean (conditional on past information):

$$\boxed{\sigma_t^2 = E[(r_t - u_t)^2|F_{t-1}}$$

where *rt* is the return at time *t*, *μt* is the expected return , and F*t*−1 represents the filtration of information available up to time *t*−1.

Closely related to conditional volatility is the phenomenon of volatility clustering. This term encapsulates the tendency for periods of high volatility to be succeeded by further high volatility intervals, and for low volatility phases to precede additional low volatility spans. Such patterns imply that volatility exhibits persistence over time, which is a crucial aspect captured by the GARCH modeling approach.

Another vital aspect is the autocorrelation function (ACF), which measures the linear relationship between lagged values of a time series, providing insights into the persistence and cyclicality of the series. For financial time series, the ACF is instrumental in identifying the presence of time-dependent structures that may influence future price movements:

$$\text{ACF(k)=} \frac{E[(rt-\mu)*(rt-k-\mu)]}{E[(rt-\mu)^2]}$$

for lag *k*, where *μ* is the mean of the series. The ACF measures the linear relationship between the values in the series separated by *k* periods.

With these pivotal concepts outlined, we can proceed to the methodological approach applied in the volatility analysis.

Even though the prediction of commodity returns remains a subject of continuous debate in the literature, the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model stands out as the most widely used model by economists and businesses for the study of volatility. A significant portion of the scientific literature has been devoted to the study of volatility using various GARCH models due to their flexibility and ability to capture volatility over different time periods.

The GARCH model was first proposed by Bollerslev in 1986 and was created to overcome the problem of parameterisation of models with a low number of observations, as the ARCH model is able to fit time series that have a high parameterisation.

Starting form the ARCH model (Autoregressive Conditional Heteroskedasticity) proposed by Engel in 1982 that was the starting point for the literature on nonlinear quantitative modeling of financial time series.

The ARCH(p) model writes:

$$r_{t=}\sqrt{\sigma_t^2}\,z_t \qquad z_t \sim D(0,1)$$

$$\sigma_t^2 = \omega + \alpha_1 r_{t-1}^2 + \alpha_2 r_{t-2}^2 + \ldots + \alpha_q r_{t-p}^2$$

Where $\omega > 0, \alpha_i > 0, \sum_{i=1}^{p} \alpha_i < 1$

Behind this process there is the simple idea of making the current conditional variance of the process a deterministic function of the past history of the squared returns. In practice, only rather rich ARCH parameterizations are able to fit financial series adequately. However, largely parameterized models can be unstable in forecasting and a pain to estimate.

In order to overcome the shortcomings of the ARCH models, Tim Bollerslev proposed a generalization of the ARCH model called GARCH (Bollerslev (1986)).

The GARCH(p,q) model is

$$r_{t=}\sqrt{\sigma_t^2}\,z_t \qquad z_t \sim D(0,1)$$

$$\sigma_t^2 = \omega + \alpha_1 r_{t-1}^2 + \alpha_2 r_{t-2}^2 + \ldots + \alpha_q r_{t-p}^2 + \beta\sigma_{t-1}^2 + \beta\sigma_{t-2}^2 + \ldots + \beta\sigma_{t-q}^2$$

Where $\omega > 0, \alpha_{i,}\beta_i > 0, \sum_{i=1}^{p} \alpha_i + \sum_{i=1}^{q} \beta_i + < 1$

The quantity α +β is the persistence of the model and it defines several properties in the GARCH, such as the decay of autocorrelation.

This model is important to study because, in addition to the low number of observations required, it assumes that the conditional variance of a time series depends not only on its past values, but also on the quadratic residuals and past conditional variances.

This view of conditional volatility makes it possible to observe the persistence of the shock in the time series, as it takes into account heteroskedasticity, thus making it possible to study more accurately the dependence between the conditional variance and the shocks of past volatilities and the dynamics of the underlying volatilities.

Furthermore, using this process better captures volatility clustering, i.e. the phenomenon in which periods of high volatility tend to be followed by other periods of high volatility, which allows for better modelling and analysis of changing volatility patterns.

This model is also flexible and adaptable to different volatility dynamics, allowing the capture of both short- and long-term dependencies, their averages and more complex characteristics that could not be captured by other processes. . In addition to observing the past phenomena of a time series, the GARCH model also makes it possible to make predictions of volatility and option prices, and it is precisely the incorporation of the view of past volatilities into the study that helps to provide more detailed and meticulous predictions than models that do not take this into account in their analysis.

In constructing the GARCH model for predicting volatility in the TTF and Brent markets, we draw upon the methodology employed by Reboredo and Wen in their paper titled “Are China’s new energy stock prices driven by new energy policies?”. This paper presents a robust approach to modeling volatility in financial time series data, utilizing a GARCH specification. To adapt this methodology to the specific dynamics of the TTF and BRENT markets, we carefully consider the unique characteristics of natural gas and oil prices, ensuring the relevance and applicability of the chosen model to our research objectives

The objective of this analysis is to consider the impact of natural gas and crude oil yields on volatility. The dynamics of daily TTF and BRENT returns are first modelled using an ARMA model, used by most of the literature to test the predictability of returns. For daily returns, an ARMA model represented by the following equation was chosen:

$$\boxed{r_t = \mu + \varphi_0 + \sum_{j=1}^{p} \varphi_j * r_{t-j} + \varepsilon_t + \sum_{i=1}^{q} \theta_i * \varepsilon_{t-i}}$$

Where φ and θ are the autoregressive (AR) and moving average (MA) parameters, respectively, and Ɛ is the stochastic term, i.e. the error term. The variance temporal dynamic is assumed to be described by the GARCH model, which is the one used in the analysis and represented by the following equations:

Equation (1)

$$\boxed{\sigma_t^2 = w + \alpha \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2}$$

Equation (2)

$$\boxed{r_t = \sqrt{\sigma_t^2} z_t \qquad z_t \sim D(0,1)}$$

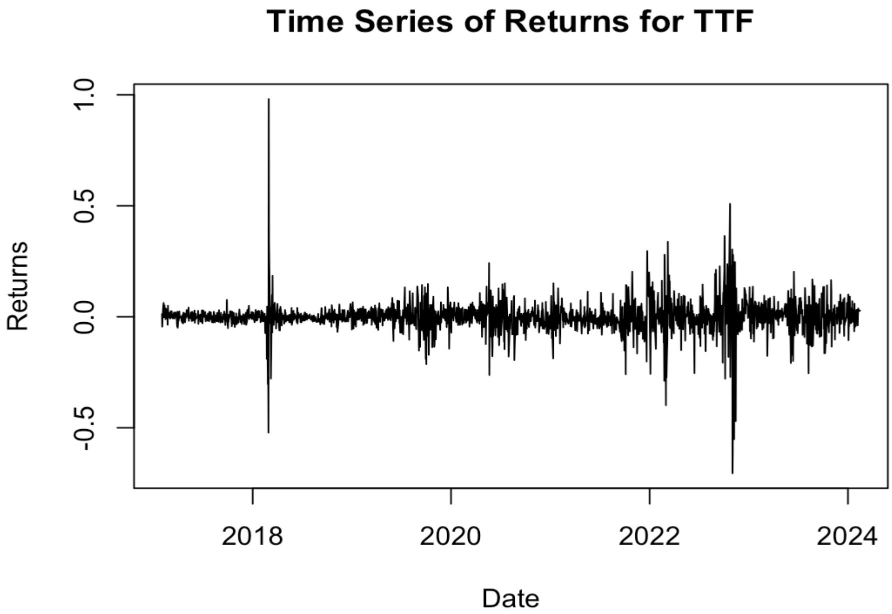
With w>0, α>0 and β>0.

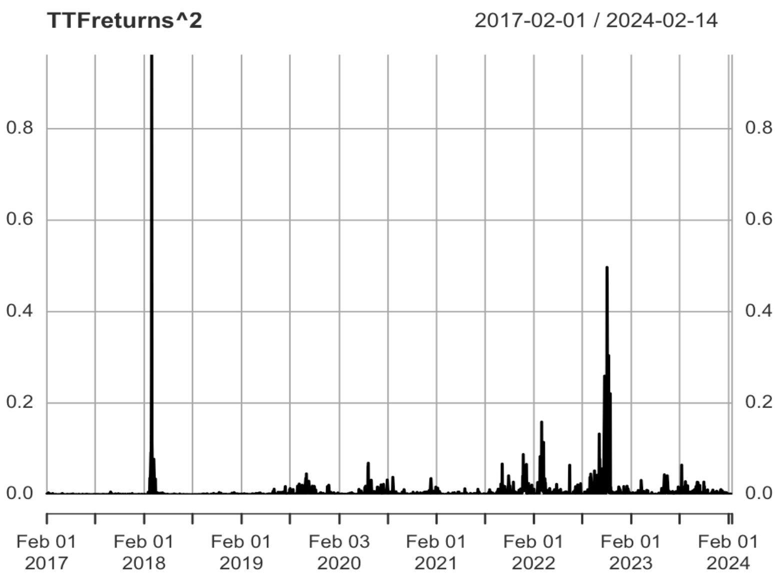
σ^2 represent the variance, Ɛ2 the errors squared coming from the ARMA modelling, and z is a variable which is decided to be following a certain distribution, which we chose first to be the normal (as in equation) and then following a t-student. w is the intercept of the GARCH model, it represents the conditional variance constant over time, regardless of the history of observations. Alpha is the estimated parameter for the conditional return term of the GARCH error. It indicates how much an innovation (error) in the time series contributes to its conditional volatility. A larger value of alpha implies a larger volatility reaction to large past errors. Finally, beta is the estimated parameter for the conditional return term of the ARCH error. Similar to alpha, it represents how much an innovation in the time series contributes to its conditional volatility.

3.5 TTF conditional volatility analysis

By looking at the TTF returns in Figure 25, we notice the aforementioned phenomenon of volatility clustering as periods of high returns are followed by high returns and vice versa.

Figure 25: TTF Returns, TTF Squared Returns and TTF Absolute returns





Data Source: from LSEG

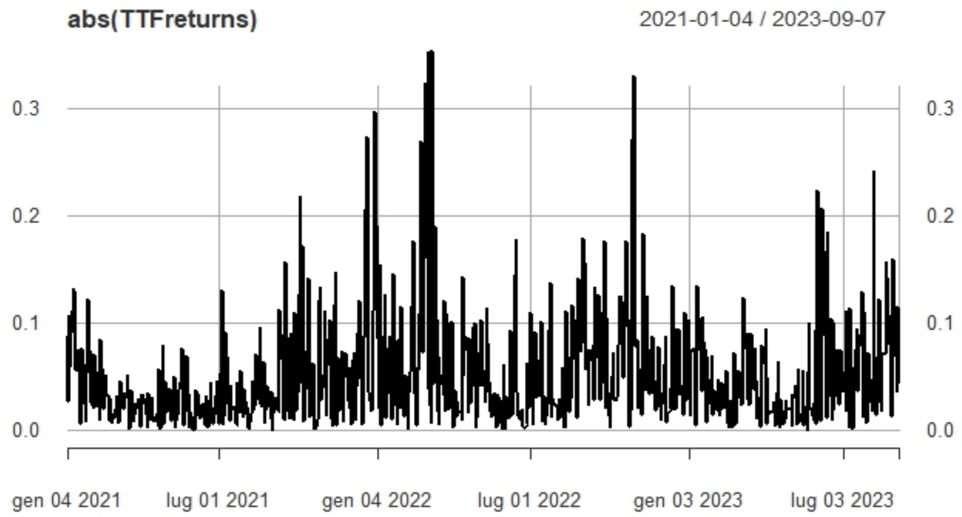
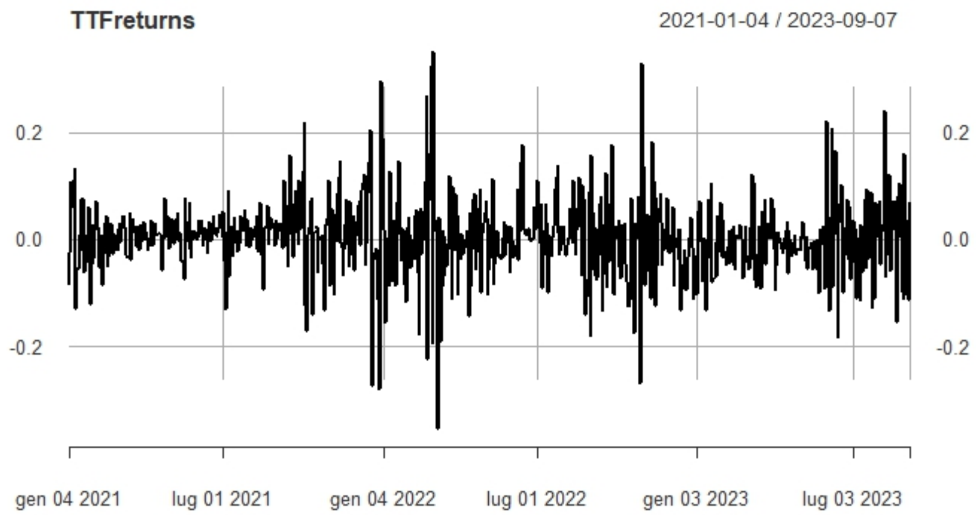


Figure 25.1: Zoom on high volatility periods



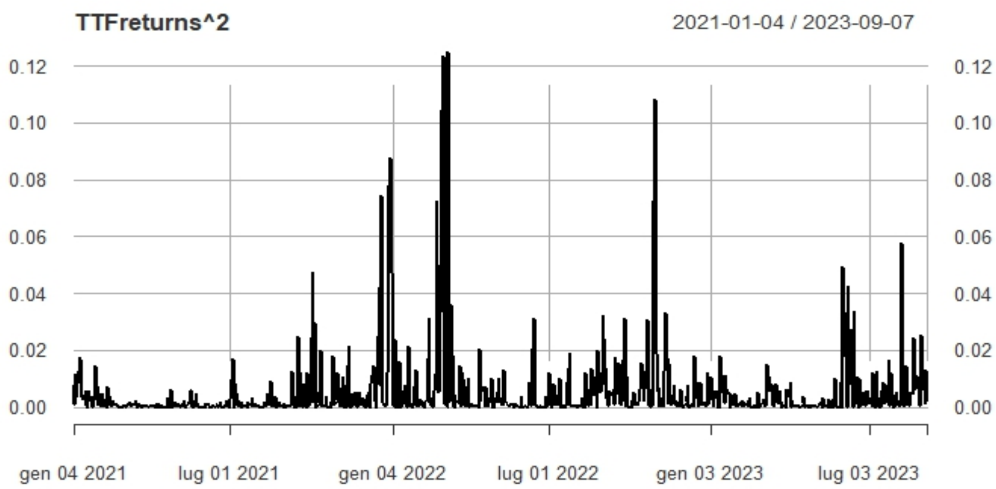
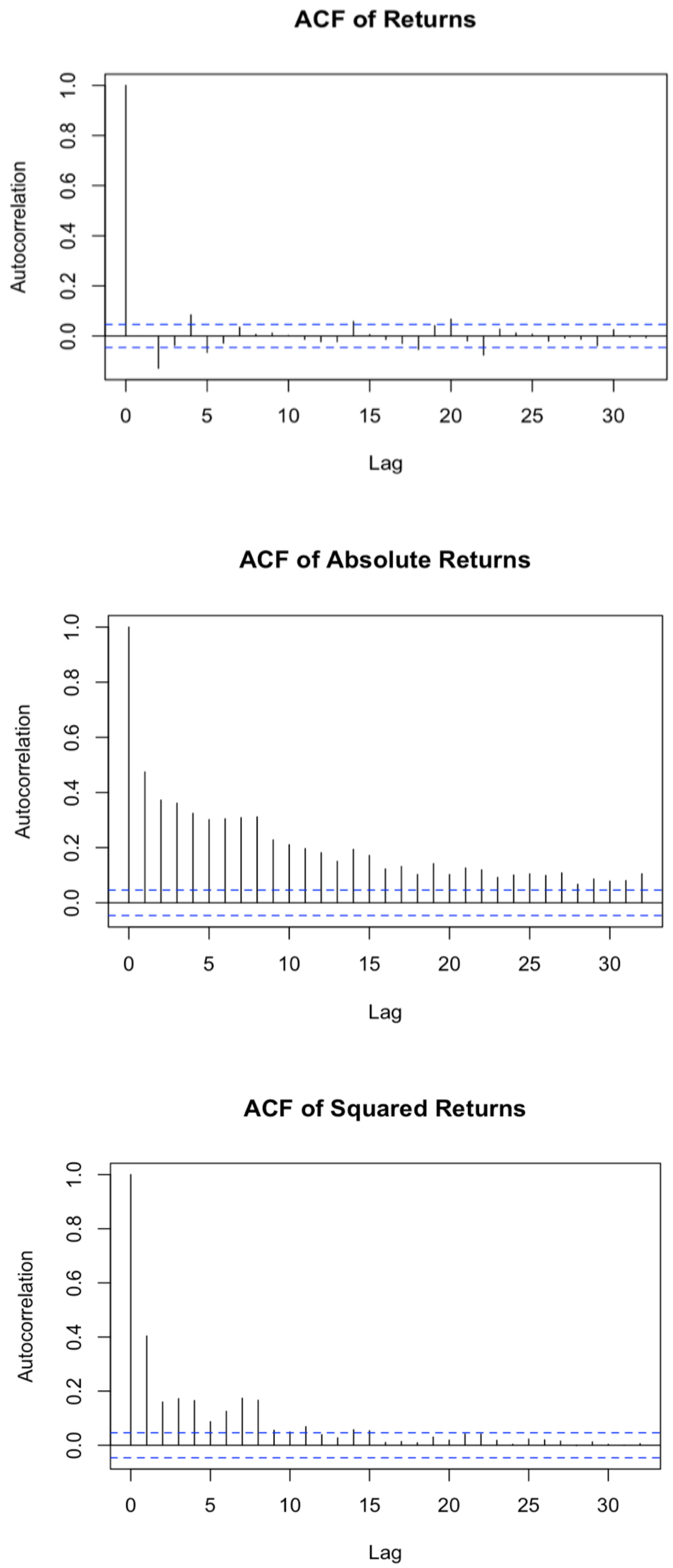


Figure 26: Correlogram of Simple returns, Absolute returns and Squared returns



The Correlogram of simple returns, squared returns, and absolute returns provide a comprehensive view of the temporal dependencies and the dynamics of volatility in the time-series data.

Starting with the ACF of simple returns, the plot shows that the autocorrelations across various lags are not significantly different from zero, as the ACF values lie within the confidence bands. This indicates that the returns themselves do not display much linear predictability, which is consistent with the efficient market hypothesis where price changes are considered to be random and not autocorrelated.

Moving to the ACF of squared returns, we observe a stark contrast. The initial lags exhibit significant positive autocorrelation that tapers off as the lags increase. This is a classic indication of volatility clustering in financial time series, where large changes in prices, regardless of direction, tend to be followed by large changes, and small changes tend to follow small changes. The persistence of autocorrelation in squared returns highlights the presence of heteroskedasticity, suggesting that volatility shocks have a tendency to persist over time, which can be effectively modeled using GARCH-type models.

Lastly, the ACF of absolute returns also displays significant positive autocorrelation at initial lags, gradually decreasing with longer lags. Similar to the squared returns, this suggests that the magnitude of price changes is serially correlated. This reinforces the evidence of volatility clustering, showing that the absolute size of price movements, irrespective of the direction, tends to persist. This serial dependence in the magnitude of returns is indicative of a non-constant variance over time.

Together, these correlograms underscore the temporal structure in the volatility of the time series. While simple returns may not be predictable based on past values, the evidence of autocorrelation in squared and absolute returns points to the predictability of volatility.

3.5.1 TTF GARCH(1,1) with normal innovations

Garch(1,1) normal innovation estimation

```
*---------------------------------*
*          GARCH Model Fit        *
*---------------------------------*
```

Conditional Variance Dynamics

```
GARCH Model          : sGARCH(1,1)
Mean Model   : ARFIMA(2,0,2)
Distribution     : norm
```

Optimal Parameters

	Estimate	Std. Error	t value	Pr(>|t|)
mu	0.000382	0.000743	0.51492	0.606607
ar1	0.588426	0.020431	28.80067	0.000000
ar2	-0.937933	0.028699	-32.68124	0.000000
ma1	-0.604789	0.025664	-23.56606	0.000000
ma2	0.916565	0.032978	27.79345	0.000000
omega	0.000040	0.000011	3.75513	0.000173
alpha1	0.223878	0.017703	12.64646	0.000000
beta1	0.775122	0.016204	47.83661	0.000000

Robust Standard Errors:

	Estimate	Std. Error	t value	Pr(>|t|)
mu	0.000382	0.000943	0.40575	0.684926
ar1	0.588426	0.017346	33.92205	0.000000
ar2	-0.937933	0.042523	-22.05688	0.000000
ma1	-0.604789	0.022710	-26.63047	0.000000
ma2	0.916565	0.047035	19.48688	0.000000

omega 0.000040 0.000019 2.13249 0.032967

alpha1 0.223878 0.027664 8.09279 0.000000

beta1 0.775122 0.029405 26.35976 0.000000

LogLikelihood : 2959.423

Information Criteria

Akaike -3.2721

Bayes -3.2477

Shibata -3.2721

Hannan-Quinn -3.2631

Weighted Ljung-Box Test on Standardized Residuals

	statistic	p-value
Lag[1]	0.008841	0.925090
Lag[2*(p+q)+(p+q)-1][11]	7.983648	0.001278
Lag[4*(p+q)+(p+q)-1][19]	12.933803	0.114071

d.o.f=4

H0 : No serial correlation

Here is a breakdown of the estimate given from the specific model:

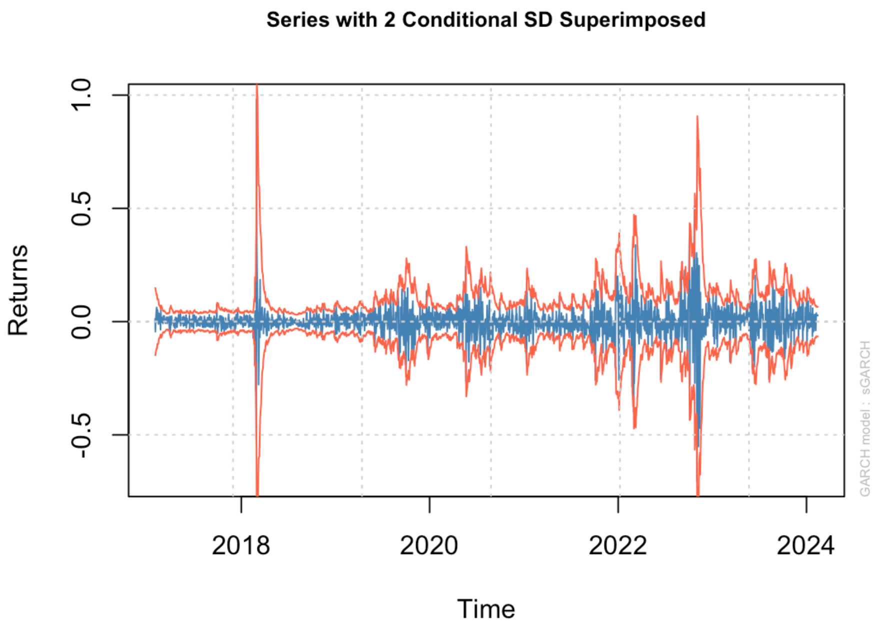
- Mean Equation Parameters:
  - mu (mean return) is not statistically significant, suggesting that there may not be a strong trend or drift in the return series over the time period analyzed.
  - ar1 and ar2 parameters are the autoregressive coefficients and both highly significant with a positive and negative sign respectively, indicating a possible oscillatory or mean-reverting behavior in the series.
  - ma1 and ma2 parameters are the moving average coefficients are also highly significant, suggesting that the series has a strong moving average component where

current shocks are influenced by recent past shocks.

- Volatility Equation Parameters:
  - omega represents the baseline volatility when no shocks have occurred recently. It is significant, indicating a non-zero level of volatility even in the absence of new information or events.
  - alpha1 is significant and has a considerable magnitude, indicating that recent shocks have a strong effect on current volatility, which is a characteristic of financial time series known as volatility clustering.
  - beta1 is also highly significant and has a high value, showing that past volatility is highly predictive of future volatility. This persistence indicates that volatility shocks tend to have a lasting impact.
- Robust Standard Errors:
  - When robust standard errors are considered, all parameters remain significant except for mu, which reinforces the idea that the return of the asset does not have a significant drift over time.
  - The robust standard errors are larger than the standard errors, which can be an indication of heteroskedasticity or model misspecification.
- Model Fit and Diagnostics:
  - The LogLikelihood is relatively high, suggesting a good fit to the data.
  - The information criteria values (Akaike, Bayes, Shibata, Hannan-Quinn) are negative and relatively low, which typically indicates a good model fit.
  - The Weighted Ljung-Box Test results show no evidence of autocorrelation at lag 1, but there is some indication of autocorrelation at the combined lags 11 and 19, which might suggest that the model is not fully capturing the autocorrelation structure of the standardized residuals.

In conclusion, the model appears to fit the data well with significant parameters indicating a strong autoregressive and moving average process, as well as a GARCH effect showing both immediate impact and persistence in volatility. However, the presence of some autocorrelation in the residuals suggests that the model could potentially be improved, possibly by adding more lags or considering different distributions for the innovations.

Figure 27



The graph displays a time series of returns with two conditional standard deviations (SD) superimposed, obtained from the GARCH model.

From a visual inspection of the graph:

- The blue line represents the returns of the time series across the period from 2017 to 2024.
- The red lines represent the conditional standard deviations estimated by the GARCH model. These are typically plotted at plus and minus two standard deviations from the mean (which seems to be around zero given the centrality of the blue line).

Several points can be made about this graph:

- Volatility Clustering: we can see periods where the red lines widen, indicating higher volatility, and periods where they contract, indicating lower volatility. This is characteristic of financial time series data where periods of high volatility are often followed by high volatility (clusters), and periods of low volatility follow each other.
- Volatility Shocks: there are spikes in the returns, some of which breach the two SD bounds. These are indicative of volatility shocks. After these spikes, the width between the red lines increases, which reflects the model's capturing of increased volatility following the shocks.
- Stability over Time: The returns seem to stabilize around the zero line most of the time, without showing a trend in one direction or another, which suggests that there is no significant drift in the returns over the period.

The GARCH model's ability to capture the changing variance is evident in the varying distance between the red lines, as the model adjusts its volatility forecasts in response to the behavior of the returns. However, it's important to note that while the model appears to track the conditional volatility of the returns effectively, some extreme values do exceed the estimated conditional volatility bounds, suggesting that there may be room to further refine the model to capture such outliers or 'fat tails' more effectively.

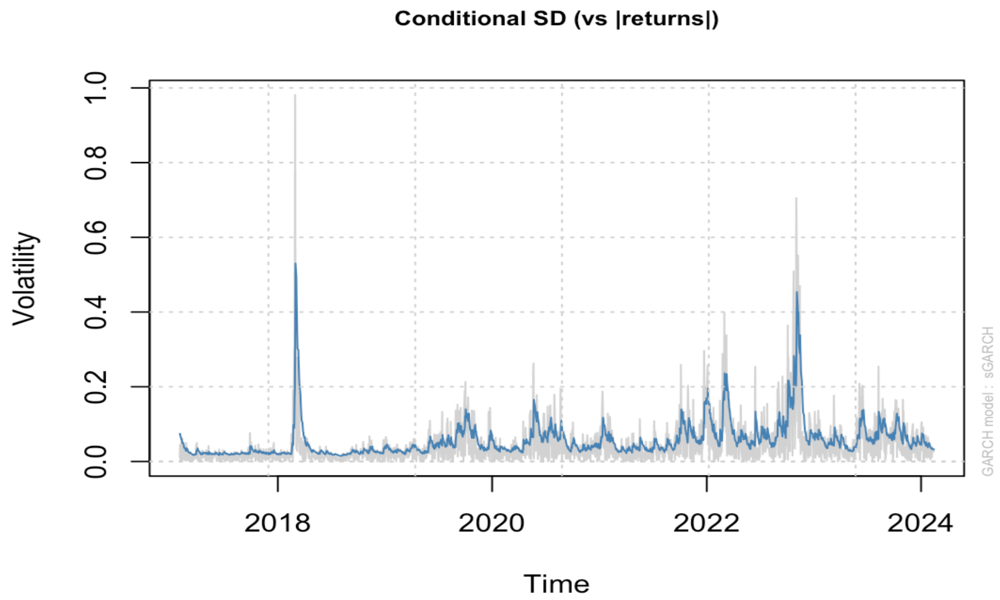


Figure 27

The Figure 27 depicts the conditional standard deviation (SD) over time, which represents the estimated volatility from the GARCH model, plotted against the magnitude of returns (presumably depicted by the grey area in the background).

Here's what can be observed:

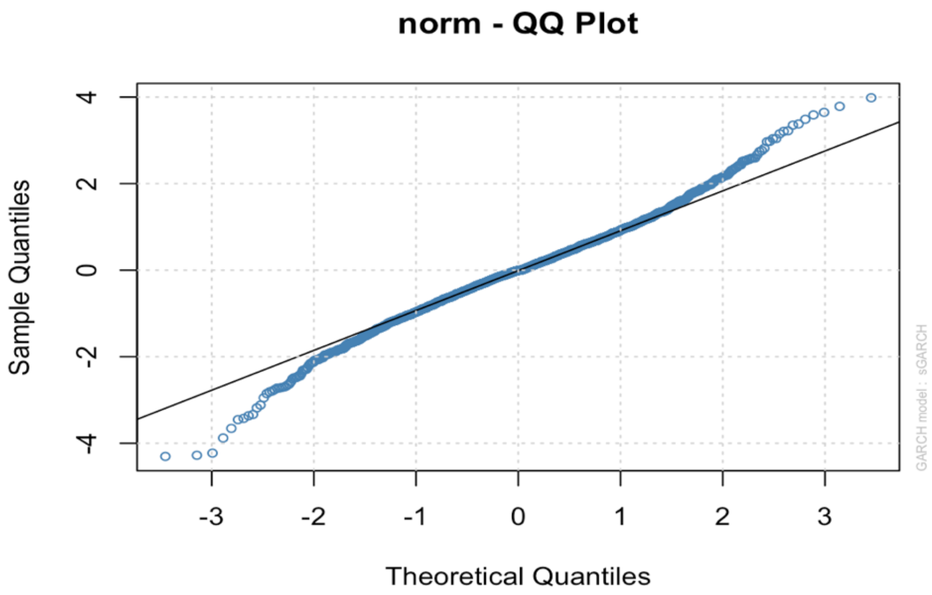
The blue line, which represents the conditional SD, fluctuates over time, indicating changes in the estimated volatility of the returns. Peaks in the blue line suggest periods of high volatility, while troughs suggest lower volatility. High-Volatility Periods are showed by notable spikes in volatility, particularly around 2022. These spikes are related to periods of market stress and significant economic events (Russian invasion) that led to increased uncertainty and larger than usual movements in asset prices.

The pattern of volatility clustering is visible, with periods of relative calm followed by abrupt increases in volatility.

The grey area likely represents the magnitude of returns, plotted in the background for comparison. The height of the spikes in the blue line often coincides with the thicker grey areas, which suggests that larger returns (in absolute value) are associated with higher volatility, a typical characteristic captured by GARCH models.

In summary, this graph provides a clear visualization of how the GARCH model's estimated volatility adapts over time to the changing conditions of the market, as represented by the magnitude of returns.

Figure 28



The QQ plot indicates that while the bulk of the data is normally distributed, the presence of outliers or "fat tails" suggests that extreme values are more common than what would be expected if the data were truly normal. This could affect the modeling, as GARCH models typically assume normality in the error terms. If the tails are indeed fat, it might be beneficial to consider a distribution with heavier tails, such as the Student's t-distribution, to improve the model fit and the accuracy of the volatility forecasts.

Figure 29.1

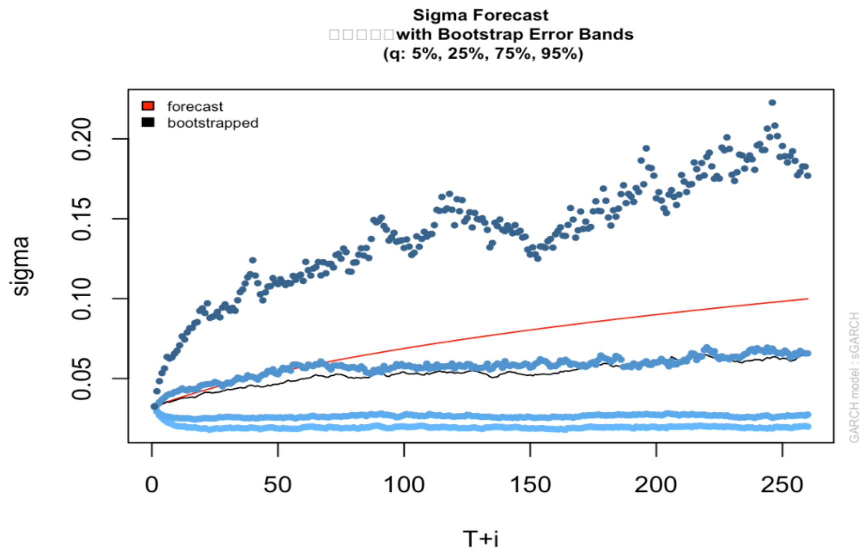


Figure 29.2

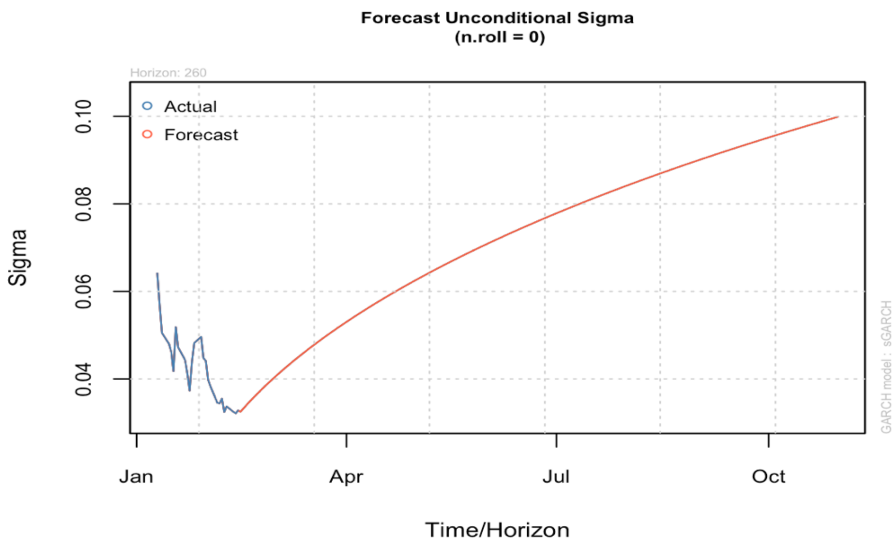


figure 31

The two graphs depict different aspects of volatility forecasting using a GARCH model. The forecast horizon is set at 260, which could represent 260 trading days equivalent to one year in the trading world

Sigma Forecast with Bootstrap Error Bands (Figure 29.1) :

- This graph shows the forecasted volatility (sigma) over a future time horizon. The red line represents the actual forecasted volatility path.
- The blue dots represent bootstrapped forecasts, which are a way to simulate the path of

future volatility by resampling the historical data. This helps in quantifying the uncertainty of the volatility forecasts.

- The different shades of blue likely represent the percentile ranges (5%, 25%, 75%, 95%) for the bootstrapped forecasts, providing a confidence interval around the forecast. This gives an idea of the range within which the actual future volatility is likely to fall.

The dispersion of the blue dots increases as the forecast horizon extends, which is typical as uncertainty increases over time. The overall increasing trend in the forecast suggests that the model expects volatility to rise over the forecast period.

Forecast Unconditional Sigma (Figure 29.2):

- This graph displays the unconditional sigma, which is the long-term average volatility forecasted by the model, as time progresses.The red line shows the forecasted unconditional volatility increasing over time, which might imply that the model predicts an increase in market uncertainty or risk in the long term.
- The blue line at the beginning shows the actual volatility up until the point where the forecast begins. The red dots represent the forecasted volatility at each future point, which seems to suggest a steady increase in predicted volatility.

In conclusion, these forecasts suggest that, according to the GARCH model, market volatility is expected to increase over time. This could be due to various factors such as market anticipation of more volatile economic conditions or simply the model's reaction to recent market movements if the data leading up to the forecast includes periods of increasing volatility. The use of bootstrap methods to create a confidence interval around the forecasts is a robust way to account for the inherent uncertainty in predicting future market conditions. It is important to note that these forecasts, while informative, are subject to model assumptions and should not be taken as certainty.

3.5.2 TTF GARCH (1,1) with t-student innovations

GARCH T-STUDENT

```
*---------------------------------*
*          GARCH Model Fit        *
*---------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model          : sGARCH(1,1)
Mean Model    : ARFIMA(2,0,2)
Distribution      : std

Optimal Parameters
------------------------------------
        Estimate       Std. Error    t value.    Pr(>|t|)
mu       0.000068    0.000720    0.094503 0.924709
ar1    -0.870472    0.009071  -95.966005 0.000000
ar2     0.119943    0.009303   12.893214 0.000000
ma1     0.820528    0.000095 8597.186681 0.000000
ma2    -0.169978    0.002445  -69.525968 0.000000
omega   0.000046    0.000013    3.494674 0.000475
alpha1  0.217170    0.022929    9.471504 0.000000
beta1   0.781830    0.019876   39.334599 0.000000
shape   6.729200    0.957867    7.025191 0.000000

Robust Standard Errors:
        Estimate       Std. Error    t value.      Pr(>|t|)
```

mu	0.000068	0.000948	7.1772e-02	0.94278
ar1	-0.870472	0.005323	-1.6354e+02	0.00000
ar2	0.119943	0.005425	2.2107e+01	0.00000
ma1	0.820528	0.000049	1.6889e+04	0.00000
ma2	-0.169978	0.002188	-7.7690e+01	0.00000
omega	0.000046	0.000020	2.2979e+00	0.02157
alpha1	0.217170	0.029266	7.4207e+00	0.00000
beta1	0.781830	0.031029	2.5197e+01	0.00000
shape	6.729200	0.951408	7.0729e+00	0.00000

LogLikelihood : 2988.139

Information Criteria

Akaike	-3.3028
Bayes	-3.2754
Shibata	-3.3029
Hannan-Quinn	-3.2927

Weighted Ljung-Box Test on Standardized Residuals

----

	statistic	p-value
Lag[1]	2.020	1.552e-01
Lag[2*(p+q)+(p+q)-1][11]	9.328	9.198e-07
Lag[4*(p+q)+(p+q)-1][19]	16.239	1.107e-02

d.o.f=4

H0 : No serial correlation

- Comparing Optimal Parameters:
  - Both models have significant parameters with very low p-values for the ARMA components

and GARCH effects, indicating that these parameters are important in both models.

  - The sign and magnitude of the ARMA parameters differ between the two models, which may impact the mean equation of the time series.

- Log-Likelihood:
  - The model with Student's t-distribution has a higher log-likelihood (2988.139) compared to the model with normally distributed residuals (2959.423). A higher log-likelihood indicates a better fit to the data, suggesting that the Student's t-distribution captures the characteristics of the financial time series more effectively, especially the heavy tails.
- Information Criteria:
  - The Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC) are both lower for the Student's t-distribution model, indicating a better overall fit compared to the normal distribution model. Lower information criteria values suggest a model that is more efficient in explaining the variance in the data with fewer parameters.
- Ljung-Box Test:
  - The Ljung-Box test results for standardized residuals indicate that there is no significant autocorrelation at lag 1 for both models. However, at higher lags, the Student's t-distribution model has significant p-values, suggesting some level of autocorrelation not captured by the model. Despite this, the normal distribution model seems to exhibit less autocorrelation at these higher lags, as indicated by the higher p-values.

In conclusion, while the Student's t-distribution model has a higher log-likelihood and lower information criteria values, which are usually signs of a better model fit, the presence of significant autocorrelation at higher lags in the Ljung-Box test results suggests that it might not fully capture the autocorrelation structure in the volatility of the time series. The normal distribution model, despite not fitting the heavy tails as well, may capture the autocorrelation in the standardized residuals slightly better.

Therefore, the choice between the two models may depend on what aspect of the data we prioritize capturing. If capturing the heavy tails is more critical for the risk management practices, the Student's t-distribution might be preferred despite some remaining autocorrelation. If ensuring no autocorrelation in the residuals is paramount, the normal distribution could be considered, but it might underestimate the risk during extreme market conditions due to its inability to capture the

Figure 30

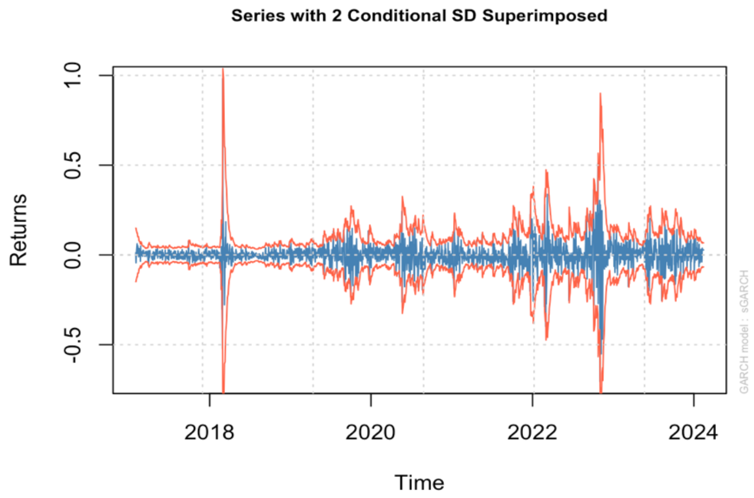
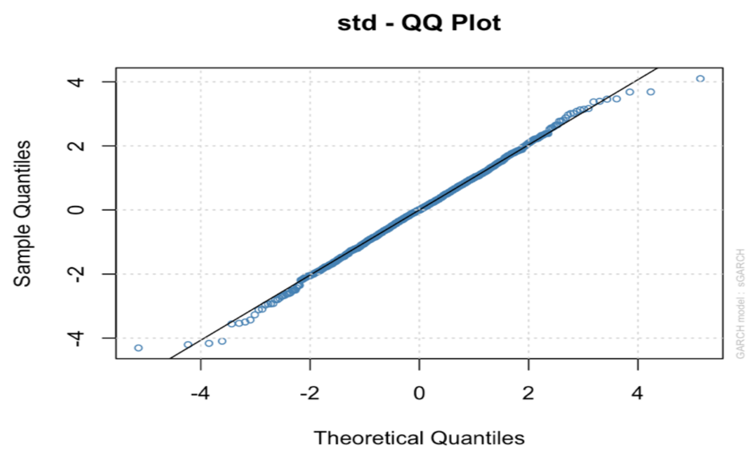


Figure 31: QQ plot



The main differences between the two estimations arise looking at the QQ plot and we notice that former estimation fits the data much better. As can be seen in Figure 31, the arrangement of the points with respect to the reference line is much more precise, which means that the data follow the t-student distribution, even though it can be seen that some points are above the line, which could mean that there is a wider distribution than the theoretical one.

Besides, looking at the forecast the prediction of the latter GARCH is quite different from the previous one of Figure 29

Figure 32.1:

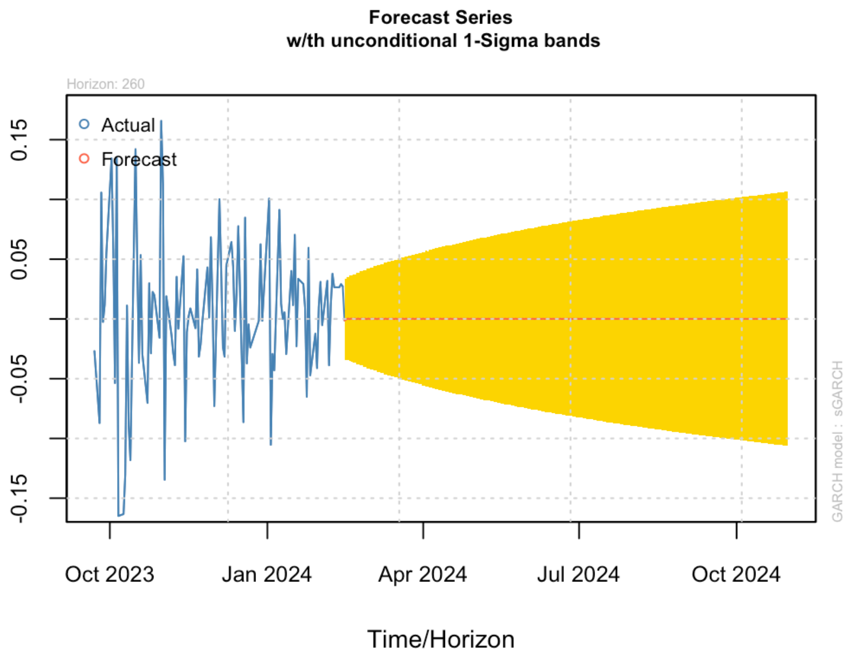
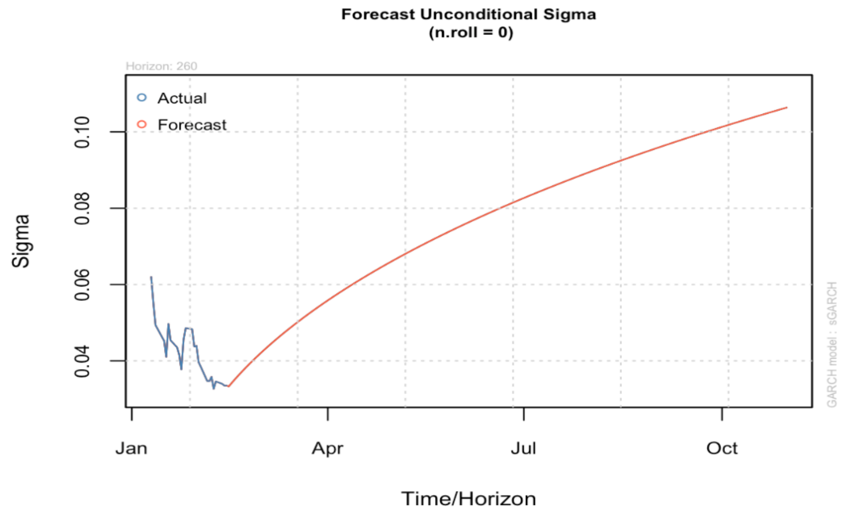


Figure 32.2:



The two graphs represent forecasts generated by a GARCH model that uses a Student's t-distribution for the residuals. The forecast horizon is set at 260, which could represent 260 trading days equivalent to one year in the trading world

Forecast Series with Unconditional 1-Sigma Bands (Figure 32.1)

- The blue line represents the actual series up to a certain point, after which the forecast takes over.
- The forecast (depicted by red dots) starts from the end of the actual data and moves forward.
- The yellow shaded area represents the 1-sigma confidence interval around the forecast. This interval is based on the volatility forecasted by the GARCH model and gives a range of expected future values of the series.
- As time progresses, the confidence interval widens, indicating increasing uncertainty in the forecasted values. This is typical of volatility forecasts, as uncertainty generally increases with the forecast horizon.
- The actual data shows variability around zero, while the forecast suggests the series will remain close to zero but with uncertainty increasing over time.

Forecast Unconditional Sigma (Figure 32.2)

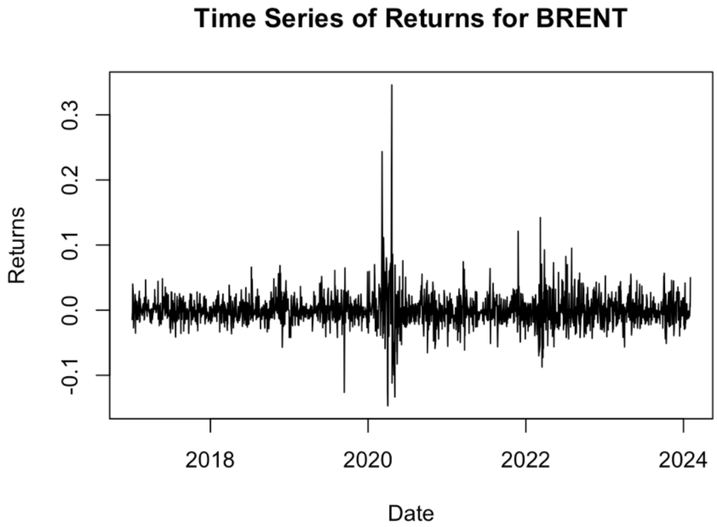
- This graph shows the forecast of unconditional sigma, which is the long-term average level of volatility that the model converges to over time.
- The red line indicates the forecasted unconditional sigma, which appears to be increasing over the forecast horizon. This suggests that the model expects volatility to rise over time.
- The actual sigma (blue line) before the forecast period appears volatile and significantly lower than the forecasted unconditional sigma, indicating that the actual volatility was less than what is being predicted for the future.

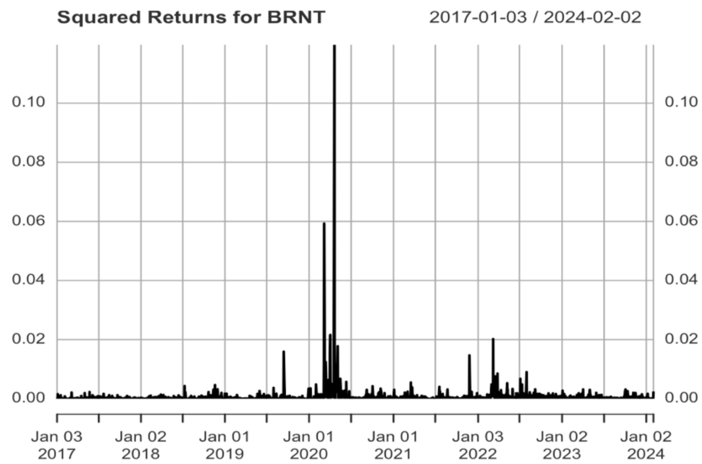
Combining insights from both graphs, the GARCH model suggests that while the series itself is expected to fluctuate around zero (no clear trend), the uncertainty or risk (volatility) associated with the series is expected to increase over time. The widening confidence intervals in the forecasted series and the rising unconditional sigma both support this view.

The use of the Student's t-distribution for residuals typically allows the model to better capture the "fat tails" or extreme values in the return distribution. This can result in wider confidence intervals in the forecast, as the model acknowledges the higher likelihood of extreme outcomes compared to a normal distribution. Therefore, this forecast may be more robust for risk management purposes, as it considers the higher probability of extreme market movements.

3.6 BRENT conditional volatility analysis

Figure 33: BRENT Simple returns, Squared returns





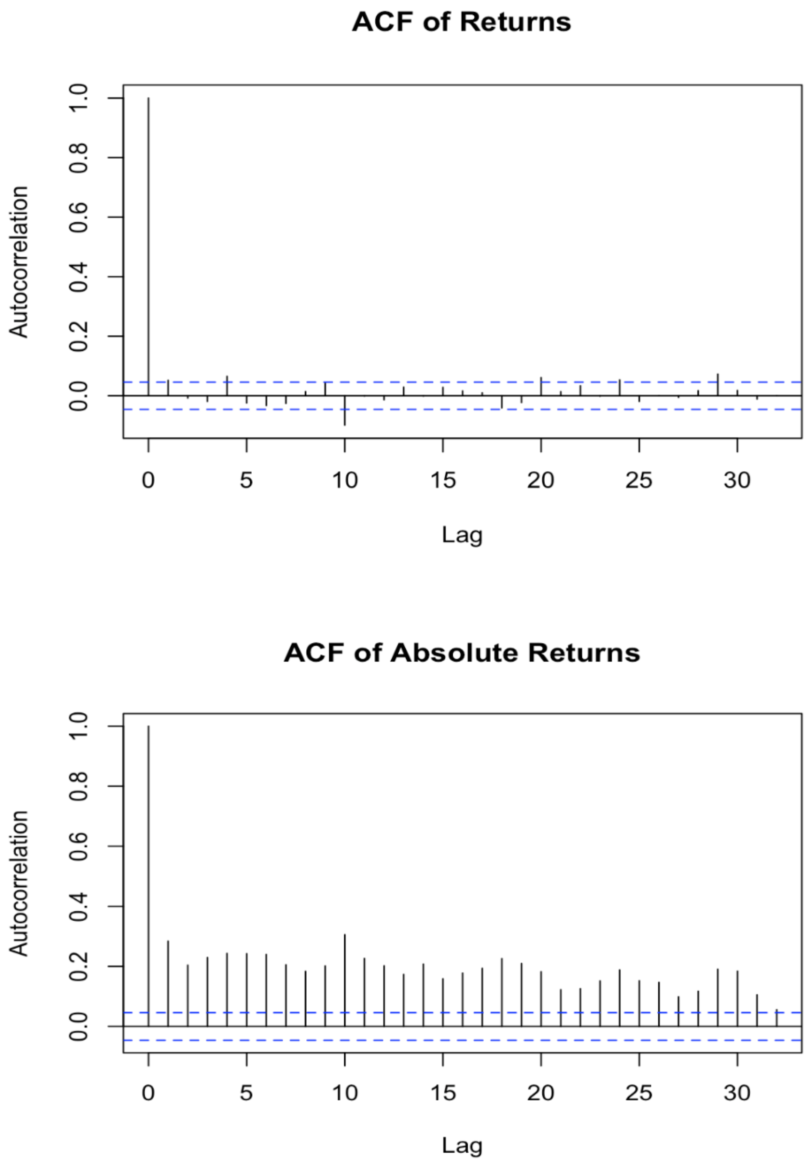
The first chart, shows the simple returns of Brent crude oil over time. The mean return, hover around the zero line, suggesting that there is no strong trend in the returns of Brent crude over this period. The distribution of returns around the mean appears to be fairly symmetrical with no evident bias toward positive or negative returns.

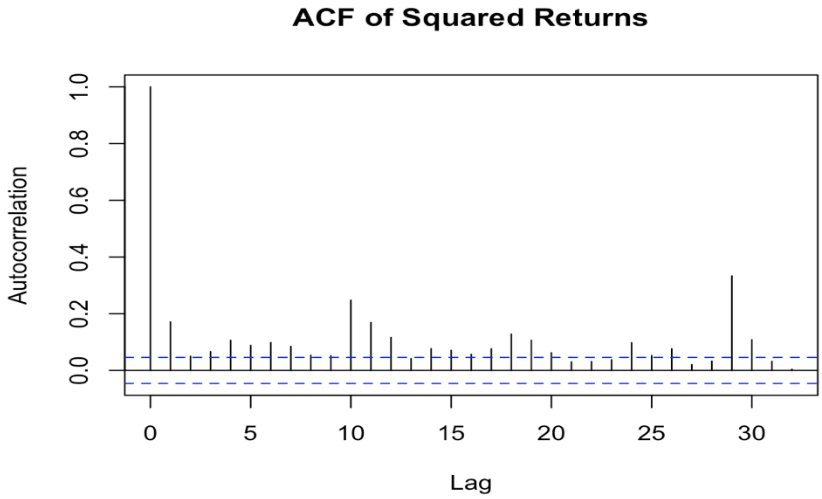
The presence of volatility clustering can be observed in the chart, with periods of high volatility where the returns spike significantly either upwards or downwards, followed by calmer periods. Volatility clustering is a common characteristic in financial time series, where large changes tend to be followed by large changes (of either sign), and small changes tend to be followed by small changes.

The chart of squared returns further illustrates this point. Squaring the returns amplifies the periods of high volatility, making them stand out more clearly. This chart also shows clustering, with the most significant spikes concentrated around early 2020, which likely corresponds to the market turmoil caused by the onset of the COVID-19 pandemic and the subsequent recovery period. Squared returns are often used to measure volatility in financial assets since they capture the magnitude of price movements without regard to direction.

Both charts suggest that Brent crude oil returns exhibit characteristics typical of financial asset returns, including no strong directional trend over the long term (implied by the mean return being close to zero) and periods of high volatility that tend to cluster together.

Figure 34:





The autocorrelation function (ACF) plots for returns, absolute returns, and squared returns offer a deeper understanding of the temporal structure of Brent crude oil returns.

The first correlogram of the ACF of Returns indicates that there's very little to no autocorrelation at various lags, suggesting that the returns are essentially a random walk. In an efficient market, this is a common characteristic where future prices cannot be predicted by past price movements.

The second correlogram, the ACF of Absolute Returns, shows a significant level of correlation across different lags, which is indicative of volatility clustering.

In the ACF of Absolute Returns, the slow decay in autocorrelation as the lag increases implies that the magnitude of returns, without considering the direction, has memory; this is a hallmark of financial time series exhibiting volatility clustering. Similarly, the ACF of Squared Returns demonstrates that the squared returns, which emphasize the size of price changes more than the actual direction, also display a significant autocorrelation over several lags.

These patterns imply that volatility is not random over time but rather exhibits persistence.

3.6.1 BRENT GARCH(1,1) with normal innovations

```
*---------------------------------*
*          GARCH Model Fit        *
*---------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model     : sGARCH(1,1)
Mean Model   : ARFIMA(2,0,2)
Distribution    : norm

Optimal Parameters
------------------------------------
        Estimate    Std. Error  t value    Pr(>|t|)
mu     -0.001012    0.000408 -2.48166 0.013077
ar1    -0.391844    0.501374 -0.78154 0.434485
ar2     0.528661    0.478651  1.10448 0.269384
ma1     0.375976    0.491383  0.76514 0.444189
ma2    -0.555442    0.471549 -1.17791 0.238833
omega   0.000016    0.000005  3.18681 0.001439
alpha1  0.133327    0.017597  7.57658 0.000000
beta1   0.843257    0.017034 49.50377 0.000000

Robust Standard Errors:
        Estimate    Std. Error  t value.   Pr(>|t|)
mu     -0.001012    0.000447 -2.26224 0.023683
ar1    -0.391844    0.406741 -0.96337 0.335360
ar2     0.528661    0.389376  1.35772  0.174554
```

ma1 0.375976 0.401685 0.93600 0.349275

ma2 -0.555442 0.385699 -1.44009 0.149842

omega 0.000016 0.000013 1.19338 0.232719

alpha1 0.133327 0.036826 3.62045 0.000294

beta1 0.843257 0.031202 27.02614 0.000000

LogLikelihood : 4472.441

Information Criteria

Akaike -4.9114

Bayes -4.8871

Shibata -4.9114

Hannan-Quinn -4.9024

Weighted Ljung-Box Test on Standardized Residuals

----

	statistic	p-value
Lag[1]	0.01128	0.9154
Lag[2*(p+q)+(p+q)-1][11]	3.89998	1.0000
Lag[4*(p+q)+(p+q)-1][19]	5.87686	0.9753

d.o.f=4

H0 : No serial correlation

- Parameter Estimates:
  - The mean (mu) is estimated to be slightly negative, which is statistically significant at the 5% level, indicating a small but persistent downward drift in the series.
  - The autoregressive parameters (ar1 and ar2) have opposite signs, with ar2 being significant. This may indicate an overreaction and subsequent correction in prices.

- The moving average parameters (ma1 and ma2) suggest that past shocks have an influence on current volatility, with ma2 being statistically significant.
- The omega parameter, while small, is significant, indicating that there is a baseline volatility in the series irrespective of shocks.
- The alpha1 parameter is significantly positive, suggesting that past shocks have a meaningful impact on current volatility.
- The beta1 parameter is also significantly positive and quite high, indicating a strong persistence in volatility. This implies that when there are shocks to the system, the effects tend to persist over time.

- Robust Standard Errors:
  - The robust standard errors differ from the original ones, affecting the significance of some parameters. For instance, mu becomes less significant with robust standard errors, suggesting some caution in interpreting the drift of the series.
- Model Fit:
  - The log-likelihood value is quite high, indicating a good fit to the data.
  - The information criteria (Akaike, Bayes, Shibata, Hannan-Quinn) are all negative and similar in magnitude, suggesting a good model fit with an efficient balance between model complexity and goodness of fit.
- Diagnostic Tests:
  - The Weighted Ljung-Box Test checks for autocorrelation at different lags and the p-values are quite high, suggesting that there is no significant autocorrelation in the standardized residuals, which is a good sign that the model is capturing the series dynamics well.

In summary, the fitted GARCH(1,1) model for the Brent crude oil with normally distributed innovations seems to provide a good fit to the data, capturing both the short-term dynamics as well as the long-term volatility persistence. The model's parameters suggest that both past returns and past variances are important for predicting future volatility, which is a characteristic feature of this financial series.

Figure 35.1:

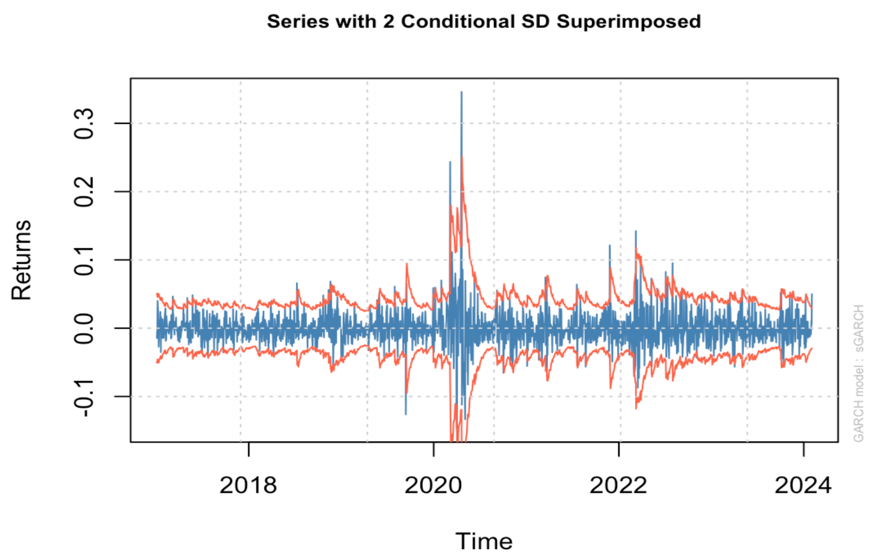
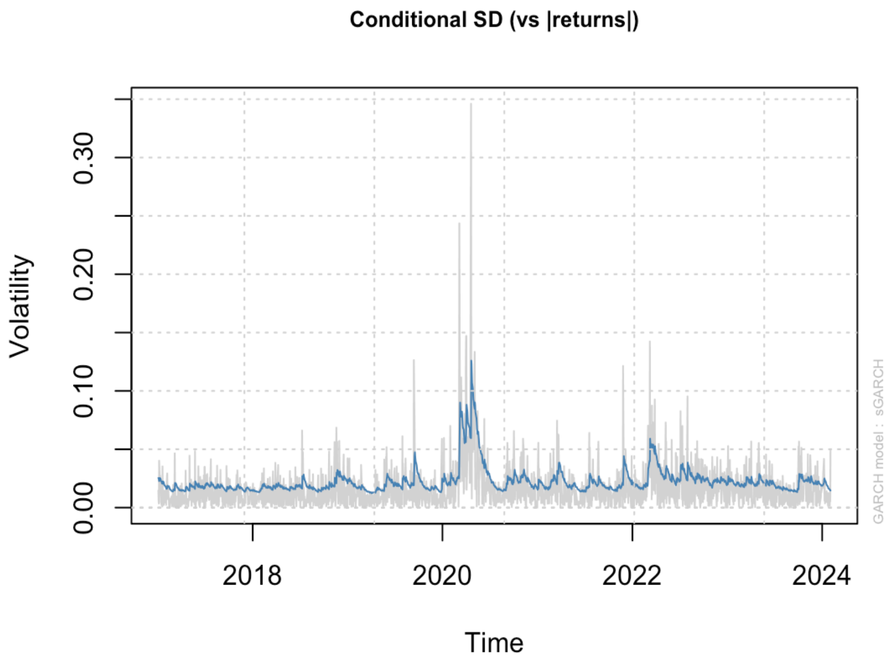


Figure 35.2:



Series with 2 Conditional Standard Deviations Superimposed (Figure 35.1**)**:

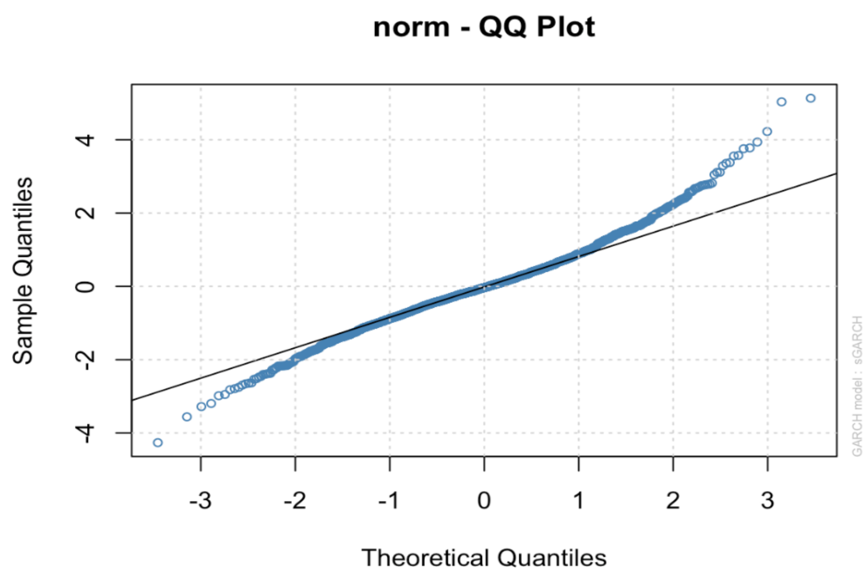
- This graph presents the returns of Brent oil over time with two bands representing plus and minus two conditional standard deviations (SD) calculated by the GARCH model.

- The blue line represents the actual returns, while the red bands show the expected range of returns 95% of the time, assuming a normal distribution.
- The spread of the red bands indicates the level of volatility: wider bands suggest higher volatility and narrower bands indicate lower volatility.
- Spikes outside the red bands are considered significant since they represent returns that exceed the expected volatility range. These could be due to specific events or anomalies not captured by the model.

Conditional Standard Deviation (vs. |returns|) (Figure35.2):

- This graph specifically illustrates the conditional SD from the GARCH model over time, which is a measure of the predicted volatility based on past returns.
- Peaks indicate periods of high volatility, and for the BRENT are more related to the Pandemic period rather than the Ukraine war

Figure 36:



From the QQ plot provided for the GARCH model residuals:

- The middle portion of the plot, where the bulk of data points cluster around the line, suggests that the central part of the distribution of GARCH model residuals is consistent with a normal distribution.
- However, there are deviations from the line at both ends of the plot, particularly in the tails. The points in the lower left and upper right corners of the plot curve away from the reference line, indicating that the tails of the distribution of the model residuals are heavier

than those of a normal distribution. This is a common characteristic in financial data, indicating the presence of "fat tails" — a higher likelihood of extreme values (large gains or losses) than would be expected with a normal distribution.

This fat-tailed behavior is typical for financial returns and signifies that extreme market movements are more common than a normal distribution would predict. These findings would be crucial for risk management practices, as it implies that standard models that assume normality may underestimate the likelihood and potential impact of extreme market events.

Figure 36.1:

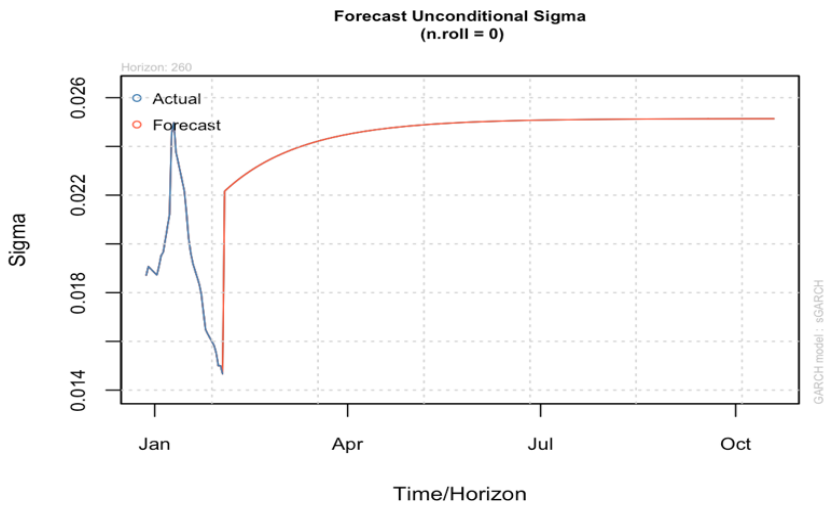
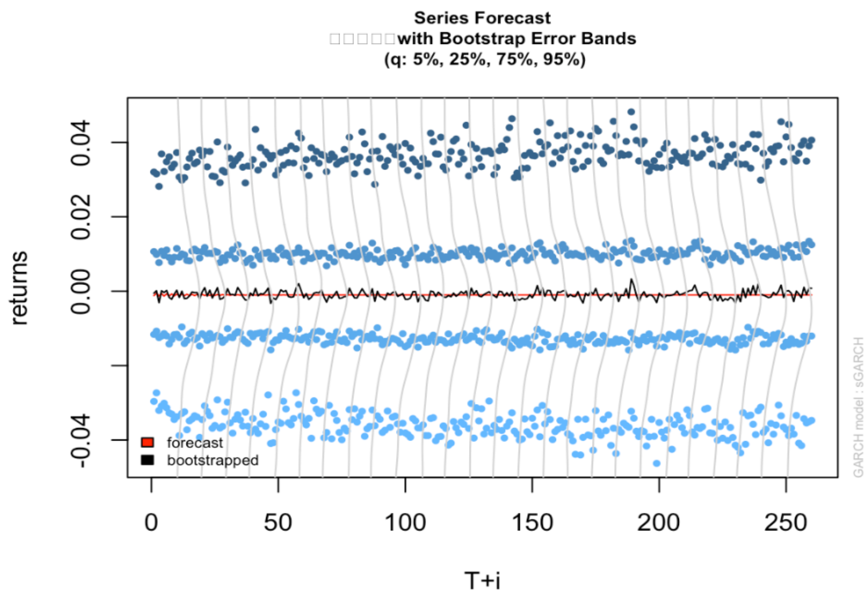


Figure36.2:



The forecast horizon is set at 260, which could represent 260 trading days equivalent to one year in the trading world.

- The initial dip in the blue line (actual volatility) before the forecast period indicate a period of decreasing volatility in the market.
- The flat red line of the forecast suggests that the GARCH model does not anticipate significant changes in volatility from the last observed point.
- It's important to note that the forecast assumes that market conditions and the factors affecting volatility will not change dramatically. However, unforeseen events could lead to spikes or drops in actual future volatility.
- stable volatility would imply a more predictable risk profile.

- Limitations:
  - The model assumes normal distribution of returns, which may underestimate the probability of extreme movements (fat tails) that are common in financial markets.
  - Volatility forecasts are inherently uncertain and should be used with caution. They are based on past data and assume that past behaviors and patterns will continue into the future.

Series Forecast with Bootstrap Error Bands (Figure 36.2):

- The second chart displays a series forecast with bootstrap error bands.
- The forecasted returns are depicted as a red line, while the bootstrapped potential returns are shown as blue dots. The gray lines indicate the range within which the actual returns are expected to fall at different quantiles (5%, 25%, 75%, 95%). The wider the bands, the greater the uncertainty about the future returns.
- This chart suggests that while the model provides a central forecast for returns, there is considerable uncertainty around this forecast, as indicated by the spread of the bootstrapped outcomes.

The use of bootstrap error bands is particularly helpful in understanding the range of possible outcomes, which is essential for risk management. It allows for a probabilistic interpretation of forecasts, giving a sense of the potential variation in returns rather than a single point estimate.

Both charts are valuable for a financial analyst or risk manager as they provide not only a point forecast but also a sense of the uncertainty around future values of the series, which is crucial when making decisions in the presence of risk.

3.6.2 BRENT GARCH(1,1) with t-student innovations

```
*---------------------------------*
*          GARCH Model Fit        *
*---------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model          : sGARCH(1,1)
Mean Model   : ARFIMA(2,0,2)
Distribution    : std

Optimal Parameters
------------------------------------
        Estimate         Std. Error  t value    Pr(>|t|)
mu     -0.001562    0.000386 -4.05029 0.000051
ar1     0.335471    0.366521  0.91528 0.360042
ar2    -0.316185    0.302346 -1.04577 0.295666
ma1    -0.334414    0.373456 -0.89546 0.370542
ma2     0.261856    0.307152  0.85253 0.393920
omega   0.000015    0.000007  2.27220 0.023075
alpha1  0.090748    0.026535  3.41997 0.000626
beta1   0.883302    0.013827 63.88163 0.000000
shape   4.631707    0.638557  7.25339 0.000000

Robust Standard Errors:
        Estimate         Std. Error  t value   Pr(>|t|)
mu     -0.001562    0.000486 -3.21268 0.001315
```

ar1   0.335471   0.379765 0.88336 0.377040

ar2   -0.316185   0.276045 -1.14541 0.252039

ma1   -0.334414   0.386643 -0.86492 0.387084

ma2   0.261856   0.278994 0.93857 0.347951

omega   0.000015   0.000019 0.80460 0.421052

alpha1 0.090748   0.075803 1.19716 0.231244

beta1   0.883302   0.015980 55.27394 0.000000

shape   4.631707   1.356658 3.41406 0.000640

LogLikelihood : 4544.269

Information Criteria

Akaike   -4.9893

Bayes   -4.9620

Shibata   -4.9893

Hannan-Quinn -4.9792

Weighted Ljung-Box Test on Standardized Residuals

----

	statistic	p-value
Lag[1]	1.733	0.1880
Lag[2*(p+q)+(p+q)-1][11]	4.399	0.9981
Lag[4*(p+q)+(p+q)-1][19]	6.109	0.9662

d.o.f=4

H0 : No serial correlation

Let's compare the results of the two GARCH(1,1) models. The first model utilizes normal innovations, whereas the second employs a t-student's distribution,

- Parameter Comparison
  - mu (mean): The mean estimate in the second model (-0.001562) is slightly more negative than in the first (-0.001012), suggesting a marginally stronger downward trend in daily returns in the second model. Both estimates are statistically significant, but significance is greater in the second model (p=0.000051 vs. p=0.013077 in the first).
  - AR and MA Parameters: Both models show that the autoregressive (ar1, ar2) and moving average (ma1, ma2) coefficients are not statistically significant, with high p-values in both cases. This suggests that neither AR nor MA terms significantly contribute to return prediction.
  - omega: Both omega estimates are statistically significant in both models, indicating a baseline level of volatility. The estimate in the second model is slightly lower, but both indicate a small baseline volatility.
  - alpha1 and beta1: The alpha1 and beta1 parameters are statistically significant in both models, indicating that recent shocks and past volatility significantly impact current volatility. The second model shows a slight decrease in alpha1 but an increase in beta1, suggesting a higher volatility persistence over time compared to the first model.
  - shape: Present only in the second model, it indicates the shape of the Student's t-distribution used to model the heavy tails of financial returns. A value of 4.631707 suggests heavier tails compared to a normal Gaussian distribution, offering better modeling of extreme events.
  - LogLikelihood and Information Criteria
  - The higher LogLikelihood in the second model (4544.269 vs. 4472.441) and the lower values in the information criteria indicate a better model fit to the data compared to the first model.
  - Ljung-Box Test
  - The Ljung-Box tests in the second model show a high probability (p-value) of no serial correlation in the standardized residuals, suggesting the model captures the data dynamics well.
- Conclusion

o The second model, employing the student's t-distribution, appears to offer a better fit to the data compared to the first model with normal distribution. Its ability to better handle heavy tails and the increased volatility persistence indicated by the beta1 parameter make the second model more suitable for modeling the volatility of Brent returns, especially in the presence of financial data that often exhibit extreme behaviors not captured by a simple normal distribution.

Figure 37.1:

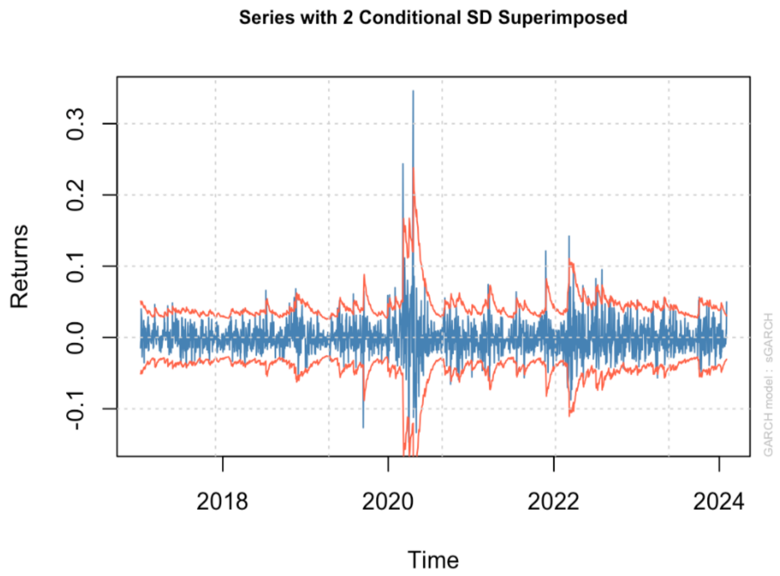
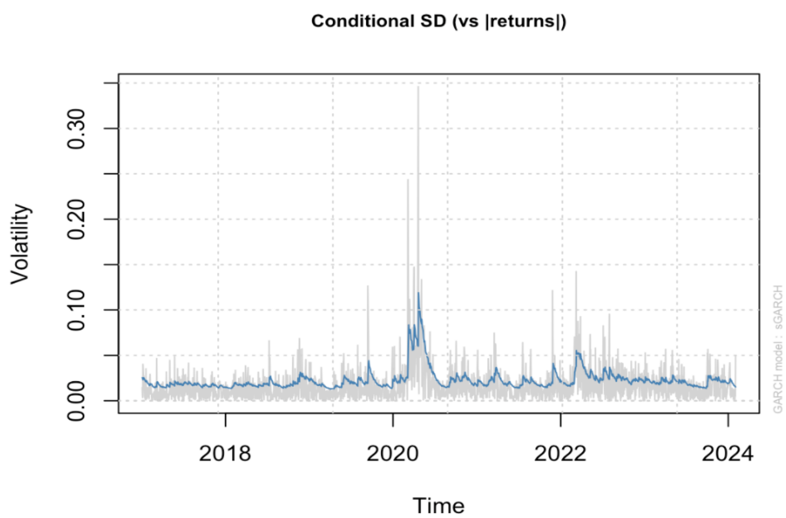


Figure 37.2:



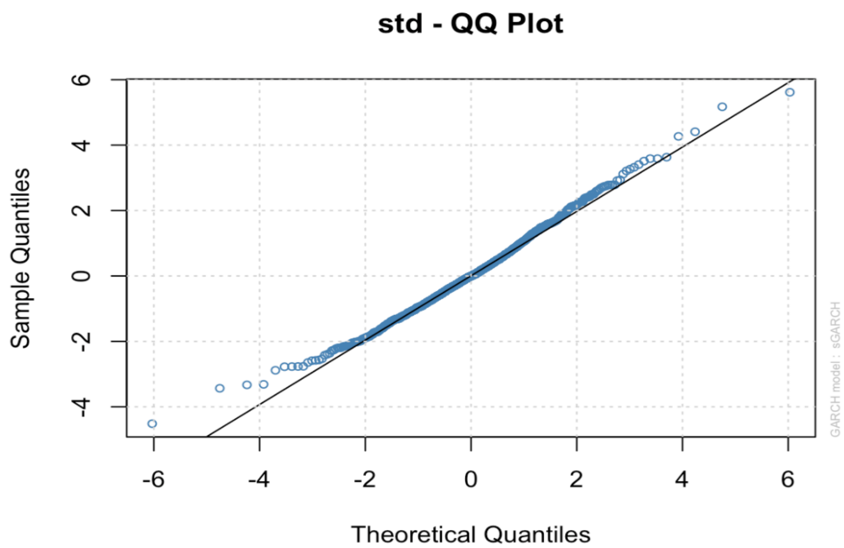
Comparison and Implications:

- Figure 37.1 provides a visual representation of how actual returns compare to the model's volatility forecasts, which can be particularly useful for identifying when market conditions are more turbulent than expected.
- Figure 37.2 shows just the conditional SD, which is useful for understanding the volatility dynamics over time without the distraction of actual return movements.

- When actual returns frequently breach the conditional SD bands, it may suggest that the GARCH model is underestimating the potential for extreme returns, or 'fat tails', which are better captured by the Student's t-distribution due to its heavier tails compared to a normal distribution.
- The consistency in the level of volatility over time and the frequency of breaches can also inform whether the current model needs recalibration or if the market conditions have changed in a way that is not captured by the historical data used to fit the model.

These graphs are powerful tools for traders and risk managers to assess market risk and to make informed decisions based on the predicted volatility. The use of a Student's t-distribution suggests that the model accounts for the higher likelihood of extreme market movements than would be predicted by a normal distribution, which is more consistent with observed financial market returns.

Figure 38:



In the QQ plot, the bulk of the data points appear to closely follow the 45-degree line, suggesting that the Student's t-distribution is a good fit for the central part of the data distribution. This is an indication that the model captures the median behavior of the data well.

However, there are some deviations in the tails; particularly, the data points veer off the line in the extreme ends. This "fat tails" phenomenon is typical in financial returns, indicating a higher incidence of extreme values (either large positive or negative returns) than what would be expected in a normal distribution. The Student's t-distribution is known to accommodate this kind of behavior in the data better than the normal distribution due to its heavier tails.

The QQ plot suggests that the Student's t-distribution may provide a more realistic representation of the underlying risks than the normal distribution.

Figure 39.1:

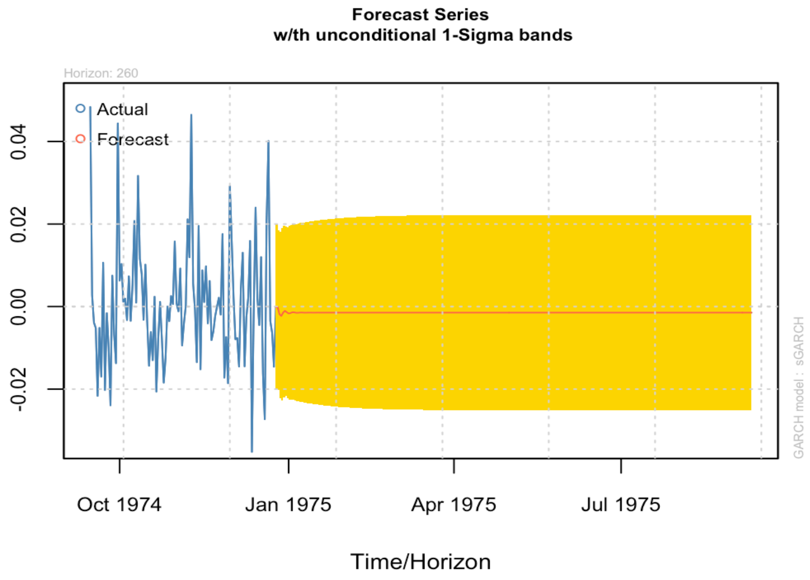
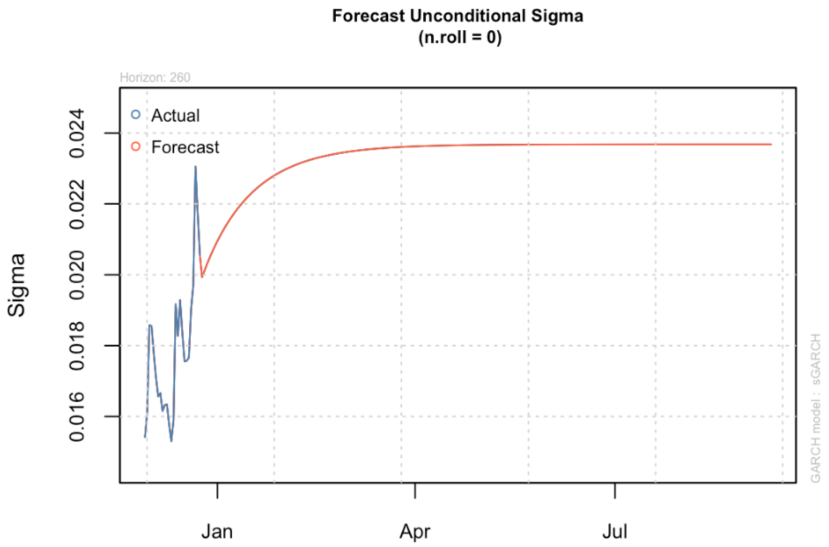


Figure 39.2:



Forecast Series with Unconditional 1-Sigma Bands:

- The first chart(Figure 39.1) shows the actual past returns and the forecasted future returns with the one standard deviation (1-sigma) bands.. It appears that the actual returns have been quite volatile, with some periods of high volatility exceeding the forecasted range.

Forecast Unconditional Sigma:

- The second chart (Figure 39.2) shows the actual past volatility and the forecasted future volatility (sigma). The forecast converges to a long-run average level, as indicated by the flattening of the red line. This suggests that the GARCH model expects the volatility to stabilize around this long-term average in the future.

In both charts, the use of Student's t-distribution is likely to provide a better fit for the financial time series data, as it accounts for the leptokurtosis (fat tails) commonly observed in financial markets. This means the model will be more sensitive to the occurrence of extreme events, which are more common in financial data than would be predicted by a normal distribution.

3.7 Implications and validation of the results

The implications of these divergent volatility paths are significant:

for BRENT Crude Oil the anticipated steadiness suggests a more predictable environment that could benefit long-term planning and investment decisions. It implies that market participants might face less short-term risk in crude oil markets compared to natural gas, allowing for more stable pricing in contracts and steadier cash flow projections.

According to the models, volatility is likely to increase in the coming year for the TTF highlighting the urgency for policymakers to enhance strategic energy reserves, diversify import sources, and develop infrastructure that can pivot between suppliers with agility. It also underpins the necessity for market participants to hedge against price volatility effectively.

Although gas consumption decreased from 2022 to 2023, according to Le Monde's data, in 2023 still 15 percent of the gas imported into the EU came from Russia (compared to 45 percent before the war), this dependence does not allow Europe to remain too optimistic about volatility with respect to Gas prices even if high storage levels balance it out to some extent.

If commodity volatility increases, specifically if there will be positive returns on the TTF, the euro would depreciate even more against exporting countries' currencies and inflation would remain above 2 percent until at least 2025.

Rising natural gas costs have been a major driver of recent issues in the electricity business, which is closely tied to the natural gas market. When natural gas prices climb dramatically, the production costs of gas-fired power plants rise as well, influencing market electricity prices. Furthermore, rising gas prices can drive gas-fired power plants with higher variable costs into service, deciding the system marginal cost of electricity; additionally, some power plants use natural gas as fuel to generate electricity. As a result, fluctuations in gas prices may have a direct impact on electricity generation and, ultimately, electricity pricing. The European economy relies heavily on electricity. Electricity is critical to the European Union's economy, and price increases have serious economic effects that must be avoided. Many European economists are currently working on a reform of the European energy and gas markets. A group of economists examines this issue in a paper for the "commission de la regulation de l'énergie," which is the body that regulates the French electricity and gas markets. The report discusses how electricity markets have been managed historically, using cost optimization theory and the ascending order of marginal production costs. However, this technique proved ineffective when natural gas prices skyrocketed, as they did in 2022, forcing energy rates to surge.

This sparked concerns about the potential negative macroeconomic effects.

These researchers underlined the need of long-term efficiency and fairness in the energy sector. The research also mentions that renewable energy providers with very low variable costs can benefit significantly when energy prices rise due to the costs of gas-fired power plants. To help consumers and companies, European authorities have taken steps to transfer a portion of renewable energy producers' earnings when prices rise above specified thresholds.

The report also questions whether the recent shocks in European energy markets caused by increased gas prices will be replicated in the future.

This is a complicated topic touched by numerous elements. According to these experts, the entrance of renewable energy into the market will result in increased volatility of energy prices, necessitating market structure modification.

The primary assumptions from which they start their study are:

• Profitable market participants can participate through bids, planning, and investment decisions. This implies that market rules and structures should allow market participants to maximize profits inside the system.

• Real-time markets require coordination by a system operator to manage complicated supply and demand offers. This emphasizes the significance of an effective system operator and a real-time pricing mechanism.

• The electrical grid is not uniform, resulting in large economic variations across locations. This has ramifications for grid management and energy prices in several areas.

As a result, the scholars came to the following findings about energy market reform.

1. To redistribute energy professionals' revenues, governments should use mechanisms outside of short-term wholesale markets, such as long-term contracts and taxation. Short-term markets should rank technologies and assets based on their economic efficiency and responsiveness to the electricity system

2. Prioritize short-term market design to ensure liquidity and integration. Changing the auction rules in wholesale energy markets is not a priority. Changing the auction rules in wholesale energy markets is not a priority. Instead, it is vital to promote good demand response, and energy storage appears to be the most efficient solution against market power. Furthermore, authorities should pursue supply expansion and anti-competitive activity, which may be more essential than market structure changes. Capacity markets must be implemented at the European level and should be accessible to all resources that contribute to system security. The criteria for designing and sizing

capacity requirements should be explained and aligned with explicit reliability standards, such as loss of load expectation and target reserve criteria.

3. Localized marginal prices can effectively address current and future wholesale power market difficulties, according to theoretical considerations. However, in Europe, important organizational and regulatory difficulties would need to be addressed in advance. The advantages of LMP would differ from one European country to another. In any case, it will be required to lead investment locations. Other solutions could include long-term localization pricing or localization components included in network charges paid by producers, which would necessitate further harmonization standards among Member States.

4. To mitigate the impact of recent energy price shocks on private agents, fiscal policy should balance support for various types of agents, particularly consumers and enterprises. Such a shock has various macroeconomic impacts through different channels (mostly demand-side effects through consumers, primarily supply-side effects through businesses), and businesses may be more badly impacted than most households are.

Local support measures must be coordinated at the European level in order to avoid market distortions that may impact businesses. It is also reasonable to raise suppliers' commitments to better safeguard consumers (industries and families) from short-term price hikes. Increased energy efficiency would significantly reduce the overall impact of a spike in energy prices.

Increased energy efficiency would significantly reduce the overall impact of a spike in energy prices. As a result, reforming the energy market structure is required to assist central banks in combating inflation and volatility, which is a political responsibility.

CONCLUSION

The period characterized by geopolitical tension and rising inflation persists, with the European Union's efforts towards establishing enduring peace still underway, thus prolonging market uncertainties. This thesis contributes to contemporary literature by framing the current milieu, beginning with an examination of inflation's genesis and central bank interventions leading up to the energy crisis. Despite core inflation typically excluding the volatile energy and food sectors, the sustained crisis in Ukraine necessitates their consideration due to persistent high energy costs, thereby preventing a reduction in core inflation. The disparate impact of inflation across European states is noted, being more pronounced in producer price indices of commodity-exporting nations versus consumer price indices of importers. This discourse unfolds along two principal vectors: the energy quandary and monetary policy.

Delving into the energy crisis, the pandemic emerges as a catalyst exacerbating demand-supply shocks, notably in crude oil markets, precipitating an inflationary spike. However, the critical juncture was Russia's incursion into Ukraine, the EU's principal energy source. The ensuing sanctions and retaliatory measures engendered a tense global atmosphere, with commodity prices soaring to remarkable heights. Invoking Milton Friedman's axiom, the thesis posits that inflation is intrinsically linked to monetary policy, evidenced by the European Central Bank's (ECB) expansive bond-buying response to the pandemic, the effects of which were palpable into 2022.

Transitioning to the second chapter, attention turns to raw materials, underscoring energy's pivotal role in Europe's economy and sectoral impacts. Amidst this, the unprecedented "Weaponization of finance" is introduced, situating commodities and foreign exchange at the sanctions' nexus, with significant Russian banking assets immobilized by the ECB. The repercussions of this are likened to a global seismic event.

In this chapter, the thesis tackles the critical question: "How does an energy shock impact exchange rates?" within the framework of European sanctions, the analysis reveals how such shocks affect the currencies of both energy-exporting and importing countries, with particular focus on the Russian Ruble. After the invasion, the Ruble experienced a significant drop, but managed to stage a partial recovery, despite a continued overall trend of depreciation and the implementation of strict monetary policies through 2023. The study highlights a general pattern where the currencies of energy-exporting nations tend to rise following an energy shock, while those of importing nations often fall, a trend clearly demonstrated by the relationship between the Euro and the Canadian dollar.

In the final chapter, the volatility of natural gas and crude oil is dissected, with a focus on the TTF and BRENT benchmarks. This selection is justified by Europe's heavy reliance on these commodities, particularly from Russia pre-conflict. The analysis, complicated by market asymmetries and manipulability, utilizes GARCH methodology to forecast heightened volatility, especially in natural gas markets.

The GARCH projections for the TTF index predict continued high volatility for natural gas, suggesting that the market may remain highly reactive to supply and geopolitical influences, leading to potential price swings. Such volatility necessitates vigilant risk management strategies and a reinforced emphasis on diversifying energy sources to ensure supply resilience.

Conversely, BRENT crude oil is forecasted to exhibit more stable volatility, maintaining levels around a median range. This relative stability, despite the global pressures that often sway crude oil markets, may stem from the diversification of global supply and established trading mechanisms that can absorb shocks more effectively than the natural gas market, which is often regionally constrained.

In conclusion, this volatility analysis not only enriches the understanding of the commodities market's current state but also provides valuable foresight for stakeholders planning for future energy policies and economic strategies in a globally uncertain landscape. The findings underscore the importance of tailored approaches to risk management in natural gas and crude oil markets, reflecting their distinct volatility profiles and the broader implications for the global economy.

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