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In search of Safe Havens for US and Scandinavian stock indices

Does volatility and negative real interest rates play a role in driving the market-asset relationship?

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Abstract

Using correlation and rolling correlation, we determine that Gold, Bitcoin, Silver, Brent crude oil, Gas, and Corn fail as Safe haven assets for the US, Norwegian, Danish, and Swedish stock markets during the Covid-19 pandemic and the Russia-Ukraine crisis. Instead, these assets act as weak/strong diversifiers for selective indices during the sample period 2014-2023. In the long-term perspective (2014-2023), we find that Sweden is the only country where there exists a strong hedge (Gold) and a weak hedge (Natural gas and Corn). Our findings represent a deviation from previous literature, where a large part of our chosen commodities have been observed to contain safe haven and hedging properties for a wide range of countries.

Investigating what causes these relationships indicates that stock and asset market returns are strongly interconnected. It also indicates that increased market volatility has a limited effect causing co-movements between Bitcoin and the Scandinavian markets and presenting a negative relationship between Brent crude oil against the US market and Silver against the Swedish market. Additionally, we find that the presence of negative real interest rates affects a selection of the relationships between the stock market and assets by either strengthening or weakening their safe haven properties.

The analysis is conducted using Microsoft Excel and R (version 4.2.1) (R Core Team, 2022) with the following packages “ggplot2”, “timetk”, “tseries”, “car”, “lmtest”, “zoo” and “PerformanceAnalytics”. (Dancho & Vaughan, 2022; Fox & Weisberg, 2019; Peterson & Carl, 2020; Trapletti & Hornik, 2022; Wickham, 2016; Zeileis & Grothendieck, 2005; Zeileis & Hothorn, 2002)

Key words: Safe haven, Hedge, Diversifier, Volatility, Interest rates, Covid-19, Russia-Ukraine war

Forord

Denne oppgaven markerer slutten på vår mastergrad i Økonomi og Administrasjon, med spesialisering innen økonomisk analyse og finans ved Handelshøgskolen UiT. Gjennom denne oppgaven har vi fått gleden av å utfordre både den teoretiske og praktiske kunnskapen vi har opparbeidet oss gjennom 5 år på studiet. Å utforske mulige trygge havner og sikringer for investorer på det Skandinaviske og Amerikanske aksjemarkedet har vært en spennende og krevende prosess med både opp og nedturer. Alt i alt har prosessen vært svært lærerik, og det har vært en fryd å se hva man kan få til med hardt arbeid og tålmodighet.

Vi ønsker å takke våre flotte medstudenter for uttalelige mengder kaffepauser, verdifulle innspill og kommentarer. Vi vil også takke vår veileder Thomas Leirvik som har bidratt med sin faglige kompetanse og Dejene Gizaw Kidane ved UiT for verdifull hjelp knyttet databehandling og bruk av regresjonsanalyse. Til slutt vil vi takke alle venner og familie som har støttet oss gjennom studieløpet.

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1. Introduction

In this thesis, we investigate the properties of commodities as safe-haven assets for the US and Scandinavian stock markets during the Russia-Ukraine crisis. Our analysis investigates the relationship using different correlation analyses between each market and asset. Additionally, we seek to explain what causes these relationships by using market returns, market volatility, nominal interest rates, inflation, and real interest rates as explanatory variables.

The financial market is notoriously affected by geopolitical events such as the Russia-Ukraine crisis, and investors worldwide are paying close attention to this conflict, as there are uncertainties surrounding the development of the war and its effect on the global economy (Hilmersen, 2022). More specifically, ample data suggests that geopolitical risk strongly affects the volatility of oil and stock indices, where increased geopolitical risk is correlated with negative returns on the equity market (Smales, 2021). In this thesis, we analyse the behaviour of several assets and indices over the last ten years, including two global crises of different natures (Covid-19 and the Russian war in Ukraine).

The recent Russia-Ukraine crisis intensified on 21 February 2022 when Russia mobilized its troops into Ukraine's Donetsk and Luhansk regions. This action was internationally acknowledged as the start of the war, resulting in numerous countries, such as the United States, the United Kingdom, and countries in the European Union, enforcing economic sanctions upon Russia (Ahmed et al., 2022, p. 1). The European Union is one of Russia's most important trading partners, with Russia supplying 41% of the natural gas and 47% of the solid fuel imported by the EU (Ahmed et al., 2022, p. 1).

Considering the scope of the Russian economy and its level of integration in the European economy through the trade of raw materials, food, gas, and oil, the sanctions against Russia would affect not only Russia, but the global economy as well (Ahmed et al., 2022, p. 1). Analysing the dynamic relationship between political uncertainty and financial market performance, Dimic et al. (2015) and Li and Born (2006) find that political stability is significant and inversely related to the risk and returns of financial assets. Political uncertainty and financial market performance seem to indicate that political instability has a

significant effect on the risk profile of financial assets and the returns of stock markets (Dimic et al., 2015; Li & Born, 2006).

"Additionally, there are studies that seek to capture the economic effect of geopolitical risk connected to the uncertainty arising from the possibility of terrorist acts, wars, and conflicts between nations (Caldara & Iacoviello, 2022)" (Ahmed et al., 2022, p. 2). The study points towards geopolitical risk having a strong impact on both financial markets and the policy of corporations through increased stock market volatility, reduced employment, and equity returns (Caldara & Iacoviello, 2022).

Volatility is one of the deciding factors an investor must consider when developing or choosing a portfolio. Even though different investors exhibit different risk tolerance levels, there is a common goal of achieving the highest return for the level of risk chosen. It is therefore in the interest of the investor to defend him/herself against the increased market risk that follows a geopolitical event, especially since financial literature indicates that the investor is more sensitive towards financial losses than gains (Benartzi & Thaler, 1995). One of the methods the investor can employ to protect against increased volatility and stock market losses is to seek out safe-haven assets. (Chen, 2021) describes safe haven assets as financial assets which hold onto or increase in value in times of market turmoil

The financial literature tends to separate traditional safe-haven assets, such as precious minerals (gold, silver, copper), and newer safe-haven assets, such as cryptocurrencies (Kliber, 2022; Shahzad et al., 2020). In particular, Gold has been considered a safe haven asset for equities for several decades. For example, see Baur et al. (2010) and the references within. Additionally, commodities such as gas, oil, and agricultural commodities have been used as safe haven assets (Rubbaniy et al., 2022). In this thesis, we consider both traditional and new assets in our investigation of whether they have safe haven properties. However, whether these assets actually exhibit the properties necessary for safe-haven assets is highly disputed in the literature, with numerous findings supporting the claim (Baur & McDermott, 2010; Bouri et al., 2017; Wu et al., 2019) and numerous findings disputing their ability (Drake, 2022; Smales, 2019). Today, the literature seems to indicate that the safe haven abilities of assets change over time, with different time horizons, market contexts, and geopolitical events warranting different results (Drake, 2022; Kliber, 2022). In this thesis, we analyse how the safe haven properties of a wide range of assets change over time.

This thesis aims to uncover numerous financial assets' safe haven, hedging, and diversifying abilities, against the US and Scandinavian stock indices during the Russia-Ukraine conflict and Covid-19 pandemic. Once obtained, the relationship between the assets and the stock indices will be investigated to uncover whether market returns, interest rates, and market volatility could be possible drivers for the safe haven abilities of the assets and the cause of their varying effectiveness. (Drake, 2022) suggests that market volatility and negative real interest rates should be controlled for, as these two variables are essential factors of the gold-stock relationship, see, for example, (Beckmann et al., 2015) and (Choudry et al., 2015).

In this thesis, we will build upon the findings of (Drake, 2022) by broadening the timeline to include the recent Russia-Ukraine crisis, expanding the analysis to Scandinavian stock markets, and including additional assets. Investigating this phenomenon is important because it can help investors succeed in the financial market by reducing losses and obtaining profits even during times of increased geopolitical risk and market turmoil. Additionally, an analysis focusing on the effects of market volatility and negative real rates could provide a newfound understanding of what causes the safe haven dynamic.

We have thus chosen the following as our main research question:

With the introduction of the Russia-Ukraine crisis, which financial assets exhibit Safe haven and hedging properties, and what are the possible drivers of these relationships?

In line with this, we must answer the following related questions:

RQ1: Which assets exhibit hedging and/or safe haven properties for US and European stock markets during the Russia-Ukraine crisis?

RQ2: To what extent do market returns, stock market volatility, and interest rates affect the relationship between stock indices and assets?

To answer RQ1, we compute the Pearson correlation coefficient between our proposed commodities and the chosen stock indices for which they are supposed to be a safe haven. This method is used during the Russia-Ukraine crisis and the Covid-19 pandemic to check for safe-haven assets for the two most recent periods of market turmoil. Furthermore, since we are mainly interested in the safe haven properties during the Russia-Ukraine crisis, an additional overlapping 30-day rolling window of the correlation coefficient between assets and indices is used during the Russia-Ukraine crisis to investigate how the correlation changes over time. Lastly, a Pearson correlation between the stock indices and assets for the

entirety of our data sample will determine the hedging properties of our assets. This type of method, where correlation-relationships are studied both during specific times of market turmoil and during longer “normal” periods, is consistent with previous literature surrounding safe haven and hedging properties (Baur & Lucey, 2010; Drake, 2022; Kliber, 2022).

Having established these capabilities, we will attempt to investigate them using the framework of (Drake, 2022) to answer RQ2. This is done by constructing a regression model where we try to explain asset returns using market returns, market volatility, and interest rates as explanatory variables (Drake, 2022). This will highlight what causes the relationships proposed in RQ1.

Moving forward with this chapter, we will briefly introduce the numerous financial markets and assets used in our analysis. Chapter 2 presents previous literature on diversifying, hedging, and safe haven topics and establishes important dynamics surrounding inflation and interest rates. Chapter 3 will present our dataset and provide a brief overview of how it was acquired and processed. Chapter 4 is dedicated to the methodology of our analysis, where we present different types of correlation and explain how to use them to determine whether the assets exhibit any safe haven, hedging, or diversifying abilities in line with RQ1. Furthermore, it is explained how we construct our regression models to answer RQ2 and the methods used to verify their integrity. Chapter 5 presents the results of our analysis; here, our results regarding our assets' safe haven, hedging, and diversifying abilities shall be presented, as well as the results showcasing whether market returns, market volatility, and interest rates help determine the correlation relationship. Chapter 6 is dedicated to discussing our findings and addressing the limitations of our study, and Chapter 7 concludes our study and summarises our findings.

1.1 Assets and Indices:

From the beginning of times, precious metals like gold and silver have been used as a medium of exchange and store of value. Its versatility and ability to act as a store of value over long periods have made investing in metals popular among investors. The popularity of these assets is still relevant to this day, as investors still choose to allocate a portion of their portfolios to these assets to achieve diversification, especially when tumultuous times are on the horizon.

Research suggests that investments in gold yield a CAPM beta that is approximately zero. This means that an investor adds virtually no systematic risk by allocating gold to their portfolio while simultaneously obtaining a higher return than Treasury bills (McCown & Zimmerman, 2006). Further research from (Baur & Lucey, 2010) seems to corroborate the ability of gold to act as a store of value. Furthermore, due to its lack of correlation with stocks and bonds, gold appears to act both as a temporary safe haven in extreme market crashes and as a hedge against stocks, inflation, and the degrading purchasing power of fiat currency.

The continuous fear of inflation and black swan events drives some investors to allocate silver in their portfolio as well in an attempt to diversify and hedge their risk, despite it being more volatile than gold (Balcilar et al., 2015). Moreover, (Balcilar et al., 2015) find that gold and silver are highly correlated with changes in the gold price, significantly affecting the price of silver.

1.2 Cryptocurrencies:

Cryptocurrencies are relatively new in the financial market. However, it has gathered much attention from professional and amateur investors recently, especially during the COVID-19 pandemic. In general, cryptocurrencies are peer-to-peer, decentralized, non-physical currencies that exist and can be transacted digitally without needing to rely on banks as counterparts in sending and receiving payments.

To secure the transactions, these digital assets are aided by cryptography to encrypt and verify transactions (Kaspersky, 2022). Being relatively new, with the first cryptocurrency Bitcoin being founded in 2009 (Kaspersky, 2022), the complexity and its potential are not yet fully appreciated (Liu & Tsyvinski, 2020), but at its core, its objective is to serve the same purpose as fiat currency and other traditional assets such as gold. As a result, Bitcoin is often visualized as the new gold in the finance world (Zigah, 2020). Its narrative is that it can act as a hedge against inflation and shock events just as well or better than traditional physical gold does.

However, evidence supporting this narrative is somewhat mixed with (Dyhrberg, 2016) finding that when looked in a short-term perspective, bitcoin can be used as a hedge against stocks and hedge against the USD. Meanwhile newer research, such as (Baur & Hoang, 2021) finds no correlation between the movement of gold and bitcoin whatsoever. As this

market is still developing, the cryptocurrency market is piping hot, with many currencies being created.

The cryptocurrency market is still under development, and with little to no governmental protections available, the market is prime ground for speculation and is highly volatile (Liu et al., 2022). An example of this is the large crypto crash in 2022, where bitcoin dropped under 16000 dollars after being valued at its peak of 68000 dollars the previous year. This was mainly caused by the rise of inflation and a cost of living crisis combined with the collapse of popular crypto exchanges like FTX and a larger regulatory scrutiny (Smith, 2023).

This makes the consideration of Bitcoin and other cryptocurrencies as safe-haven assets challenging. For example, bitcoin might exhibit the properties of a weak safe haven, meaning a negative correlation in periods of market turmoil. However, it could be considered counterintuitive to assess such an asset as a safe haven when it exhibits such extreme levels of volatility. (Baur, 2018; Kristoufek, 2023)

1.3 Stock index:

A stock market index is a statistical measure that represents the performance of a specific group of stocks or the overall market. It provides a snapshot of the price movements and changes in the value of a selected set of stocks, which are typically representative of a particular market or sector. Stock market indices are typically calculated using a weighted average of the constituent stocks' prices or market capitalizations. The weights assigned to each stock depend on various factors, such as its market value, liquidity, and other predetermined criteria. The most common is capitalization weighted, meaning that each firm in the index is weighted by its relative market capitalization to the entire capitalization of all firms in the index. Stock indices can be focused on a specific subset of the market, like technology (NDXT), medium-sized firms (S&P Midcap), large firms (S&P500), and other types, see, for example, (Caplinger, 2022). For the purpose of our investigation, we will use the S&P500 stock index. The Standard & Poor's 500 Index is a widely followed index representing the performance of 500 large-cap companies listed on U.S. stock exchanges. It covers a broad range of industries and is often used as a benchmark for the overall U.S. stock market, and is regarded as the best gauge of the US large capitalization stock market(Kenton, 2023)

In addition, we consider three main stock indices for the Nordic countries; Norway's OBX Total Return Index, comprised of the 25 most liquid companies in Norway, Sweden's OMXS30, comprised of the 30 most liquid companies in Sweden; and Denmark's OMXC20 comprised of the 20 most liquid companies in Denmark. It is worth noting that approximately 35% of the OBX Total Return Index comprises companies operating in the oil and gas sectors (Teigen, 2022, 16.March). Therefore, movements in these sectors are highly likely to influence the price of OBX.

1.4 Oil:

Over the last few decades, oil has emerged as a significant financial asset, becoming one of the most important commodities in the world. This importance is due to energy's vital role in any functioning economy. It comes, therefore, as no surprise that fluctuations in the price of oil have a negative influence on global growth and financial markets (Gogolin et al., 2018), being able to bring recessionary and inflationary periods for the broader economy (Gogolin et al., 2018; Zhao et al., 2016), especially for countries that have oil as their main export (Moshiri, 2015).

On the side of commodities, such as natural gas, metals, and agriculture, research seems to suggest a pass-through effect from oil to commodities (Baffes, 2007), indicating that the prices of the commodities show a strong response to the price of oil when it is high for a more extended period.

Oil trading as a commodity occurs across four major benchmarks internationally. These benchmarks are West Texas Intermediate (WTI), a light, sweet crude oil that serves as reference for the USA. The Dubai Crude Oil, a medium sour crude oil that serves as a reference for the Middle and Far East. Tapis crude, a light and sweet crude that serves as reference for the Asia-Pacific region, and Brent crude, which serves as a reference for the North Sea and which will be used in our analysis.

1.5 Natural Gas:

While the world is experiencing a shift in energy sources, with renewable energy steadily growing its share of the world's energy mix, replacing fossil energy sources such as oil and coal, some fossil sources will remain more relevant than others. Natural gas, due to having a smaller carbon footprint than its other fossil counterparts, is expected to not only retain its

position as a source of energy but even increase it in areas outside the OECD (CASSCO, 2017), as making the switch from coal to natural gas in these areas is seen as a cost-effective way of improving air quality and reducing greenhouse emissions (Zeynalova, 2023).

While natural gas accounts for 23% of the total global energy mix, the *Gas Exporting Countries Forum* (GECF) expects this mix to rise to 26% by 2050. As a result, demand and supply are expected to increase by 22% and 36% by the year 2050 (GECF, 2022).

Such events pointing toward a future demand increase for the commodity could have a beneficial effect on the commodity's price today and in the future. On the surface, this could point towards Natural gas holding or increasing its value, making it a possible hedging and/or safe haven asset.

In 2021 Russia was responsible for 40% of the total natural gas delivered to Europe. However, these deliveries were strongly impacted by the start of the Russia-Ukraine conflict. As a result, Russia saw its natural gas exports to Europe fall below 10% by the end of 2022 (IEA, 2023). Although no legally binding ban on Russian natural gas exports is in place (GECF, 2022), complications in logistics, disruption in supply chains, scorching hot summers, and colder winters put Europe, and to a lesser extent, the USA in an energy crisis, with natural gas prices skyrocketing reaching a record price of US$ 321/MWh on *The Dutch Title Transfer Facility* (TTF) (ICE, 2023).

1.6 Corn:

For most people, the first thing that springs to mind when asked about corn is food. Corn is, however, much more than that, with human consumption taking a back seat in a larger spectrum.

Corn is a vital ingredient in several key industries, functioning as a critical component for the production of several different consumables, such as ethanol, biofuels, livestock feed, and environmentally friendly corn-based plastic (Magdaraog, 2022). Such versatility makes corn a very sought-after and investible asset.

Called the breadbasket of Europe, Ukraine is the fourth largest exporter of corn in the world, accounting for 12% of total global export (Feingold, 2022). However, with the start of the Russia-Ukraine conflict, farmers could not ship crops, agricultural infrastructure was

destroyed, and Ukraine saw its wheat and corn exports drop by 20% from projections before the conflict (Janzen & Zulauf, 2023).

The immediate impact of the conflict caused the prices of agricultural commodities to skyrocket to prices not seen before, with the price for old-crop delivery reaching a price of USD$ 1,32 per bushel, representing an increase of 19%. (Janzen & Zulauf, 2023). The volatility in the market has, however, faded over time in part due to UNs Black Sea Grain Initiative (UN, 2022), giving an appearance of balance in the supply chain (Janzen & Zulauf, 2023).

While analyzing the safe haven abilities of soft commodities during Covid-19, (Rubbaniy et al., 2022) finds that corn manifested safe haven abilities for long-term investors in the futures market, while the opposite was observed for short-term investors in the spot market.

2. Theory

2.1 Diversifier, Safe Haven, and Hedge:

In this paper, we use a variety of terms to categorize correlation relationships. Hence we will differentiate between a safe haven, a hedge, and a diversifier when we describe the risk-reducing abilities of our chosen assets. These terms were initially coined by (Baur & Lucey, 2010), and represent the base of most safe haven-themed literature. (Baur & Lucey, 2010, p. 219) propose the following definitions:

A hedge is defined as an asset that is uncorrelated or negatively correlated with another asset or portfolio on average

A diversifier is defined as an asset that is positively (but not perfectly correlated) with another asset or portfolio on average.

A safe haven is defined as an asset that is uncorrelated or negatively correlated with another asset or portfolio in times of market stress or turmoil.

These definitions have been expanded upon to grant them a higher precision grade by differentiating between weak and strong forms (Baur & McDermott, 2010, p. 1889).

A strong (weak) hedge is defined as an asset that is negatively correlated (uncorrelated) with another asset or portfolio average.

A strong (weak) safe haven is defined as an asset that is negatively correlated (uncorrelated) with another asset or portfolio in certain periods only, e.g., in times of falling markets.

The main difference between a hedge, diversifier, and a safe haven is that the hedge and diversifier hold on average. In contrast, a safe haven only needs to hold during times of market turmoil (Baur & Lucey, 2010). This is an important distinction; we expect the hedge and diversifier to hold in the long term, while there are no expectations for their behaviour during market turmoil, while the opposite is true for the safe haven asset, which is strictly expected to perform during market turmoil.

2.2 Safe Haven and Hedging Findings:

The earliest literature surrounding safe havens and hedging properties focused on precious minerals as a store of value (Baur & Lucey, 2010; Baur & McDermott, 2010). Since the inception of the financial market, investors have shared anecdotal evidence of gold as a store of value, perhaps because gold was among the first forms of currency and due to its scarce nature when compared to fiat currency (Baur & Lucey, 2010, p. 218). Establishing the safe haven, hedging, and diversifier terms (Baur & Lucey, 2010) were the first to investigate the correlation relationship between gold and stocks in this manner theoretically and found that gold could work as a long-term hedge and a safe haven during market turmoil.

Their findings also suggest that investors tend to buy gold during times of recession but quickly sell it once the market volatility decreases and investors regain confidence in the stock market (Baur & Lucey, 2010, p. 228). The results of their theory and empirical findings helped strengthen the legitimacy of the financial anecdote of gold as a hedge and safe haven. This idea was then furthered by (Baur & McDermott, 2010) where gold was found to be a safe haven for the global financial market during the 2008 financial crisis.

Once the theoretic framework for determining hedging, diversifier, and safe haven abilities was constructed, it opened the gate for the investigation of many other assets and markets. (Lucey & Li, 2015) expanded upon the findings of (Baur & Lucey, 2010) by including additional precious minerals such as silver, platinum, and palladium when exploring the correlation related to the US stock- and bond market during different recessionary periods from 1989 to 2013.

(Lucey & Li, 2015) found gold to have the highest utility as a safe haven against US equity, seeing as it protected against multiple different recessionary periods throughout the 1990s while also being an efficient safe haven during the global financial crisis of 2009 and after the European sovereign debt crisis late in 2010. On the other hand, Silver only worked as a safe haven during the crisis of 2009 and 2010, while platinum provided protection against US stock falls of 2000 and 2001 caused by the Afghan war and the 9/11 attack (Lucey & Li, 2015, p. 39).

(Lucey & Li, 2015) therefore concluded that a variety of precious minerals could be used as safe haven assets and that their performance may differ depending on the geopolitical event. Whereas gold outperformed all the other assets during the 1990s, platinum outperformed gold during the stock falls of 2000 and 2001, proving that diversification through different precious minerals could be helpful to the investor trying to reduce risk. (Lucey & Li, 2015)

(Li & Lucey, 2017) later reassessed the safe haven capabilities of precious minerals by including additional countries in the analysis (UK, Germany, Italy, Switzerland, Canada, France, Japan, China, India, and South Africa). Here it was found that precious metals provided protection at different times across countries and that no precious metals could consistently provide the safe haven effect over time or across different markets (Li & Lucey, 2017, p. 5).

To explain these results (Li & Lucey, 2017) attempt to characterize the periods in which safe haven assets work to see which political, economic, and financial conditions must be in place to give the precious minerals their diversifying ability. It is concluded that political risk drives safe haven abilities for the precious minerals. However, the effect of stock volatility, exchange rates, interest rates, and credit spreads are mixed depending on the market/asset and lack any identifiable pattern (Li & Lucey, 2017, p. 14).

As time has passed, investors seek new assets as a store of value and do not simply limit themselves to precious minerals. Cryptocurrencies, specifically bitcoin, which has been described as the "digital gold," has been the subject of numerous safe haven and hedging-themed analyses. (Feng et al., 2018) used a tail-based method to evaluate the diversifying and safe haven abilities of seven selected cryptocurrencies in numerous different intervals from 8th August 2015 to 1st of August 2017.

(Feng et al., 2018) Finds that Bitcoin is "left tail independent" with four major stock indices (USA, Europe, Japan, China) and two commodity indices (Gold and Crude oil). This implies

that the correlation between Bitcoin and the chosen indices is low in times of market turmoil, making Bitcoin a good diversifier for both stock- and commodity markets.

(Boadu et al., 2021) finds that Bitcoin exhibits diversifying, hedging, and safe haven abilities for long-term investors in Ghana, Egypt, Kenya, Nigeria, and Tunisia. The same abilities can also be seen in the Ghanaian stock market from a short-term perspective.

(Choi & Shin, 2022) tested whether bitcoin could act as an inflation hedge and a safe haven for the US stock market by comparing its price dynamics to gold from July 21, 2010, to December 31, 2020. Here it is found that Bitcoin appreciates against expected inflation and inflation shocks, confirming the inflation-hedging property (Choi & Shin, 2022, p. 1). However, it is also concluded that, unlike gold, Bitcoin depreciates in value following financial uncertainty shocks, making Bitcoin an insufficient safe haven.

(Bouri et al., 2017) vouches against Bitcoin as both a hedging and safe haven tool for the US stock market, concluding that Bitcoin is a poor hedge and can only work as a diversifier from 18th July 2011 to 22nd December 2015. (Bouri et al., 2017) goes on to say that Bitcoin is a strong hedge against Japanese and Asia-specific stocks, once again showing that safe haven abilities are inconsistent across countries and markets.

Most interestingly (Bouri et al., 2017) conclude that the volatility of Bitcoin could be a problem in determining its effectiveness as a diversifier, hedge, or safe haven. Bitcoin prices are notoriously volatile, meaning that the diversification ability of Bitcoin might very well be inconsistent over time and highly dependent on the sample data chosen.

Some investors turn to energy commodities such as Brent crude oil and natural gas as a store of value, with (Majumder, 2022) finding that Brent crude oil and natural gas act as a safe haven for the Indian stock market during Covid-19. Contrarily (Ciner et al., 2013) found that the oil market does not act as a safe haven asset towards the stock market in general but exhibits safe haven properties during specific periods such as the 2007 global financial crisis.

Seeing as energy commodities are a significant input factor in the production of goods, (Rodriguez & Sanchez, 2005) finds that an increase in oil price could decrease expected cash flows and thereby reduce the stock market returns. This phenomenon is further investigated by (Miller & Ratti, 2009), who concludes that there is a negative relationship between stock market returns and brent-crude oil returns for a selection of OECD countries. Contrarily, this

relationship appears to be positive for the stock markets of net exporting oil countries (Arouri et al., 2011)

There are limited studies on how agricultural commodities could hedge or act as safe havens for portfolios or stock indices. However, recent studies have been conducted to see whether agricultural commodities could act as a safe haven during the Covid-19 pandemic for the US and European stock markets.

(Siemaszkiewicz, 2021) Compared the safe haven attributes of agricultural commodities during the global financial crisis of 2008 and the Covid-19 recession for US- and European-stock markets. She found that corn futures were a sufficient safe haven for Spain, Germany, and Poland during the Covid-19 pandemic. However, during the global financial crisis of 2008, corn could only act as a safe haven for the Polish market, once again showing that the safe haven abilities of assets change over time and across countries.

(Siemaszkiewicz, 2021) Proposes a valuable lesson for investors looking for safe haven instruments. All market turmoil is not created equal, meaning that the market turmoil caused by the Covid-19 pandemic and the global financial crisis of 2008 will differ in their fundamental characteristics, resulting in inconsistent safe haven abilities of assets.

An alternative approach to determining the safe haven abilities of agricultural commodities comes in the way of (Rubbaniy et al., 2022). Instead of focusing on the diversification ability of the agricultural commodities towards a specific stock market or portfolio (Rubbaniy et al., 2022) attempts to explore the co-movement of a global COVID-19 fear index with both futures- and spot-prices of agricultural commodities. This is done to track the development of the safe haven abilities during different levels of fear and turmoil caused by the pandemic. The total dataset spans from January 28th, 2020, to April 29th, 2021.

Interestingly (Rubbaniy et al., 2022) finds that the safe haven abilities of agricultural commodities vary across the spot- and futures market as well as across short- and long-term investment horizons. For example, commodities such as wheat, cotton, and sugar are successful in their role as safe-haven assets for long-term investors across both the spot- and futures markets; however, both fail the short-term investor (Rubbaniy et al., 2022, p. 12). Contrarily, cocoa works as a safe haven asset for short-term investors both in the spot- and futures market but fails the long-term investor (Rubbaniy et al., 2022, p. 12).

The safe haven ability of corn is different when comparing its spot- and futures market, where the futures market for corn works as a safe haven for long-term investors, while the spot market fails as a safe haven. (Rubbaniy et al., 2022) proposes the following explanation, corn spot prices are susceptible to demand shocks, and as Covid-19 hit and demand faltered, the spot price of corn fell. However, as Covid-19 began and fear surrounding the pandemic increased, so did the demand for corn futures from equity investors hoping to realize later returns on their investment. This pushed the future prices of corn upwards, making it a safe haven for long-term investors during the Covid-19 pandemic (Rubbaniy et al., 2022, p. 6).

As evident from the findings above, investors seeking safe haven instruments struggle to find financial assets that act consistently across markets and across different geopolitical events. To understand what causes the safe haven dynamics, the next section will dive into the macroeconomic effects of inflation and real rates and the effects of increased market volatility on investor behavior. Additionally, the difference between the spot- and the futures market will be discussed to establish whether choosing each market could have different implications for investors looking for safe-haven assets.

2.3 The Spot and Futures Market:

Commodities such as precious minerals, agricultural commodities, oil, and gas can be bought at their spot- or futures-price (Nickolas, 2022). The spot price represents the commodity's cost if it is immediately purchased and delivered, while the futures-price locks in the cost of the commodity that will be delivered sometime in the future (Nickolas, 2022).

The futures market's primary function is to cause price stability for producers and customers by locking the commodity's price in advance. The purchaser of the futures contract hopes that the market value of their purchased commodity will increase before delivery, or just simply want the commodity delivered in the future when they need it without having to store it themselves (Nickolas, 2022). Hence futures are appealing to investors trying to diversify or hedge their portfolios against events in the future. The seller wants to ensure itself against price drops in the future as well as “locking in” the costs of production.

Newer evidence points towards the futures market as the best representative of price development in the commodity market. This is because changes in the price of the commodity appear first in the futures market, as informed investors prefer trading in this market which is characterized by lower prices and a high-leverage effect. Afterward, the

information transmitted in the futures market makes its way over to the spot market through arbitrageurs' activity (Ameur et al., 2022).

The use of commodity futures as hedging and safe haven instruments is common in safe haven literature, with (Lucey & Li, 2015; Rubbaniy et al., 2022; Siemaszkiewicz, 2021) all using the futures market as a part of their safe haven analysis.

2.4 The effects of Inflation and negative real rates:

Macroeconomic factors such as nominal interest rates, inflation and real interest rates have the potential to affect the behavior of the investor. A rise in inflation reduces the purchasing power of the consumer, meaning that one unit of money buys fewer goods and services, which then affects the population's cost of living, ultimately leading to a reduction in economic growth (Fernando, 2023). Periods of persistent and high inflation make it harder for companies across almost every industry to generate value, meaning lower returns for investors and a reduction of reliable investment opportunities (Goedhart & Kotsev, 2023).

The most crucial tool to stabilize the economy and encourage growth is that of the nominal interest rate determined by the central bank. In general, during times of market turmoil and recession, the nominal interest rate can be set at an artificially low level to stimulate economic activity through lower interest rates, which encourages investors to spend money and take out loans (Kenton, 2021).

However, lowering interest rates in periods of high inflation is not usually done, as it would further diminish the rate of return for the investor. Hence, instead of exclusively paying attention to the nominal interest rate, the investor pays close attention to the difference between the nominal rate and inflation, also known as the real interest rate (Nickolas, 2023). The real interest rates represent the actual cost of funds to the borrower and the real yield obtained by the lender or the investor. From the investor's point of view, the level of the nominal interest rate by itself is insufficient information, as the level of inflation could erode the investor from any expected returns.

Negative real rates occur when the inflation rate is higher than the nominal interest rate making it harder to realize returns. One potential consequence is that investors shift their investments away from traditional fixed-income securities such as bonds and rather place

them towards assets that are perceived as inflation-resistant, such as commodities, real estate, or stocks in companies that can pass higher costs onto the consumer (Smith, 2022).

This coincides with the findings of (Drake, 2022), who concluded that the correlation between gold- and stock returns increased during times of negative real rates, as investors chose to allocate their funds to both the stock and gold markets.

3. Data

This section will present the analysis's dataset and some key descriptive statistics.

The dataset is comprised of the daily prices of four major stock indices and six different assets spanning the period from the 18th of September 2014 through the 4th of February 2023. The four indices used in the analysis are the American S&P500, the Norwegian OBX, the Danish OMXC20, and the Swedish OMXS30. For the assets, we employ the futures GC=F (gold), SI=F (silver), BZ=F (Brent crude oil), NG=F (Natural gas), ZC=F (corn), and the closing spot price BTC-USD for (Bitcoin). Throughout the thesis, we will refer to all these commodities under the common name assets. For each daily price of the stock indices, we match the corresponding daily price of the assets and eliminate the days where values are missing. In total we are left with 10 time series, with 2120 observations each.

Gold and Silver are part of the analysis as these two assets have long been perceived as a safe haven against stock indices. Bitcoin is part of the analysis because been proposed as a safe haven in recent scientific literature. Brent, natural gas, and corn are also analysed because of the vital role they play as commodities, see (Bouri et al., 2019; Bouri et al., 2020; Robiyanto et al., 2017)

The prices for the indices and the assets are retrieved from yahoo finance. In addition, to obtain a dataset with homogeneous currency, we also retrieve from yahoo finance the daily currency conversion for NOK, SEK, and DKK to USD to convert the prices of the OBX, OMXS30, and OMXC20 indices from local currency into USD, respectively.

The dataset is subsequently transformed from daily prices into daily returns for each index and asset by taking the difference in price from today and yesterday and dividing it by the price of yesterday.

$$r_t = \frac{P_t - P_{t-1}}{P_{t-1}} \quad (1)$$

As bitcoin is the only asset traded daily, having seven trading days in a week as opposed to 5 for stocks, we remove the weekend trading from the dataset to achieve a uniform length for all the time series.

Drake (2021) applies the 30-year US Treasury Inflation-Indexed Bond as a proxy for the real interest rate in the US economy. However, bonds with similar properties to the 30-year US Treasury Inflation-Indexed Bond are challenging to find for European markets, and another method of obtaining real interest rates is needed. We, therefore, retrieve policy rates from each individual central bank (Norges Bank, Sveriges Riksbank, Danmarks Nationalbank, and Federal Reserve) before adjusting for inflation by using the CPI for each individual country retrieved from OECD.

"*Inflation measured by consumer price index (CPI) is defined as the change in the prices of a basket of goods and services that are typically purchased by specific groups of households. Inflation is measured in terms of the annual growth rate and in index, 2015 base year with a breakdown for food, energy, and total excluding food and energy"(OECD, 2023)*

The employment of this method not only allows for a uniform procedure of finding the real interest rates and therefore allows for a comparison between each country, but it also allows for a more trustworthy analysis as it uses the real interest rates of each country instead of a proxy.

The data for both the policy rate and inflation retrieved from the central banks and OECD are given in year-on-year. We therefore adjust this data into monthly using the following formula:

$$r_m = \sqrt[12]{(1 + r_y)} - 1 \tag{2}$$

where:

$r_m = monthly\ rate$

$r_y = yearly\ rate$

And obtain thereafter the real rates of interest using Fishers Equation:

$$(1 + i) = (1 + r_{real}) \cdot (1 + \pi) \tag{3}$$

$$r_{real} = \frac{i - \pi}{1 + \pi} \tag{4}$$

Where:

$i = nominal\ interest\ rate$

$r_{real} = real\ rate\ of\ interest$

$\pi = rate\ of\ inflation$

3.1 Descriptive statistics:

Table 1: Descriptive Statistics on daily returns for the indices and assets in the analysis.

	Min	Max	Mean	Std.	Skewness	Kurtosis	IQR	Dickey-Fuller
SP500	-0.12	0.094	0	0.012	-0.541	14.007	0.01	-12.913
OBX	-0.109	0.079	0	0.015	-0.439	4.775	0.016	-13.125
OMXC20	-0.08	0.057	0	0.013	-0.262	2.151	0.015	-13.852
OMXS30	-0.12	0.087	0	0.014	-0.49	6.794	0.015	-14.031
Gold	-0.05	0.059	0	0.009	0.087	4.459	0.009	-12.568
Bitcoin	-0.372	0.252	0.003	0.045	-0.07	6.158	0.037	-11.627
Silver	-0.116	0.093	0	0.018	-0.314	5.883	0.016	-12.337
Brent	-0.244	0.315	0	0.027	0.164	16.917	0.024	-12.741
Nat. Gas	-0.26	0.465	0	0.038	0.818	13.507	0.038	-12.712
Corn	-0.174	0.08	0	0.016	-0.808	9.874	0.017	-12.164

Table 1 provides the descriptive statistics for the daily returns of the indices and the assets used to perform the analysis. Here we can see the minimums, maximums, averages and standard deviation, Skewness, Kurtosis, Interquartile range (IQR), and Dickey-Fuller.

The standard deviation suggests that the indices are less volatile than the assets, as these return a lower standard deviation. Perhaps not surprisingly, we see that the assets with a larger standard deviation, and therefore more volatile, are Bitcoin, Brent, and Natural gas. Silver and corn appear to be just as volatile as the indices in the analysis, while gold is the least volatile asset in the analysis.

The skewness results suggest that the data in our analysis is moderately symmetrical, with most of the assets and indices returning values ranging between -0.5 and 0.5. The only two assets that differ and present significant levels of skewness are Corn and Natural Gas, with a skewness of -0.808 and 0.818, respectively, indicating that Corn is negatively skewed while Natural gas is positively skewed. Positively skewed distributions are characterized by more outliers or extreme values in the right tail, that is, the positive side, presenting a fatter right tail. Conversely, negatively skewed distributions are characterized by many outliers in the left tail or negative side.

Kurtosis is the degree to which a distribution is more or less peaked than a normal distribution. A distribution is said to be leptokurtic if it is more peaked than the normal

distribution, and platykurtic if it is less peaked. It is evident from Table 1 that all assets and indices in the analysis are leptokurtic.

Table 1 indicates that all assets and indices return an excess kurtosis above 0, meaning that all assets and indices are leptokurtic. This suggests that both assets and indices have a peaked center and fatter tails than a normal distribution. When combining kurtosis and skewness, SP500 appears as a riskier index. It has a negative skew and high excess kurtosis, which translates into a fatter left tale in the distribution, indicating a higher probability of extremely adverse outcomes occurring.

Interquartile range (IQR) measures the variability in the dataset between the first and third quartiles. This gives us an idea of how spread the middle of the data is without being affected by the extreme values. Here we see that Natural gas, Brent, and Bitcoin present the largest IQR, which speaks to the spread of the assets. This once again indicates that these assets are the most volatile in our dataset.

Lastly, the Dickey-Fuller allows us to determine whether the data we analyze is stationary or non-stationary. The test returns a statistic between -11 and -14 for all the time series, indicating strong evidence against the null hypothesis and favoring the alternative: the absence of unit root in our data. This implies that the time series in our dataset are likely stationary and do not have a trend or systematic pattern.

3.2 Policy rates, Inflation, and Real rates:

As seen in Figure 1, the European nations have held their policy rates lower than that of the US during most of our sample period. This is especially evident when observing the policy rates of Sweden and Denmark, where the Swedish central bank employed a negative policy rate from 2015-2020, while Denmark employed a negative policy rate from 2021 to medio 2022.

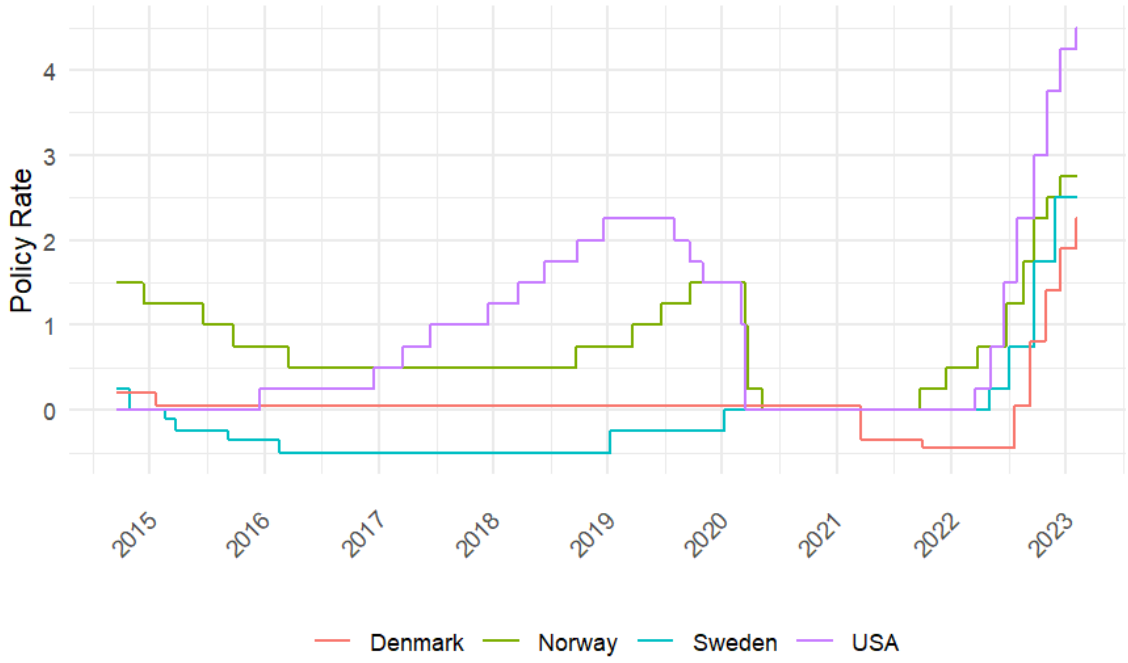

Figure 1: Policy Rates

Figure 2 shows the year-on-year development of inflation for each country over time. Here we see that both Denmark and Sweden have inflation lower than 2% for most of the period in analysis, which could explain the need to take their policy rates into negative territory to try to keep their inflation at the ECB target of 2% (European Central Bank, 2023).

From Figure 2, we see that year-on-year inflation started to rise uncontrollably around the start of 2021, which in turn forced central banks to raise their policy rates to try to rein in inflation, as seen in Figure 1 above.

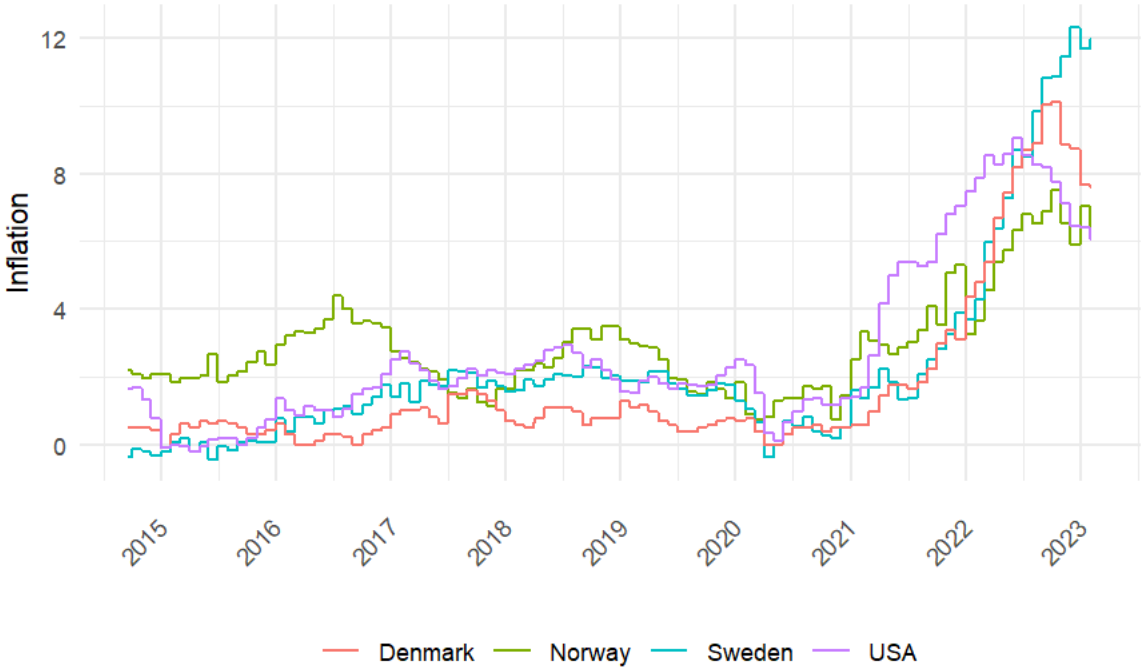

Figure 2: Year-on-year inflation

Figure 3 presents the year-on-year development of the real interest rates in the four countries of our sample, that is, the difference between policy rates and inflation.

Real rates are negative during most of the sample period in our analysis, with a substantial decrease in real rates taking place from the beginning of 2020 to the end of 2022. The start of 2023 shows an upward trajectory in all real interest rates as policy rates increase in an effort to stagnate inflation. The rampant rise of inflation in 2021, with perhaps a slow reaction from the central banks in raising policy rates, originated increasingly negative real interest rates.

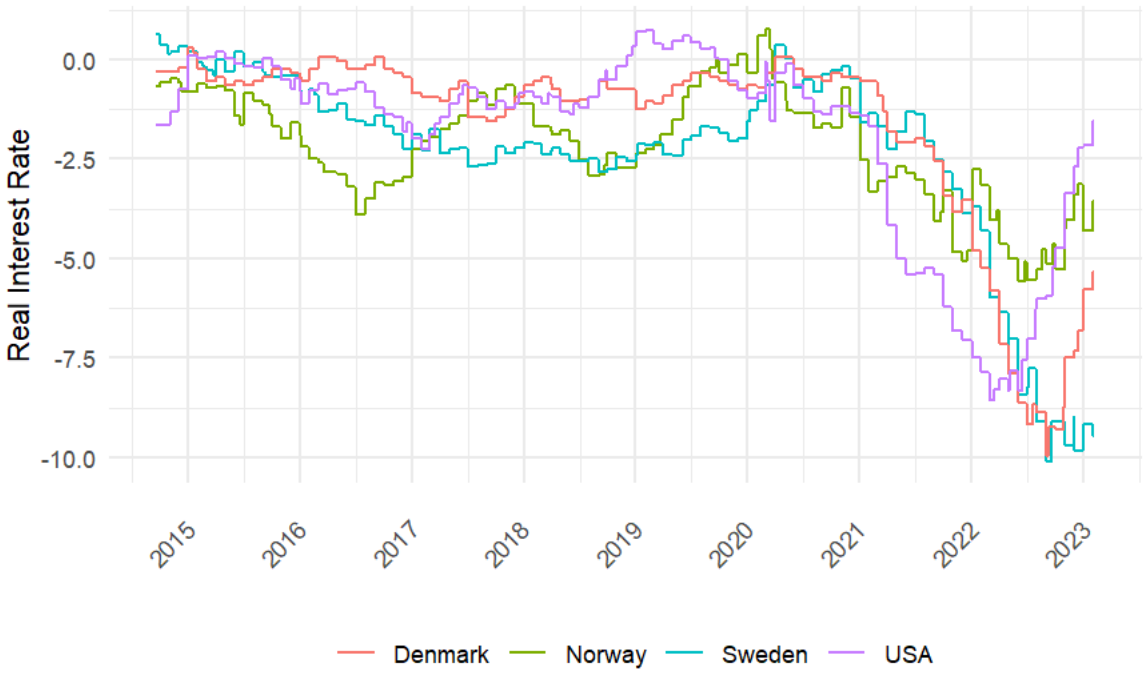

Figure 3: Year-on-year real interest rates

Figures 1,2 and 3 are presented year-on-year purely for illustrative purposes. For our analysis, both policy rates and inflation have been monthly adjusted.

Table 2 shows the number of days with positive and negative real interest rates for each of the markets.

Table 2: Partition of the dataset in days with negative and positive real interest rates

	SP500	*OBX*	*OMXC20*	*OMXS30*
Days with positive real interest rates	326	60	122	152
Days with negative real interest rates	1794	2060	1998	1968
Total number of days	2120	2120	2120	2120

3.3 Index and asset pricing:

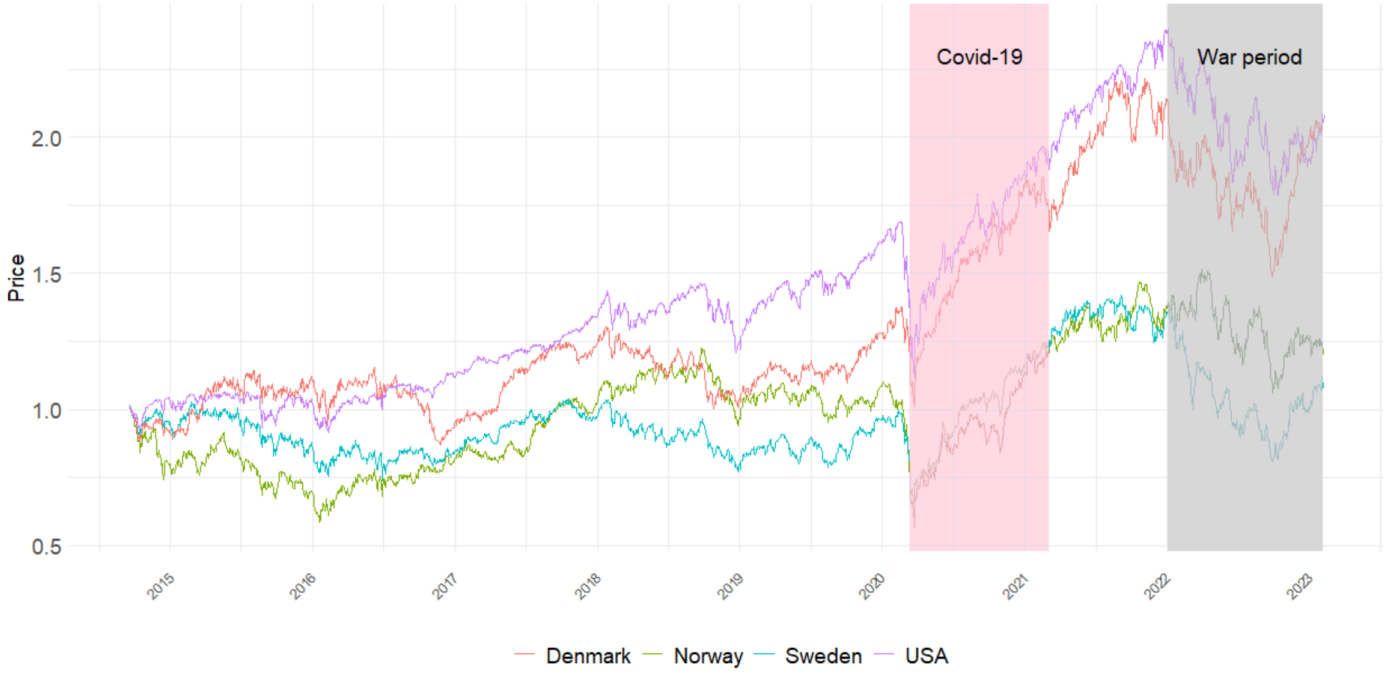

Figure 4: Price development of indices with Covid-19 (pink) and War (grey) periods highlighted.

Figure 4 shows the price development of the indices and assets present in the analysis using the value of $1 invested on September 18, 2014.

The graph shows that all indices were in an uptrend from 2015 to the beginning of 2020 when the global pandemic hit, causing a crash in the economy. After the initial crash, there is a recovery phase, with all indices returning to their pre-crash price before 2021. The following period was marked by steady growth all up until the early stages of 2022 when the Russia-Ukraine crisis escalated, causing geopolitical distress, the introduction of sanctions, and an increase in the price of commodities such as gas, wheat, and corn.

Figure 4 shows that the Russia-Ukraine crisis seems to have little effect on OBX, causing minor fluctuations, while the effects on the other indices are more substantial. This could be explained by the increase in the price of Brent Crude oil following the start of the war and subsequent sanctions between Russia and Europe, as it can be seen in Figure 5. Norway, a net oil exporter, reaps the benefits of sanctions against Russia and the following price increase of Brent Crude oil.

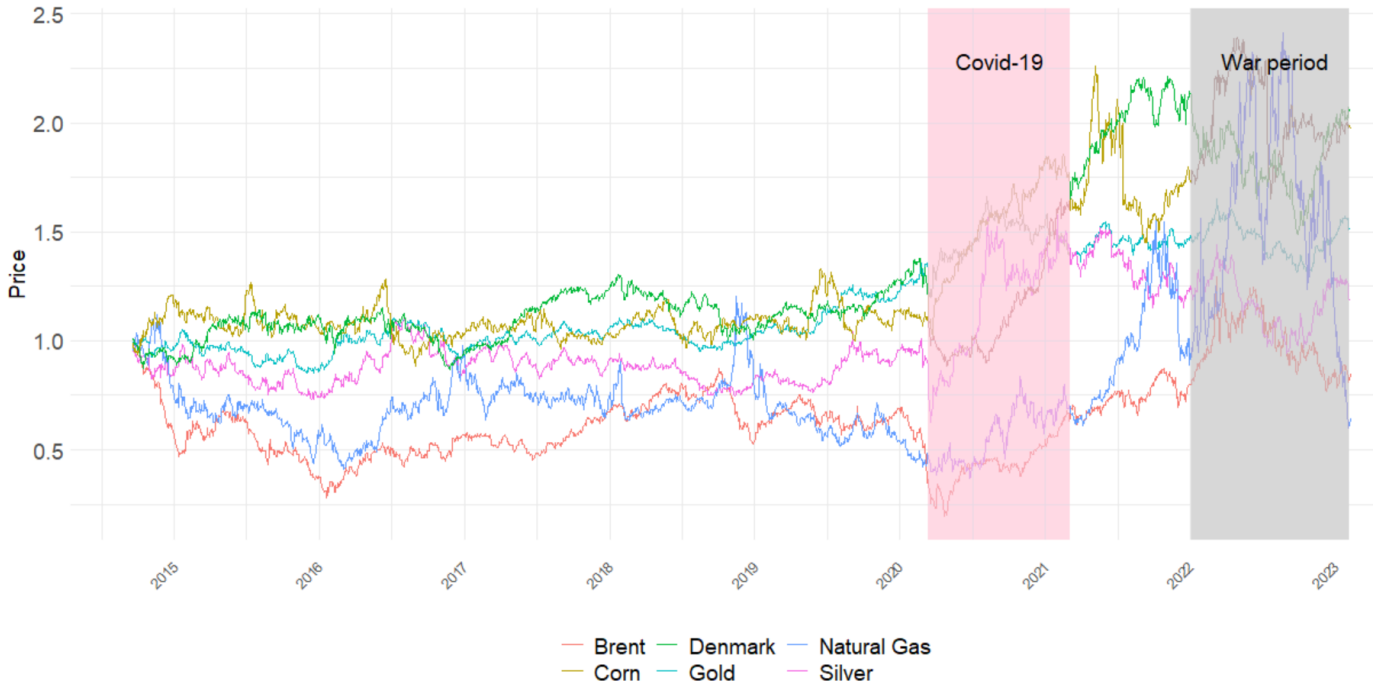

Figure 5: Price development of assets with Covid-19 (pink) and War (grey) periods highlighted.

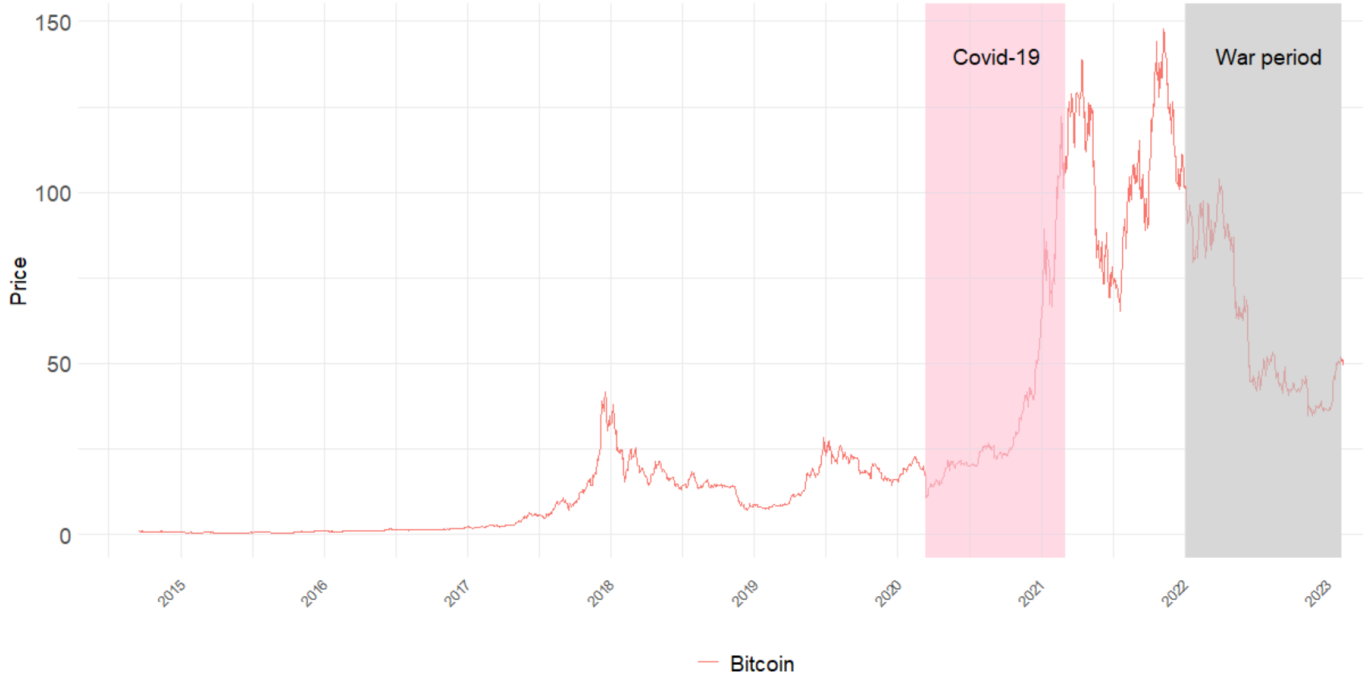

Figure 6: Price development of Bitcoin with Covid-19 (pink) and War (grey) periods highlighted.

For the most part, the assets show a negative return on investment until the start of the Covid pandemic. Then, the beginning of the pandemic is marked by a decrease in the value of the

assets, just as it was the case with indices, and after a sharp rise in the value of all the assets is observed.

Even though there can be seen significant volatility in energy assets during the period between covid and the start of the war, the volatility of energy-related assets increased substantially, with natural gas and corn achieving all-time highs. However, gold and silver saw a drop in their value, with silver returning to 2015 prices before slightly recovering.

The start of the Covid-19 pandemic saw an explosion in the price of Bitcoin, with a $1 investment in 2015 more than 100x by the end of 2021. Figure 6 compares the development in the price of bitcoin and gold. We see that the return of Bitcoin totally eclipses the return of gold. However, the enormous Bitcoin rally was short-lived, with Bitcoin erasing a good portion of its gains after the pandemic was officially over. The extreme rally and extreme pull-back indicates that Bitcoin is a highly volatile asset. Figure 6 shows that the drop in the value of Bitcoin started before the invasion of Ukraine and that the war is therefore, not a culprit for the crash. It is however, unclear if the invasion exacerbated the continuity of the downward trajectory.

4. Methodology

This section explains the methodology and parameters used in our analysis to determine our chosen commodities' safe haven, hedging, and diversifying properties. Additionally, our method for determining whether volatility and negative real interest rates play a role in determining the asset-market relationship is explained.

4.1 Correlation and 30-day rolling correlation:

To answer RQ1, a correlation, and a rolling correlation test are performed. The Pearson correlation test measures the degree to which two securities move in relation to each other (Hayes, 2022). It ranges from -1, where securities are perfectly uncorrelated, to 1, where securities are perfectly correlated, moving in tandem. A correlation of 0 indicates no correlation between the two securities.

We opt to give the designation of *safe haven* or *hedge* for securities that present a negative correlation, *weak safe haven* or *weak hedge* for securities that demonstrate a correlation no

greater than 5%, *strong diversifier* to securities with a correlation between 5-10%, and lastly *weak diversifier* to securities that have a correlation that is between 10-20%.

Table 3: Designation of hedge and diversifier

Designation	Correlation
Strong hedge/safe haven	< 0%
Weak hedge/safe haven	< 5%
Strong diversifier	< 10%
Weak diversifier	< 20%

We first analyze the correlation between assets and indices in our dataset for the whole study period to determine whether the asset is a hedge. After the initial correlation analysis, the dataset is divided into two separate periods, assessing the correlation between an asset and index in shorter timeframes where significant geopolitical events took place. Table 4 shows the division of the dataset and respective dates:

Table 4: Sectioning of the dataset into two periods

Entire Sample Period	18/09/2014 - 04/02/2023
Covid-19 Period	11/03/2020 - 03/03/2021
War Period	03/01/2022 - 04/02/2023

For our Covid-19 period, we have chosen a sample period from the 11th of March 2020 to the 3rd of March 2021. This is because the start date coincides with the announcement from the World Health Organization declaring Covid-19 as an international pandemic (WHO, 2020), and ends in approximately one year as the stock markets recover.

We employ a sample period from the 3rd of January 2022 to the 4th of February 2023 for the Russia-Ukraine war period. As we know, the Russia-Ukraine war officially started on the 24th of February 2022, resulting in a downturn for the US and European stock markets. However, we also want to include the negative effect of the tensions surrounding the prelude of the Russia Ukraine-War. Therefore, based on key events such as US President Joe Biden warning Putin of "strong economic measures" if Russia were to attack Ukraine (7th December 2021) (France-Presse, 2022). Furthermore, Putin's proposed prohibition on Ukraine from joining NATO (17th December 2021), the deployment of Russian troops in Belarus (17th January 2022), and the evident downturn in each of our chosen stock markets at the beginning of

2023 (France-Presse, 2022), we set our start date to 3rd of January 2022 for the war period. As a result, our timeline for the war ends on the 4th of February, 2023.

We perform a 30-day rolling correlation throughout the war period as a second test to visualize the correlation between assets and indices and whether it evolves over time. This test makes it easier to visualize the correlation and confirms the first correlation analysis.

4.2 The use of interactive variables:

Interactive variables are variables that allow us to construct a model in which some regression model parameters, as well as the intercept, change depending on the observations in the sample. The core concept is to break down a good into different component pieces before estimating the value of the characteristics. (Hill et al., 2018, p. 318)

4.2.1. Intercept dummies

We use indicator variables to account for chosen qualitative factors, which we assume to have an influence on the econometric model. The indicator variable takes on the value of one or zero, indicating whether the assumed characteristic is in place. For example, we define the indicator variable *D* in the following way:

$$D = \begin{cases} 1, & if\ condition\ present \\ 0, & if\ \ condition\ absent \end{cases}$$

(Hill et al., 2018, p. 318)

Using an indicator variable lets us capture both changes in the model slope, intercept, or both. To answer RQ2, we will rely on the change in slope of the model to measure the effects of market volatility and negative real rates on the returns of our assets.

4.2.2. Slope-indicator variables

If we assume a regression model where we attempt to regress the returns of the asset (R_{at}) on X, we can add the indicator variable D to the regression model. (Hill et al., 2018, p. 320)

Where X is another variable, for example, the market return, to capture the change in the slope due to the presence of the condition, for example, volatility or negative real rates, our model specification is extended with the new parameter (δ):

$$R_{At} = \alpha + \beta_{\text{asset}} X + \delta(X \cdot D) + \epsilon_{\text{t}} \quad (5)$$

The variable $(X \cdot D)$ is the product of variable X and the indicator variable, also known as a slope-indicator variable, because it allows for a change in the slope of the relationship. The slope-indicator variable is treated like any other explanatory variable in a regression model. Comparing the regression model when D=1 and D=0 help us illustrate the effect of including the slope-indicator variable. Using the partial derivate of expected asset returns with respect to X will give the following slope relation:

$$\frac{\partial E(R_{At}|X,D)}{\partial X} = \begin{cases} \beta + \delta & if \quad D = 1 \\ \beta & if \quad D = 0 \end{cases}$$

(Hill et al., 2018, p. 320)

Conventional use of regression models would have us combine each significant coefficient in to determine the overall result and the level of the slope. However, to answer RQ2, we only want to look at the individual effects to see whether increased market volatility and negative-real rates affect the relationship between market and asset. Therefore, interpretation will only be imposed for one coefficient at a time and when coefficients are significant, that is, if we are able to reject the null hypothesis:

$$\begin{cases} H_0: \beta \; and \; \delta \; = 0 \\ H_1: \beta \; and \; \delta \; \neq 0 \end{cases}$$

4.3 The econometric model:

There are many ways of examining the role of an asset as a diversifier, hedge, or safe haven. Following the framework of (Drake, 2022), we construct three regression models that together help us explain what drives the relationship between asset and index.

4.3.1 Regression Model 1

"The ideal hedge should have returns that are negatively correlated with the market, therefore we model the returns of our asset. R_A, regressed against the returns on the market R_M "(Drake, 2022)

$$R_{At} = \alpha + \beta_{asset} R_{Mt} + \varepsilon_t \quad (6)$$

The slope coefficient β_{asset} determines the hedging ability of the asset. If the slope β_{asset} is equal to one or above, its said that there is no diversification potential, while the diversifying effect increase as the value of β_{asset} diminishes (Drake, 2022). Since traditional hedging literature suggests a negative relationship between market and asset returns on average, one would expect the slope coefficient to be negative or close to zero with a significant P-value to confirm these claims. The results of regression model 1 will therefore determine if the asset has any hedging ability and whether the returns of the stock market drive asset returns.

4.3.2 Regression Model 2

In model 2, we account for times when the market volatility increases. The variable $Volatility_t$ takes the value of the market return when market volatility increases and is zero otherwise. In short, Model 2 is given by:

$$R_{At} = \alpha + \beta_{asset} R_{Mkt} + \delta_{Mkt} Volatility_t + \varepsilon_t. \quad (7)$$

This additional term is intended to assess if increased volatility in the market plays a role in the relationship between an asset and the market; we include an interactive variable to the previous model. This interactive variable aims to capture the volatility of the market. Thus, the variable takes the value of the market returns when there is an increase in volatility and zero otherwise.

$$Volatility_t = \begin{cases} r_{mkt} & if\ \Delta\sigma(r_{mkt}) > 0 \\ 0 & if\ else \end{cases}$$

(Drake, 2022) uses the CBOE VIX index to proxy the market's volatility. However, a likewise proxy for volatility is unavailable for the European markets in our analysis. To resolve this, we use a 5-day rolling standard deviation of the returns of the market and use this as a proxy for volatility for all the indices. This presents a slight deviation from the methodology used in Drake, but it provides for more consistent and concise results in our analysis.

By looking at the slope-coefficient δ, we effectively determine whether a safe haven relationship exists between the asset and index in times of market turmoil, where the ideal safe haven would exhibit a significant negative coefficient or close to zero. If the δ coefficient is significant and positive, it would seem as though market and asset returns move in together during periods of increased market volatility, making it an insufficient safe haven. This would also imply that increased market volatility helps drive the relationship between assets and indices.

If the volatility coefficient δ is significant and negative, it would suggest that an increase in market volatility results in investors choosing the asset market instead of the stock market or that the investor moves their funds from the stock market to the asset market during troubling times. This, in effect, would mean that the asset functions as a safe haven.

4.3.3 Regression Model 3

The model is further expanded to determine whether negative real rates, which tend to restrict the amount of investment opportunities, could contribute to the asset-market relationship.

$$R_{A_t} = \alpha + \beta_{asset} R_{Mkt} + \delta_{Mkt} Volatility_t + \gamma_{Mkt} RR_t + \epsilon_t \qquad (8)$$

This is done by using an interactive variable that takes on the value of the market returns when the countries' real rates are negative and zero otherwise.

$$RR_t = \begin{cases} r_{mkt} & if\ r_{real} < 0 \\ 0 & if\ else \end{cases}$$

Suppose the coefficient γ is significant and positive. In that case, there is an indication that a decrease in investment opportunities causes investors to move funds to both stocks and asset markets, driving the relationship between asset and index. On the other hand, if the coefficient γ is negative and significant, we conclude that the asset works as a safe haven during times of negative real rates.

5. Empirical results

This section presents the results from the Granger analysis, Pearson correlation, and 30-day rolling correlation used to answer RQ1 and the econometric model used to answer RQ2.

5.1 Granger Causality:

Table 5: Granger causality test.

	SP500		*OBX*		*OMXC20*		*OMXS30*	
Null hypothesis:	*p-value*	*lag*	*p-value*	*lag*	*p-value*	*lag*	*p-value*	*lag*
Index does not granger cause Gold	0,005	9	0,932	1	0,324	1	0,319	2
Gold does not granger cause Index	0,118	9	0	1	0	1	0	2
Index does not granger cause BTC	0,082	9	0,564	1	0,583	1	0,518	1
BTC does not granger cause Index	0,113	9	0	1	0,004	1	0	1
Index does not granger cause Slv	0,009	16	0,05	1	0,055	1	0,814	2
Slv does not granger cause Index	0,05	16	0	1	0	1	0	2
Index does not granger cause Brent	0	16	0	24	0	6	0	6
Brent does not granger cause Index	0	16	0	24	0,003	6	0	6
Index does not granger cause Nat. Gas	0	14	0,787	1	0,371	1	0,982	1
Nat. Gas does not granger cause Index	0,141	14	0,013	1	0,05	1	0,225	1
Index does not granger cause Corn	0,929	9	0,653	1	0,148	1	0,475	2
Corn does not granger cause Index	0,004	9	0,039	1	0,002	1	0	2

Table 5 shows the Granger causality test performed on the index and assets. The test was performed with selected lags based on the Akaike Information Criterion (AIC). SP500 appears to "Granger cause" returns on most of the assets at a 1% significance level and to bitcoin when a 10% significance level is considered; however, nothing suggests that SP500 "Granger causes" returns on corn, as the null hypothesis cannot be rejected. This indicates that the SP500 returns of the 9 previous days help predict the returns of Gold and Bitcoin,

while the returns of the 14 previous days help predict the returns of Natural Gas, and with the returns of the previous 16 days help to predict the returns of Silver and Brent.

The existing relationship between the SP500 and the assets is mainly unidirectional, with SP500 “Granger causing” the returns of the assets and no evidence of the opposite being true. Evidence indicates the existence of a bidirectional causality between SP500 with both Brent and silver at a significance level of 1% and 10%, respectively. Additionally, it can be seen in Table 5 that there is a unidirectional relationship between SP500 and corn, with corn “Granger causing” SP500.

The analysis, when performed on the rest of the indices, that is, Norway’s OBX, Denmark’s OMXC20, and Sweden’s OMXS30, indicates that none of the index’s granger cause the assets. However, a unidirectional effect can be seen from the assets to the indices, with the returns of the previous day being able to predict the asset returns on the next day. This is the case for all assets except Brent. Here we can see that there is, in fact, a bidirectional effect, with Brent Granger causing the indices and the indices Granger causing Brent. From table 5, we can see that the OBX returns of the previous 24 days can predict the future returns of Brent and vice versa, and the returns of the previous 6 days for both OMXC20 and OMXS30 can predict the future returns of Brent and vice versa. The bidirectional effect between Brent and the indices can perhaps be explained by the fact that the indices present in the analysis are all heavily industrialized. In the case of OBX, firms that operate in the energy sector make up a large part of the index.

5.2 Hedge and safe haven analysis:

Table 6: Correlation between Indices and assets

SP500	Gold	Bitcoin	Silver	Brent	Nat. Gas	Corn	Days
All Time	0.032	0.207***	0.207***	0.278***	0.07***	0.056**	2120
War Period	0.130**	0.575***	0.202***	0.076	0.104*	-0.094	282
Covid period	0.221***	0.395***	0.237***	0.314***	0.118*	0.161**	248

*Significance level at *10%, **5% and ***1%*

OBX	Gold	Bitcoin	Silver	Brent	Nat. Gas	Corn	Days
All Time	-0.013	0.082***	0.122***	0.321***	0.083***	0.096***	2120
War Period	0.126	0.18***	0.2***	0.243***	0.188***	0.129**	282
Covid period	-0.011	0.221***	0.12*	0.249***	0.05	0.184***	248

*Significance level at *10%, **5% and ***1%*

OMXC20	Gold	Bitcoin	Silver	Brent	Nat. Gas	Corn	Days
All Time	-0.012	0.088***	0.072***	0.095***	0.082***	0.021	2120
War Period	0.127**	0.251***	0.162***	-0.005	0.2***	-0.056	282
Covid period	0.142**	0.286***	0.155**	0.054	0.122*	0.062	248

*Significance level at *10%, **5% and ***1%*

OMXS30	Gold	Bitcoin	Silver	Brent	Nat. Gas	Corn	Days
All Time	-0.044**	0.102***	0.1***	0.195***	0.048**	0.049**	2120
War Period	0.108*	0.220***	0.178***	0.045	0.095	0.048	282
Covid period	0.095	0.286***	0.218***	0.194**	0.113*	0.16**	248

*Significance level at *10%, **5% and ***1%*

The first test in our analysis, presented in Table 6, examines the Pearson correlation between the indices and assets to determine hedging and safe haven abilities. To test the hedging ability of our assets, we calculate the Pearson correlation between asset and index for the entirety of our sample before we split the timeline into a Covid-19 and War-period to test the safe haven abilities of the assets during the pandemic and Russia-Ukraine crisis.

When considering the entirety of our timeline spanning 2120 days, there is only evidence of gold acting as a hedge for the Swedish index OMXS30, where the correlation between gold and the index is (-0.044) and significant. As for the safe haven abilities of gold, it appears to fail for all indices appearing as a weak diversifier for S&P500 and OMXS30 during the Russia-Ukraine crisis and a weak diversifier for OMXC20 during both the war and pandemic period.

Considering the hedging ability of Bitcoin, it is observed that the long-term correlation between Bitcoin and SP500 is too high to be considered a hedge or diversifier. However, for

the Scandinavian indices, Bitcoin works as a strong diversifier for OBX and OMXC20 and as a weak diversifier for OMXS30 in the long-term perspective. As for Bitcoin's safe haven abilities, it appears to fail for all indices during both the war and pandemic period, only working as a weak diversifier for OBX during the Russia-Ukraine crisis.

Silver exhibits similar dynamics to Bitcoin, failing as a hedge and long-term diversifier for SP500 while exhibiting long-term diversifying abilities towards the Scandinavian indices. In the long-term perspective, Silver is considered a strong diversifier for OMXC20, OMXS30 and a weak diversifier for OBX. Regarding the safe haven abilities of silver, it is observed to be nothing more than a weak diversifier for OBX, OMXC20, and OMXS30 during the Russia-Ukraine crisis, as well as a weak diversifier for OBX and OMXC20 during Covid-19.

When considering the hedging ability of Brent crude oil, it is found to be a strong diversifier exclusively towards OMXC20. However, for its safe haven abilities, it fails for all indices during the Russia-Ukraine crisis and the Covid-19 pandemic, only acting as a weak diversifier for OMXS30 during the pandemic.

For the hedging ability of Natural gas, we find that it works as a weak hedge for OMXS30 and as a strong diversifier for SP500, OBX, and OMCX20 in the long term. As for its safe haven abilities, we find that Natural Gas acts as a weak diversifier for SP500, OBX, and OMXC20 during the Russia-Ukraine crisis and for SP500, OMXC20, and OMXS30 during Covid-19.

When determining whether the agricultural commodity known as corn could act as a hedge, we find that corn acts as a weak hedge for OMXS30 and a strong diversifier for SP500 and OBX in the long term. During market turmoil, corn does not exhibit any safe haven abilities; however, it acts as a weak diversifier for SP500, OBX, and OMXS30 during the Covid-19 pandemic and for OBX during the Russia-Ukraine crisis.

5.3 30-day Rolling Correlation:

The 30-day rolling correlation analysis performed during the war period indicates that S&P500 is negatively correlated with almost all of the assets in the analysis at the start of the war except for bitcoin, as seen in figures 7 through 12. After the first few months of the war, however, it is seen that the correlation between SP500 and the assets starts to increase,

becoming positive. Only corn does not correlate with SP500, presenting fluctuations between positive and negative correlation in that period, with the average correlation being negative.

The 30-day rolling correlation between the Norwegian OBX and the chosen assets is, for the most part, very high during the period, with only a few sporadic moments where the assets and OBX return a negative correlation, as seen in figures 13 through 18.

In figures 19 through 30, we see that for both the Danish OMXC20 and the Swedish OMXS30, a decrease in correlation between the assets and the indices is present at the beginning of the war, with the correlation turning negative. However, and just as seen in the case of SP500, after the first few months, the correlation between the indices and the assets again turns positive. Also, as seen in the case of SP500, these indices appear to have a negative average correlation in the 30-day period with Corn, fluctuating between negative and positive. Looking at the rolling correlation alone, corn could appear to be a safe haven, however when looking at the Pearson correlation in table 6, the P-values are not significant which lends us unable to determine them as safe haven.

5.4 Regression 1: Market Returns

$$R_{At} = \alpha + \beta_{asset} R_{Mkt} + \epsilon_t \qquad (6)$$

Table 7: Coefficients of Regression 1

Regression 1		*SP500*	*OBX*	*OMXC20*	*OMXS30*
Gold	Intercept	*0.00024*	*0.0002*	*0.0003*	*0.0003*
	β	*0.026*	*-0.008*	*-0.008*	*-0.029***
Bitcoin	Intercept	*0.003****	*0.003****	*0.003****	*0.003****
	β	*0.80****	*0.258****	*0.316****	*0.340****
Silver	Intercept	*0.000*	*0.0002*	*0.0002*	*0.0003*
	β	*0.221****	*0.152****	*0.102****	*0.132****
Brent	Intercept	*-0.0001*	*0.000*	*0.000*	*0.0001*
	β	*0.646****	*0.605****	*0.203****	*0.388****
Nat. Gas	Intercept	*0.0004*	*0.0004*	*0.0004*	*0.0003*
	β	*0.227****	*0.219****	*0.244****	*0.135***
Corn	Intercept	*0.0004*	*0.0005*	*0.0005*	*0.0005*
	β	*0,08****	*0.106****	*0.027*	*0.057***

*Significance level at *10%, **5% and ***1%*

The first regression aims to assess if the assets in the analysis can be used as a diversifier or a hedge for the indices. If there are no prospects for diversification, we expect to see a β that is close to or over one, and a β further away from one indicating greater diversification in line with (Drake, 2020). Table 7 shows the test coefficients of the regression. Again, we see that there is no evidence to support Gold as a hedge or diversifier for the SP500, giving us the same results as (Drake, 2020).

The lack of evidence for the case of Gold acting as a hedge or a diversifier can be seen in both the Norwegian and Danish indices. However, when analyzing the Swedish index, we get a significant and negative β which seems to suggest that Gold can be used as a hedge against the Swedish index.

The analysis also indicates that there is a significant positive relation between the returns of the indices and the returns of bitcoin, silver, Brent, and natural gas. This suggests that market returns drive the returns of the asset's limiting their hedging and diversification potential.

However, the same cannot be said about corn, as the level of β suggests that corn can be used as a strong diversifier for the SP500 and OMXS30 as the coefficient is close to zero.

5.5 Regression 2: Market Volatility

$$R_{At} = \alpha + \beta_{asset} R_{Mkt} + \delta_{Mkt} Volatility_t + \varepsilon_t. \quad (7)$$

Table 8: Coefficients of Regression 2

Regression 2		SP500	OBX	OMXC20	OMXS30
Gold	Intercept	0.00025	0.0002	0.0003	0.0003
	β	-0.046	-0.007	-0.003	0.008
	δ	0.09**	0.001	-0.006	-0.047
Bitcoin	Intercept	0.003***	0.003***	0.003***	0.003***
	β	0.602***	-0.068	0.0662	0.085
	δ	0.243	0.408**	0.325*	0.321*
Silver	Intercept	0.000	0.0002	0.0002	0.0003
	β	0.162**	0.207***	0.118*	-0.117*
	δ	0.07	-0.069	-0.021	-0.117*
Brent	Intercept	-0.0001	0.000	0.000	0.0001
	β	0.868***	0.679***	0.192**	0.335***
	δ	-0.273**	-0.094	0.014	0.067
Nat. Gas	Intercept	0.0004	0.0004	0.0004	0.0003
	β	0.259	0.137	0.349***	0.263**
	δ	-0.041	0.103	-0.135	-0.162
Corn	Intercept	0.0004	0.0005	0.0005	0.0005
	β	0.07	0.054	0.078	0.087
	δ	0.007	0.067	-0.067	-0.038

*Significance level at *10%, **5% and ***1%*

The first regression aimed to assess whether assets could be used as diversifiers or hedges against the indices. In the second regression, δ aims to capture the interaction between the assets and the indices in times when the volatility in the market increases, that is, it aims to test if the assets can be used as a safe haven against the indices. The coefficients of the second regression model are presented in Table 8.

Contrary to (Drake, 2020), the analysis finds a significant and positive relationship between gold and S&P500, indicating that gold cannot be used as a safe haven in times of market instability. There is, however, enough evidence to suggest that gold can take on the role of a strong diversifier against the SP500. Despite that, the evidence does not repeat itself for the other indices. An explanation for the divergence between our findings and those of Drake can be the distinct ways used to calculate the volatility of the indices. Drake employs the VIX index to proxy volatility, where we use a 5-day rolling standard deviation of each market.

The results suggest a positive relationship between bitcoin and every index in the analysis when volatility rises, indicating that bitcoin cannot be used as a safe haven nor a diversifier in times of turbulence.

From the analysis, we find that the opportunity for assets that act as a safe haven during times of turbulence is scarce, finding evidence of safe haven abilities only for silver against the Swedish index and for Brent against the S&P500. It's also evident that an increase in market volatility appears to have a limited effect on the relationship between index and assets, seeing as there are few significant coefficients.

5.6 Regression 3: Negative Real Rates

$$R_{A_t} = \alpha + \beta_{asset} R_{Mkt} + \delta_{Mkt} Volatility_t + \gamma_{Mkt} RR_t + \epsilon_t \quad (8)$$

Table 9: Coefficients of Regression 3

Regression 3		*SP500*	*OBX*	*OMXC20*	*OMXS30*
Gold	Intercept	0.00024	0.0003	0.0002	0.0003
	β	-0.186***	0.156***	0.021	-0.023
	δ	0.085*	-0.007	-0.006	-0.047
	γ	0.158***	-0.173***	-0.026	0.035
Bitcoin	Intercept	0.003**	0.003	0.003***	0.003***
	β	-0.313	1.292***	-0.538	-0.016
	δ	0.224	0.359**	0.321*	0.319*
	γ	1.038***	-1.445***	0.635*	0.115
Silver	Intercept	0.000	0.0002	0.0002	0.0003
	β	-0.018	0.426***	0.283*	0.259**
	δ	0.069	-0.077	-0.019	-0.116*
	γ	0.205*	-0.233**	-0.174	-0.038
Brent	Intercept	-0.0002	0.000	0.000	0.0001
	β	0.803***	1.597***	-0.187	0.078
	δ	-0.275**	-0.127	0.012	0.060
	γ	0.073	-0.974***	0.398*	0.292**
Nat. Gas	Intercept	0.0003	0.0004	0.0003	0.0005
	β	0.166	0.166	0.600*	0.356*
	δ	-0.043	0.101	-0.134	-0.159
	γ	0.107	-0.031	-0.265	-0.106
Corn	Intercept	0.0004	0.0005	0.0005	0.0005
	β	0.140	0.199**	0.071	0.169*
	δ	0.009	0.061	-0.068	-0.036
	γ	-0.079	-0.155*	0.157	-0.094

*Significance level at *10%, **5% and ***1%*

The last regression aims to assert if the existing relationship between the assets and the indices is due to the market's lack of investment opportunities during negative-real interest rates. When real interest rates fall below zero, both a positive and a negative relationship between the assets and indices, given by γ, can be seen. The coefficients of the third regression model are presented in Table 9.

Gold and Silver exhibit a positive relationship with S&P500 during times of negative-real rates, meaning that when the real rates in the market turn negative, S&P500-, gold- and silver returns move in the same direction, indicating that returns of the market drive returns of the assets in periods of negative real interest rates. A possible explanation is that as inflation increases at a faster pace than nominal interest rates, real interest rates turn negative.

Therefore, the earning potential for T-bills and bonds is reduced, causing investors to flee from these markets to the stock-, gold- and silver markets, which then causes them to move in tandem.

The opposite relationship is observed for the Norwegian market OBX, where negative real rates result in a negative relationship, meaning that OBX-, gold-, and silver returns move in the opposite directions when real rates fall below zero. In addition, we see the same negative relationship present in Corn and Brent. This suggests that when negative real rates are present, most assets have a stronger diversifying ability toward the Norwegian OBX.

The relationship between Bitcoin, SP500, and OBX is more extreme during negative real interest rates, as evident in table 9. When real rates fall below zero, a 1 unit increase in S&P500- returns will result in a 1,04 unit increase in BTC returns. Following this, an investor with funds in S&P500 would increase his/her risk by investing in BTC during times of negative real rates, as a negative change in market returns would lead to an even more significant fall in the returns of BTC. The same positive relationship is found between BTC and OMXC30, although less extreme in nature, as a 1 unit increase in OMXC30-returns will only result in a 0,635 unit increase in BTC. Once again, negative real rates reduce the diversifying ability of the asset.

The opposite relationship is observed between OBX and BTC, where a 1 unit increase in OBX returns would result in a 1,445 unit decrease in BTC returns during times of negative real-rates and vice versa. This would mean that BTC's diversification ability towards OBX is strengthened during negative real rates, as any decrease in OBX returns would result in a higher increase in BTC returns.

For Brent crude oil, we observe a positive relationship towards OMXC20, and OMXS30 and a negative relationship for OBX during negative-real rates, meaning that as real rates become negative, Brent’s ability as a diversifier is reduced towards both OMXC20 and OMXS30 while it increases towards OBX. For corn, it is observed that during negative-real rates, there is a negative relationship towards OBX, implying that as real rates fall below zero, the diversifying abilities of corn increase.

6. Discussion:

6.1 Safe Haven discussion:

The results in section 5.2 reveal that there are no safe-haven assets for the US or Scandinavian stock indices during the Russia-Ukraine crisis.

Our findings go against that of (Baur & Lucey, 2010; Lucey & Li, 2015), who suggest that gold and silver could act as a safe haven during times of market turmoil. Instead, our findings align with that of (Drake, 2022), stating that the safe-haven properties of gold have been absent in recent times. The recent failure of gold and silver as safe-haven assets for all our chosen indices could signify a change in the dynamic between the stock- and precious mineral market.

As for the "digital gold," also known as bitcoin, our findings contradict that of (Feng et al., 2018), who found that bitcoin could act as a diversifier for US and European stock markets during times of market turmoil. In our case, bitcoin acts as a weak diversifier for the Norwegian stock market during Covid-19 but fails as both a diversifier and safe-haven for all other indices during both the pandemic and war period.

A possible explanation for the contradicting findings may lie in Bitcoin's extreme volatility over time, as revealed in Figure 6. From the start of the pandemic, we see bitcoin skyrocketing in price, reaching $68.000, in tandem with the stock market's recovery. This was followed by a crash that saw its value more than halved in the period between the end of Covid-19 and the start of the Russia-Ukraine war, while at the same time, the indices maintained an uptrend. As the war progressed and the market trend started to shift downwards, bitcoin continued its downtrend, hereby causing positive co-movements between each index and bitcoin.

This supports the idea proposed by (Bouri et al., 2017), that the volatility of Bitcoin makes it hard to determine its overall effectiveness as a diversifier and safe-haven, as its volatility rate creates inconsistent results over time. This could be a sign that the cryptocurrency market as an emerging market has yet to be entirely accepted by investors and that Bitcoin is still considered a speculative investment instead of a good store of value. Furthermore, the degree of volatility observed in Bitcoin may have caused low confidence in investors seeking a safe store of value, causing the demand and price of Bitcoin to falter during Covid-19 and the Russia-Ukraine crisis.

Contrary to (Majumder, 2022), we find that Brent crude oil and Natural gas do not exhibit safe haven properties. Instead, our findings support that of (Ciner et al., 2013), indicating that the energy market does not act as a safe haven for the stock market, at least for the type of market crisis represented by the duration of the Russian war against Ukraine.

Macroeconomic factors and policies during the Covid-19 pandemic and the Russia-Ukraine crisis are plausible explanations for why Brent crude oil fails as a safe haven asset in our chosen periods. As the pandemic raged on in the earlier stages of 2020, many countries enforced restrictions to stop the spread of the virus. These restrictions caused an abrupt fall in oil demand to the point where WTI futures were traded in negative territory for the first time. Moreover, the abrupt fall in demand led to production cuts in the US and OPEC nations (Domm, 2020; EnerData, 2020).

As the lockdown restrictions were lifted and economies were set to recover, oil demand increased substantially, with insufficient supply to match it. This led to a spike in the price of oil, just as the stock market was on an upward trajectory.

As for the safe haven abilities of Brent crude oil during the Russia-Ukraine crisis, sanctions restricting the oil and gas trade between Europe and Russia caused the price of Brent crude oil to increase in the first half of 2022, as seen in Figure 5. As a large distributor of Brent, Norway benefits from the price increase, as seen in Figure 4 by the rise in the OBX index at the inception of the Russia-Ukraine crisis. However, in the second half of 2022, Brent crude oil prices declined as concerns about a possible recession reduced demand, this coincides with a decline in the OBX index, making Brent crude oil an insufficient safe haven throughout the period. This falls in line (Arouri et al., 2011; Miller & Ratti, 2009), suggesting that the stock market of net exporting oil countries' have a positive relationship against the Brent crude oil price.

The opposite trend is observed for the US, Danish, and Swedish stock markets, where an increase in the price of Brent crude oil meets the initial decline in the stock indices. The second half of 2022 sees the stock indices recover, as Brent crude oil is declining, as seen in Figures 4 and 5. The correlation relationship between Brent crude oil, and the US, Danish, and Swedish stock markets is close to zero/negative during the war period, as seen in Table 6. However, the lack of significant p-value makes us unable to determine them as Safe havens or diversifiers. Nevertheless, a larger data sample could potentially provide significant values,

which could result in Brent acting as a safe haven for the US, Danish, and Swedish stock markets.

Natural gas exhibits a better-diversifying ability towards the stock indices compared to brent-crude oil during the Covid-19 pandemic by acting as a weak diversifier for the US, Danish, and Swedish stock markets. Nevertheless, the correlation is once again too high to be considered a safe haven, and we offer a similar explanation as for Brent crude oil. As Covid-19 causes the stock-market and global production to plummet, so does the demand for energy sources and the price of natural gas. When the stock market recovers and global production increases, so does the demand for natural gas, implying a positive correlation throughout the pandemic period.

Unlike Brent crude oil, natural gas exhibits weak-diversifying abilities during the Russia-Ukraine crisis towards the US-, Norwegian- and Danish stock markets. However, it is worth noting that the level of correlation is at the upper limit of what our parameters could consider a weak diversifier for the Norwegian- and Danish markets, implying that any slight increase in correlation for these indices would cause natural gas to fail as a diversifier during the Russia-Ukraine war.

To understand the possible reasons why Natural gas fails as a safe haven during the Russia-Ukraine crisis, we discuss the price development of Natural gas throughout the period. Firstly, the sanctions towards Russia, which restricts oil and Natural gas export to Europe, cause European countries to seek natural gas from countries such as Qatar and the United States (Tollefson, 2022). This results in an initial demand increase, causing the price of Natural gas to soar in the first half of 2022. This would seem beneficial for the safe haven abilities of Natural gas as our stock indices plummet simultaneously as the price of natural gas increases. However, this price increase is only temporary, and as the war rages on, natural-gas prices plummet in the second half of the war period together with the stock market.

Possible reasons and speculations surrounding natural gas as an energy source could have had a negative effect on the price. Winters were not as cold as first thought, and thus the demand for natural gas was not as high as expected in the second half of 2022, resulting in an oversupply (Agnolucci et al., 2023). Additionally, Russia’s unprovoked attack on Ukraine has caused many European countries to reconsider their use of oil and natural gas, as they have been largely dependent on imports from Russia. The possibility of a European energy

diversification could have reduced demand and price for natural gas (Agnolucci et al., 2023; Hartman, 2023).

For the safe haven properties of corn (Rubbaniy et al., 2022; Siemaszkiewicz, 2021) found, corn to be a safe haven for investors during times of market turmoil. However, our results do not align with this sentiment during either the Covid-19 pandemic or the Russia-Ukraine crisis period.

During the pandemic, corn obtains the status of a weak diversifier for the US-, Norwegian-, and Swedish-index but fails as a safe haven. A large portion of the corn produced globally is used for animal feed, cattle production, and ethanol fuel production (Magdaraog, 2022). The worldwide lockdown caused people to stay at home, temporarily reducing meat production and lowering the necessity for fuel as the population traveled less. This resulted in the demand and price of corn declining together with the stock indices at the start of the pandemic, as seen in Figures 4 and 5. As Covid-19 restrictions were lifted and the stock indices began to recover, so did the demand and price for corn. This represents a possible reason for the positive correlation between corn and the stock market during the Covid-19 pandemic, causing corn to fail as a safe haven.

As for the safe haven abilities of corn during the Russia-Ukraine crisis, corn acts as a weak diversifier for the Norwegian index but is more effective than during the pandemic. For the US-, Danish-, and Swedish-index, we receive correlation coefficients close to zero and negative; however, these coefficients are not significant. In the short term, corn prices shot up at the initiation of the war, as supply chains were broken and the corn export from Russia and Ukraine was limited (Janzen & Zulauf, 2023). This caused hoarding and bidding wars in the corn market, which would seem beneficial to the safe haven property of corn. However, as global food stocks proved sufficient to cover the initial loss of corn and other grains from Ukraine and deals such as the UN's Black Sea Grain Initiative were set in place, the price of corn was normalized again (UN, 2022).

6.2 Hedging discussion:

To assess the hedging ability of the assets, we employed both a Pearson correlation for the entirety of our dataset from section 5.2 and a regression model where the returns of the market are used to explain the returns of the asset, as seen in section 5.4. The traditional idea of gold as a hedge appears to be correct only for the Swedish stock market. For the American

market, our findings coincide with that of (Drake, 2022), who concludes that there is insufficient evidence to prove gold as a hedge. Additionally, the same lack of significance is observed for the Norwegian- and Danish- markets.

Silver also fails as a hedge but acts as a diversifier for the Scandinavian markets, with regression 1 suggesting that the return for each market drives the return of silver. Hence our findings mostly contradict that of (Baur & Lucey, 2010; Baur & McDermott, 2010; Shahzad et al., 2020) as our chosen precious minerals fail as a hedge, except for the case of gold against Sweden.

As for the hedging ability of Bitcoin, supposed to be the new "digital gold," it also fails in its role as a hedge for all markets. In fact, the results from sections 5.2 and 5.4 indicate that Bitcoin offers little in terms of hedging ability against the markets, especially for the US. This result falls in line with (Bouri et al., 2017), who suggest that Bitcoin is an insufficient hedging tool towards the US stock market. However, according to our stipulated parameters for what comprises a diversifier, there is evidence of bitcoin acting as a such for Scandinavian-stock indices. Additionally, it is evident from regression 1 that each stock market's returns drive bitcoin returns, causing them to move together.

As for our energy commodities, we find from section 5.2 that only natural gas provides any sort of hedging ability, being a weak-hedge for the Swedish stock market and a strong diversifier towards the other markets, with Brent crude oil acting as a strong diversifier towards the Danish market and a weak diversifier against the Swedish market. This differs from what (Majumder, 2022) observes for the Indian market, where Natural gas and Brent crude oil exhibit hedging properties.

In terms of the relationship between the stock markets and the two energy commodities, regression 1 finds that the returns of each stock market drive the returns of Brent crude oil and natural gas. This is especially true for the relationship between the Norwegian- and US-market against the Brent crude oil market, with the possible explanation of Norway- and the US- being large oil exporters. This falls in line with (Arouri et al., 2011), suggesting a positive relationship between that of Brent crude oil and the stock markets of net exporting oil countries, which could limit the hedging properties of the asset.

Lastly, corn exhibits hedging ability towards the Swedish stock market while acting as a strong diversifier for the US- and Norwegian-market, as seen in sections 5.2 and 5,4. Therefore, the analysis seems to suggest that the stock-market returns do not broadly impact

the returns of corn. The findings in section 5.2 and 5.4 adds to the hedging literature by casting doubt upon the hedging properties of numerous assets previously assumed to act the role of a hedge.

6.3 Granger causality test:

SP500 appears to have a unidirectional causality to all the assets in our analysis except corn. This indicates that the returns of SP500 can be used to predict the returns of the assets. However, this does not necessarily imply a direct relationship between the index and the assets. The same effect is not observed for the other indices in the analysis, perhaps due to the size of these indices not being as significant in an overall perspective as SP500 is.

We see that in the case of Brent, there is bidirectional causality between it and the indices. This is perhaps due to Brent being not only a vital energy source for the economies in the analysis but also accounting for a large part of the composition of the indices, as is the case of SP500 and OBX.

6.4 The effects of market volatility and negative real rates:

In analysing the effects of market volatility on the relationship between our assets and stock indices, we find that an increase in market volatility in the US market causes a positive relationship between gold- and market returns, as seen in section 5.5.

This result differs from that of (Drake, 2022), as our analysis results in a higher value for delta. As mentioned before, this difference in results is most likely explained by the different methodologies in determining volatility increase in the market.

As for the effect of market volatility on Bitcoin returns, there is a strong and positive relationship between Bitcoin returns and the returns of the Scandinavian markets during times of increased volatility. This indicates that Bitcoin and the Scandinavian markets move together in times of market turmoil, limiting any safe haven ability. A possible explanation could be that investors move their funds from higher-risk assets, such as stocks and cryptocurrencies, when volatility increases in favor of safer investments, such as bills and bonds. However, evidence suggests that no significant relationship exists between the returns of Bitcoin and an increase in volatility of the US stock market.

An increase in market volatility appears to negatively affect the relationship between returns of brent-crude oil and the US market as well as the relationship between returns of silver and the Swedish market. According to regression 2, an increase in market volatility will strengthen the diversifying ability of brent-crude oil against the US market and silver against the Swedish market, providing them with safe haven abilities. However, none of these abilities are observed during the pandemic or war period, as seen in Figure 6. The regression does not determine whether the index or the asset experiences a return loss during the market turmoil, only that they move in opposite directions. With that said, we offer the following possible explanation, as the stock-market experiences an increase in volatility, investors move their funds from the Swedish market to the silver market to relieve themselves of the stress surrounding volatility.

The same reasoning is used for the relationship between Brent and the US market, where the investor chooses to invest in one or the other during market turmoil. No effects can be found when considering how an increase in market volatility would affect the relationship between natural gas, corn, and stock indices. All in all, the way in which an increase in market volatility affects the relationship between stock index and asset proves to be inconsistent across each asset class and the stock market.

Regression 3 in section 5.6 looks at the relationship between index and asset returns when negative real interest rates are present in the market. Negative real interest rates occur when inflation exceeds the nominal interest rate. For the traditional safe haven assets gold and silver and the “new gold” bitcoin, it is evident that when real rates turn negative, there is a positive relationship between the returns of gold/silver/bitcoin and the US market. A possible explanation is that as inflation increases, the yield of bonds and bills is reduced, causing investors to seek other investment opportunities that are less impacted by inflation. This results in investors moving their funds to both the US and gold/silver/bitcoin markets, causing a positive relationship during negative real interest rates.

However, this effect is not uniform across countries, as we observe a negative relationship between many of the assets and the Norwegian stock market during negative real interest rates. A possible explanation could be that investors in the Norwegian market are looking for alternative investment opportunities to diminish the effects of negative real rates. They, therefore, choose to move their funds from the stock market to precious metals, bitcoin, Brent, and corn to preserve their value.

The analysis shows that negative real interest rates have a limited effect on the relationship between the Danish/Swedish stock market and our chosen assets. It only affects the relationship towards Bitcoin and Brent crude oil in the case of Denmark and Brent crude oil in the case of Sweden. Here we observe the relationships to be positive and offer the following explanation. A lack of investment opportunities causes investors to move their funds to both the stock and asset markets in search of potential returns and as a store of value.

In summary, it appears that market volatility and negative-real rates do affect the relationship between the returns of the stock market and the asset market. However, the results are inconsistent between different countries and assets, making it hard to identify any definitive pattern. However, it provides investors with a valuable lesson, to be aware that variables such as market volatility and the presence of negative real rates could affect the relationship between the stock and asset market, changing their diversifying properties.

As evident in our analysis, the well-worn adage of hedging and safe haven properties of assets towards stock indices is challenged, with negative real rates both strengthening and reducing safe haven properties. This builds upon the recent findings of (Drake, 2022) and adds to the safe haven and hedging literature by suggesting that both market volatility and negative real rates play a part in deciding the stock market and asset relationship.

6.5. Limitations

There are a couple of limitations when considering the results of our study. Firstly, the time horizon of Bitcoin caused us to constrain our data sample for all assets and stock indices from 18.09.2014 - 04.02.2023. Therefore, a broader data sample could return different hedging properties than the ones found in this study. Also, regarding the effect of negative real rates, our data sample is heavily weighted toward days with negative real rates. Therefore, expanding the data sample would provide more days with positive real rates, which could further highlight its effect on the relationship between the asset and the stock market. Another limitation surrounding our data comes from the process of transforming all assets and markets into a single currency. This could cause a biased performance comparison throughout our data sample, as converting stocks at a single exchange rate might not accurately reflect the currency movements during the analysis period. In addition, converting stocks to a single currency does not consider the difference in purchasing power between countries and local economic conditions.

Limitations surrounding the crypto market are also worth considering, and due to Bitcoin's short lifetime and high volatility rate, findings related to its safe haven and hedging properties are considered questionable.

Additionally, our methodology could limit our study's interpretation of safe haven and hedging results. We arbitrarily divide our analysis into sample periods based on key events such as Covid-19 and the Russia-Ukraine crisis. Arguments could be made to change these sample periods, which could affect the results. Furthermore, we settle upon arbitrarily chosen levels of correlation to determine safe haven, hedging, and diversifying properties of the assets, and different studies could potentially use different metrics to determine these properties.

7. Conclusion:

This master thesis has aimed to investigate the safe haven, hedging, and diversifying properties of Gold, Silver, Bitcoin, Brent crude oil, Natural gas, and Corn against the US and the Scandinavian stock market.

Our thesis expands upon the existing literature by including the recent Russia-Ukraine crisis adding to the ongoing debate about commodities as a safe haven and hedging tool. Additionally, our paper expands upon that of (Drake, 2022) by investigating whether increased market volatility, and negative real rates play a role in determining the safe haven properties of the assets.

Our answer to RQ1 is based on the Pearsson correlation between stock markets and assets during the entire sample period in addition to the Covid-19 pandemic and the Russia-Ukraine crisis. For the hedging properties, we find Gold to act as a strong hedge against Sweden, while Corn and Natural gas act as a weak hedge. None of the other stock markets appear to have hedging opportunities, with the chosen commodities being limited to weak and strong diversifiers. During the Covid-19 pandemic and Russia-Ukraine crisis, we found that none of our chosen commodities exhibit safe haven properties towards the US and Scandinavian stock market, with some instead acting as diversifiers.

To answer RQ2, we construct a regression model which explains asset returns using market returns with the inclusion of slope indicator variables to determine whether increased market volatility and negative real rates have an impact on the relationship. The results indicate that market returns tend to drive the returns of the asset, limiting their hedging properties, and that the presence of market volatility strengthens or weakens this relationship in a few cases; as for the effect of negative real rates, it is observed to play a more prominent role than that of market volatility, by either reducing or strengthening the safe haven properties of a majority of the assets.

To conclude our main research question, we posit that no assets present safe haven properties towards the US or Scandinavian stock markets during the Covid-19 pandemic or Russia-Ukraine crisis, with the long-term hedging opportunities being few and far between. Hedging and safe haven properties previously observed have therefore vanished. Additionally, it is evident that the market returns, increased market volatility and negative real rates play central roles in the asset and stock market relationship.

Any investor exposed to the US or Scandinavian stock market seeking diversification should consider the findings in our thesis. Furthermore, it should also be helpful for investors trying to understand which factors cause the hedging and safe haven properties to fail or succeed.

As seen in our thesis, many of the previously observed safe and hedging properties are not supported by our data; further research should therefore expand the data to include newer dates to investigate the development of the hedging and safe haven properties. Further research could also include additional assets and markets; as our analysis is solely focused on developed markets, the inclusion of emerging or even commodity markets would be interesting.

Further investigation as to what causes the relationship between stock markets and assets could also be done by adding additional slope-dummy variables based on an index for political instability, macroeconomic factors such as GDP growth, or industry-specific factors related to the commodity or market in question. Lastly, it would be interesting to examine how the assets would fare as a hedge or safe haven towards different portfolios containing multiple financial assets instead of investigating their properties strictly towards a country's stock market.

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Appendix:

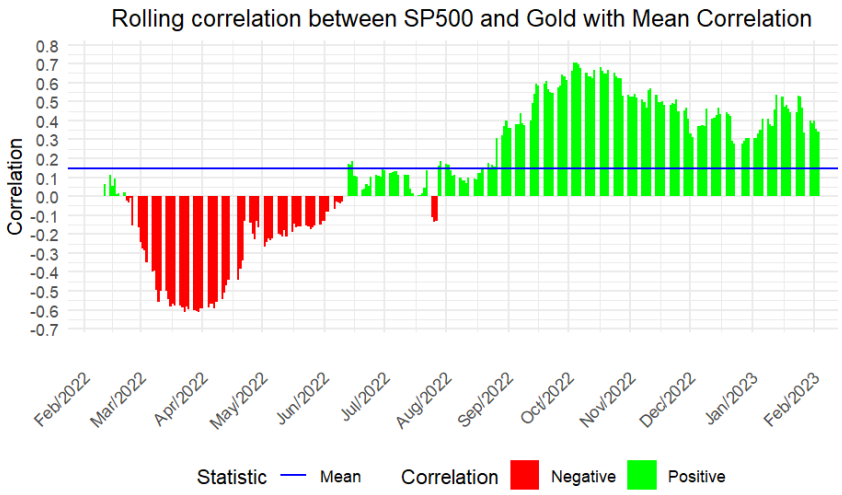

Figure 7: 30-day rolling correlation between SP500 and Gold during the war period

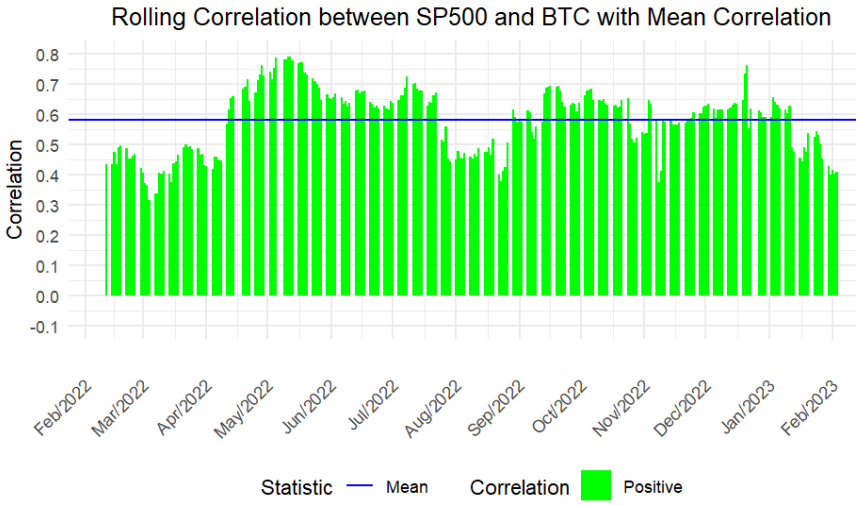

Figure 8: 30-day rolling correlation between SP500 and Bitcoin during the war period

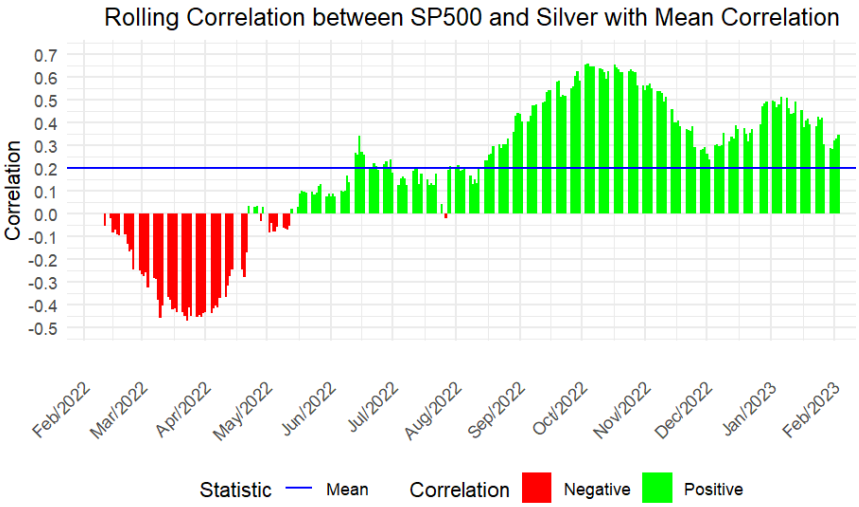

Figure 9: 30-day rolling correlation between SP500 and Silver during the war period

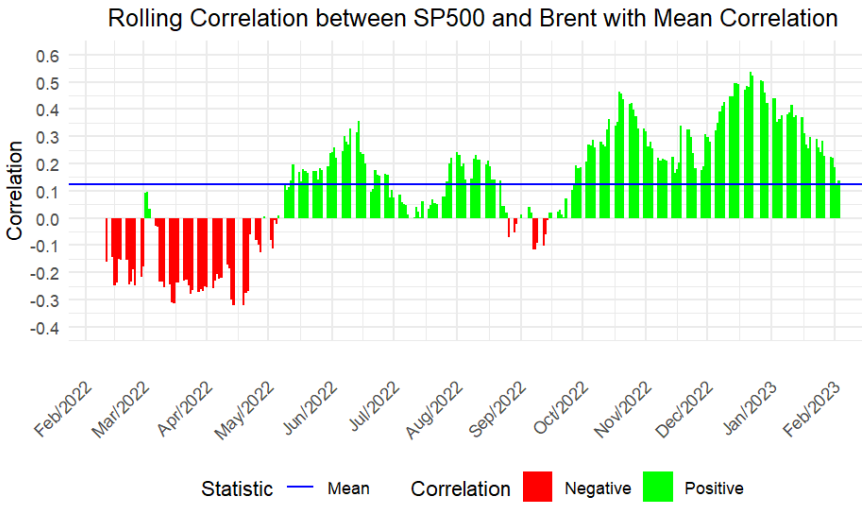

Figure 10: 30-day rolling correlation between SP500 and Brent during the war period

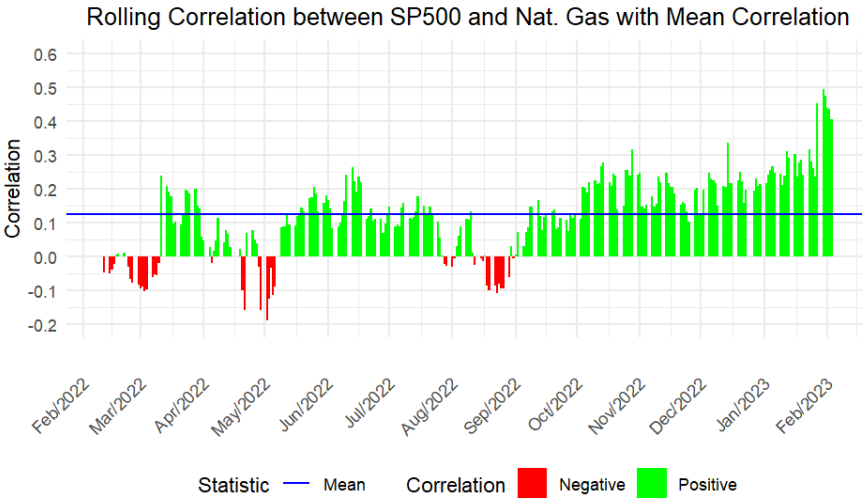

Figure 11: 30-day rolling correlation between SP500 and Nat. Gas during the war period

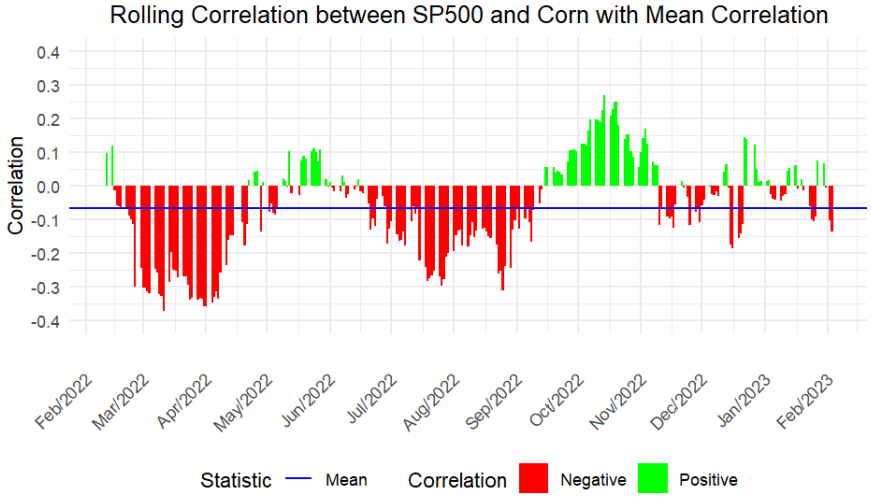

Figure 12: 30-day rolling correlation between SP500 and Corn during the war period

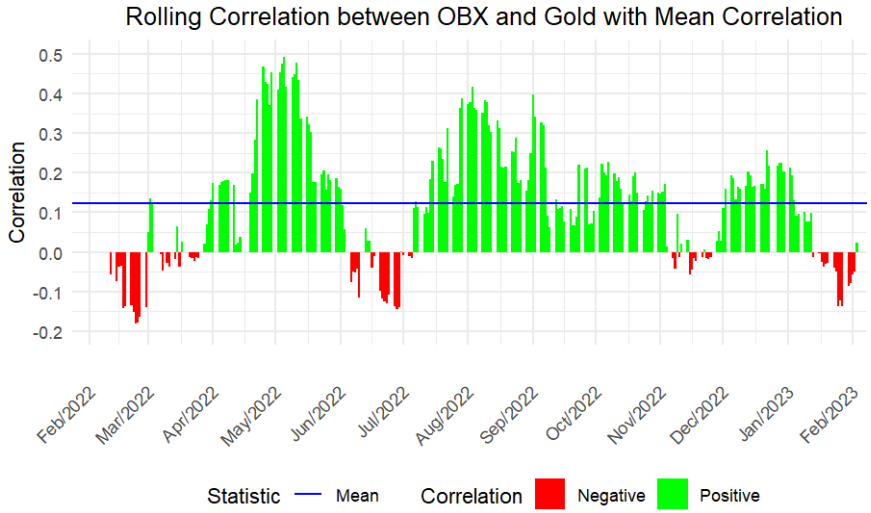

Figure 13: 30-day rolling correlation between OBX and Gold during the war period

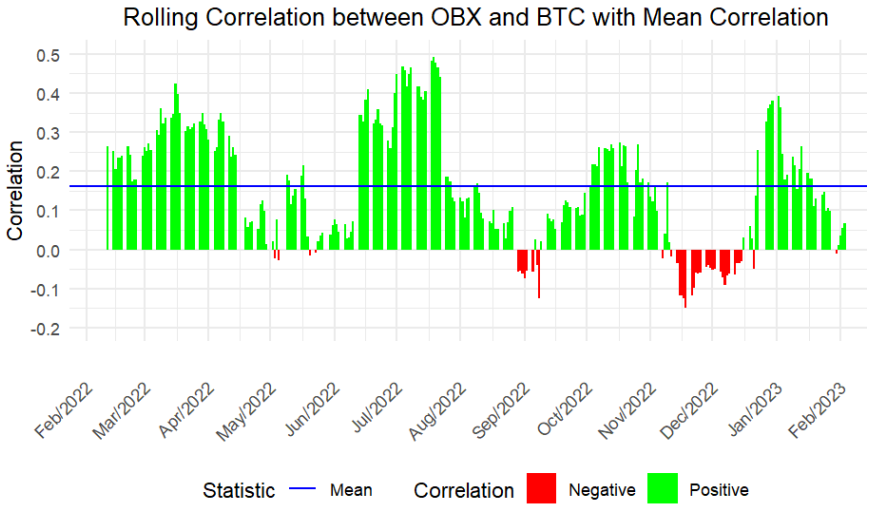

Figure 14: 30-day rolling correlation between OBX and Bitcoin during the war period

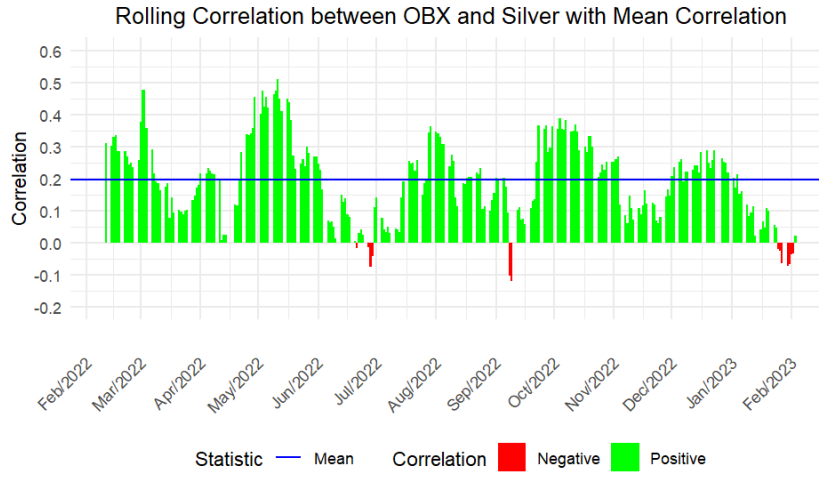

Figure 15: 30-day rolling correlation between OBX and Silver during the war period

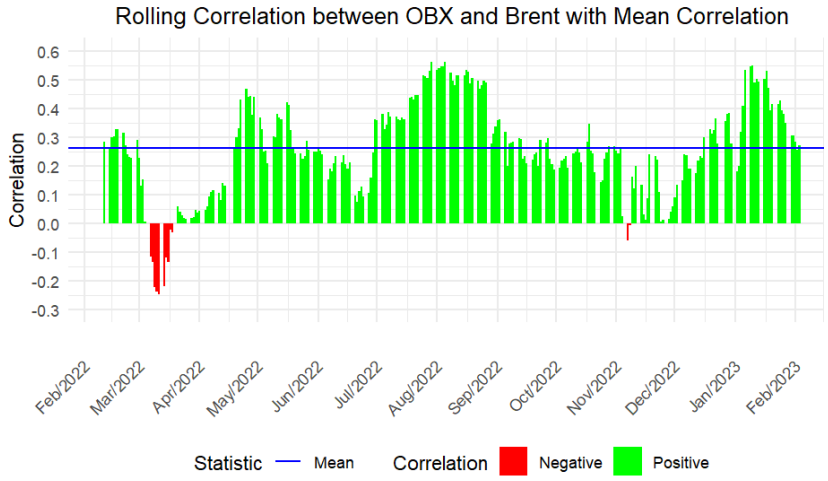

Figure 16: 30-day rolling correlation between OBX and Brent during the war period

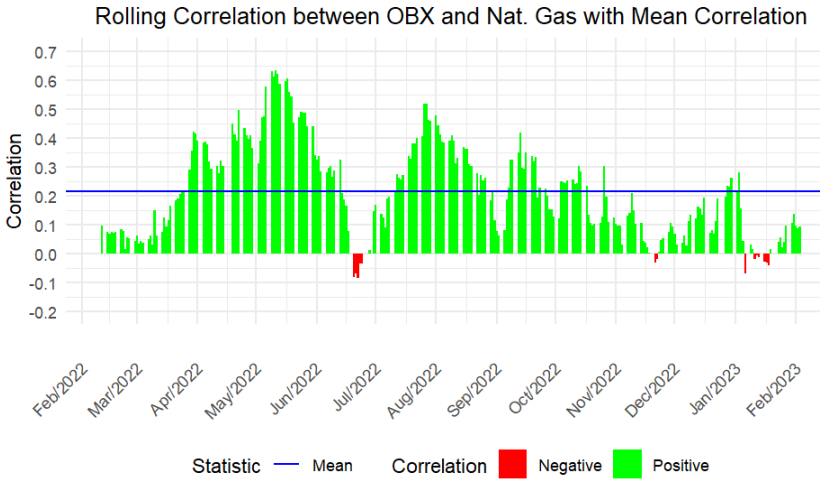

Figure 17: 30-day rolling correlation between OBX and Nat. Gas during the war period

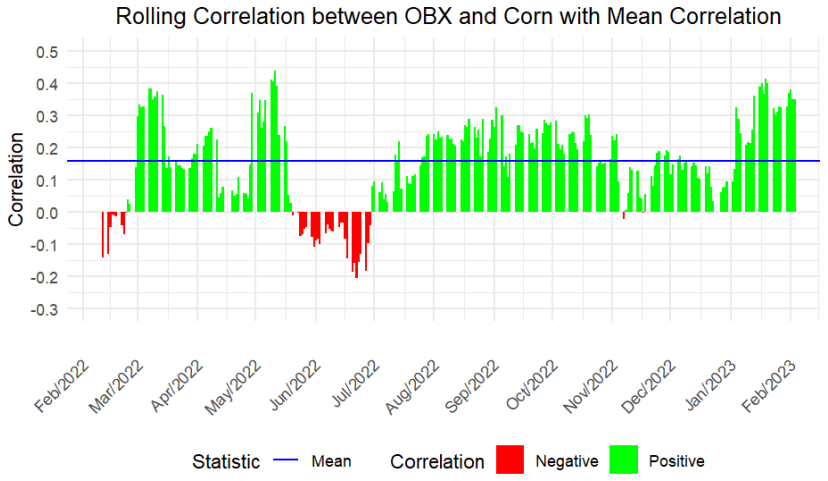

Figure 18: 30-day rolling correlation between OBX and Corn during the war period

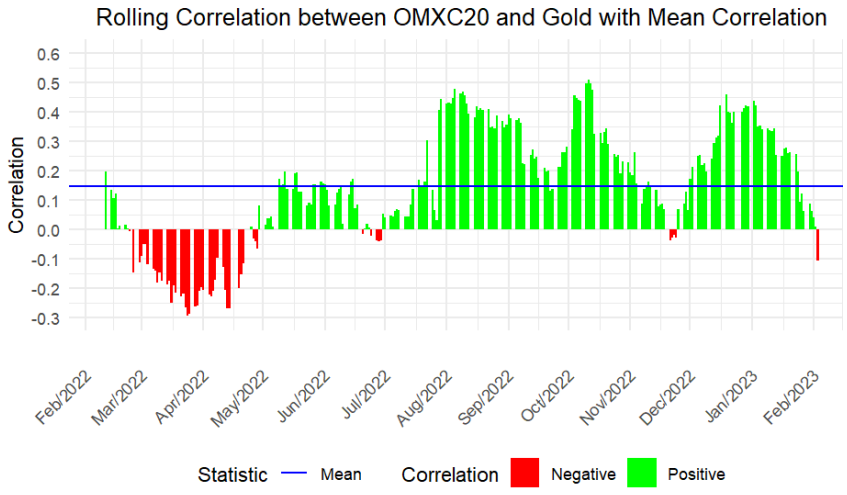

Figure 19: 30-day rolling correlation between OMXC20 and Gold during the war period

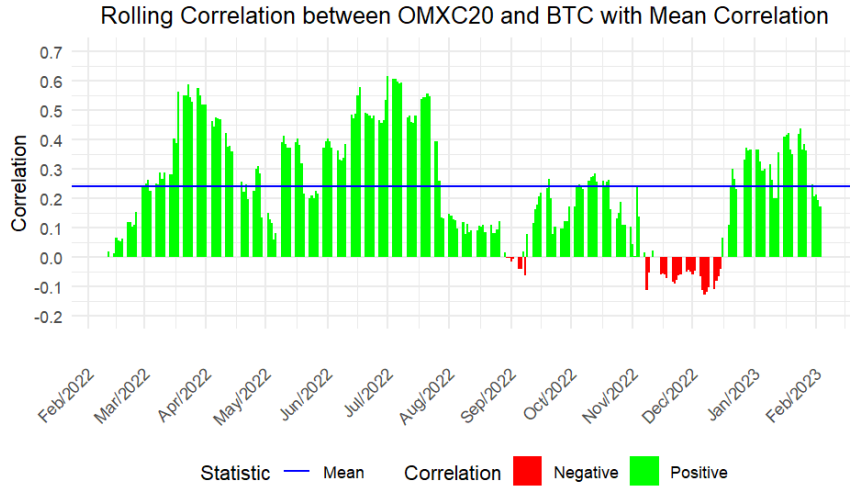

Figure 20: 30-day rolling correlation between OMXC20 and Bitcoin during the war period

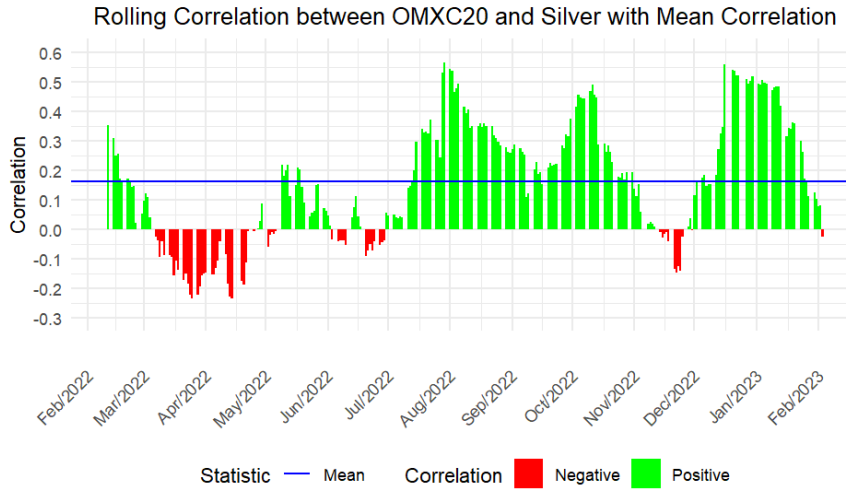

Figure 21: 30-day rolling correlation between OMXC20 and Silver during the war period

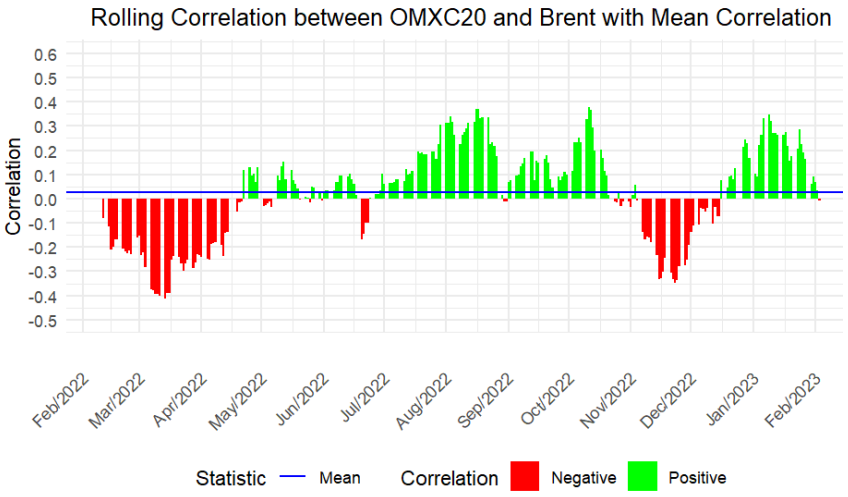

Figure 22: 30-day rolling correlation between OMXC20 and Brent during the war period

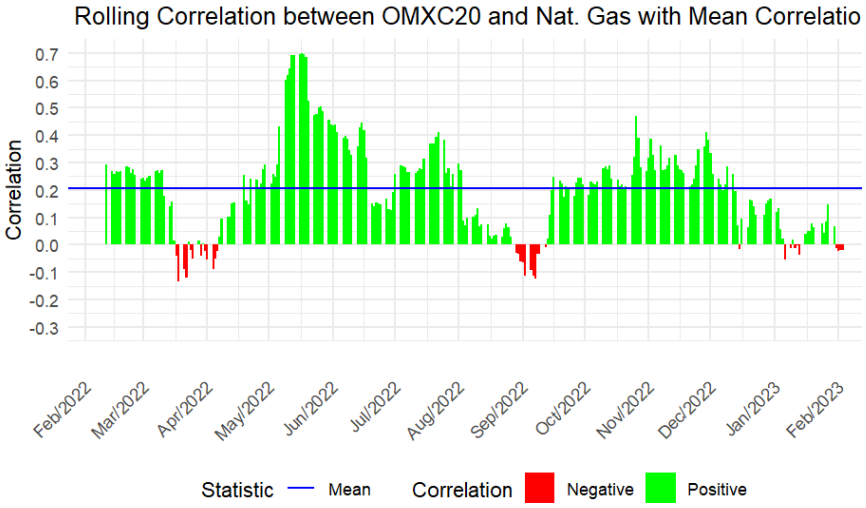

Figure 23: 30-day rolling correlation between OMXC20 and Nat. Gas during the war period

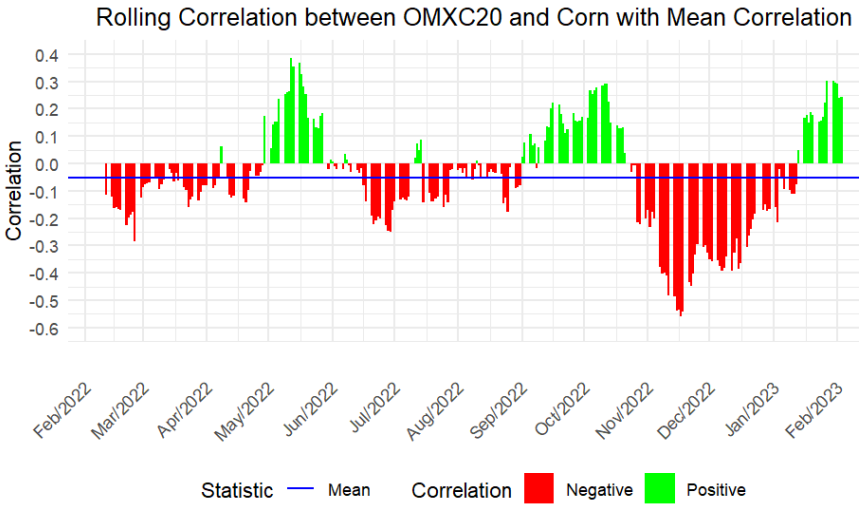

Figure 24: 30-day rolling correlation between OMXC20 and Corn during the war period

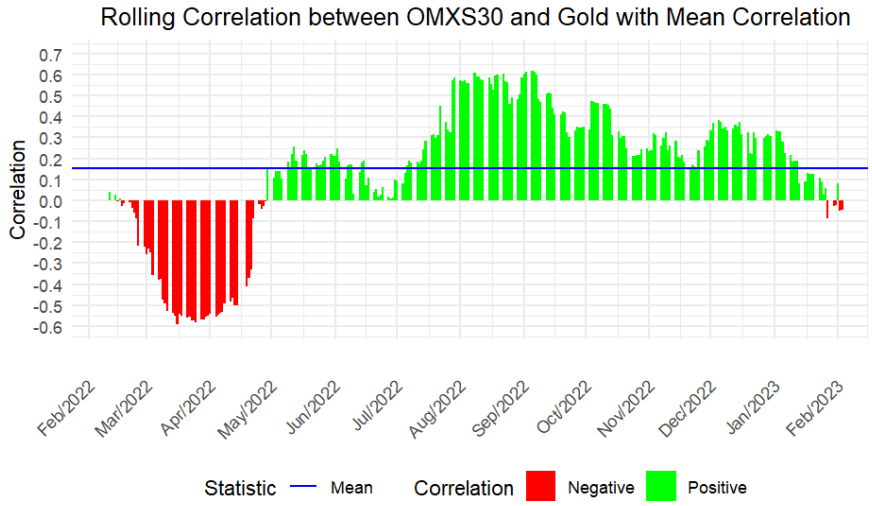

Figure 25: 30-day rolling correlation between OMXS30 and Gold during the war period

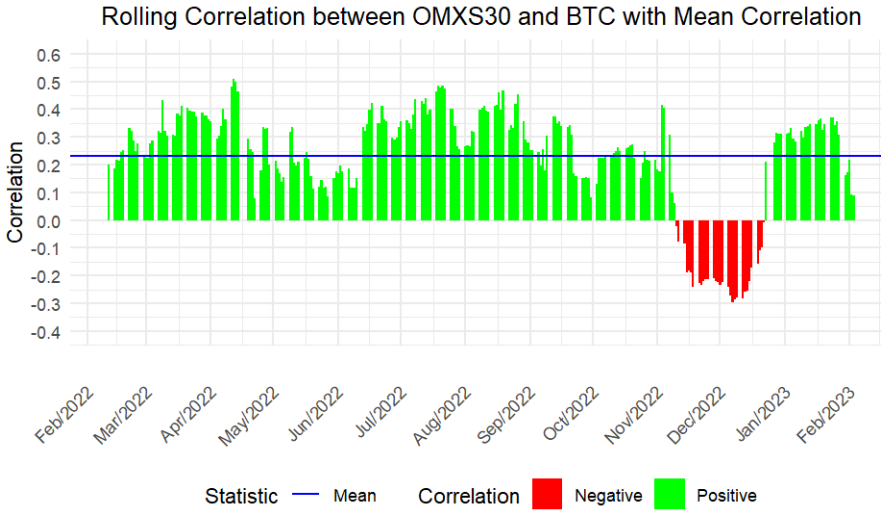

Figure 26: 30-day rolling correlation between OMXS30 and Bitcoin during the war period

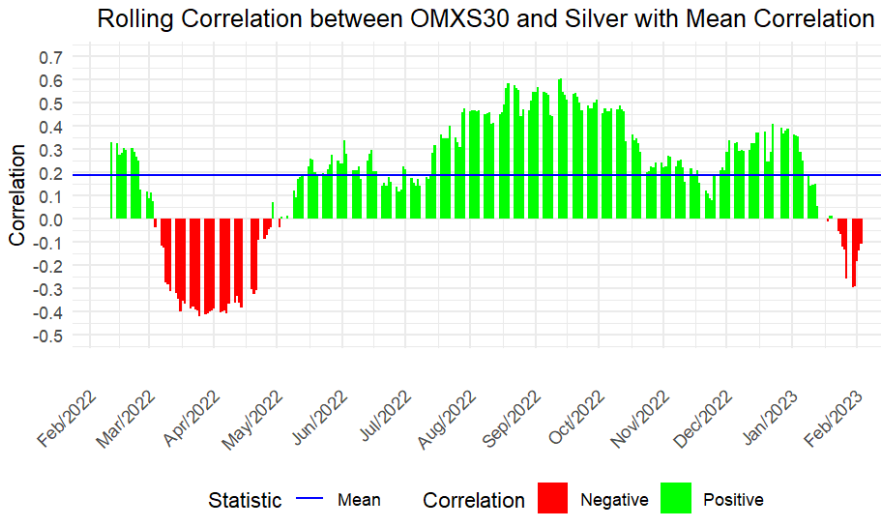

Figure 27: 30-day rolling correlation between OMXS30 and Silver during the war period

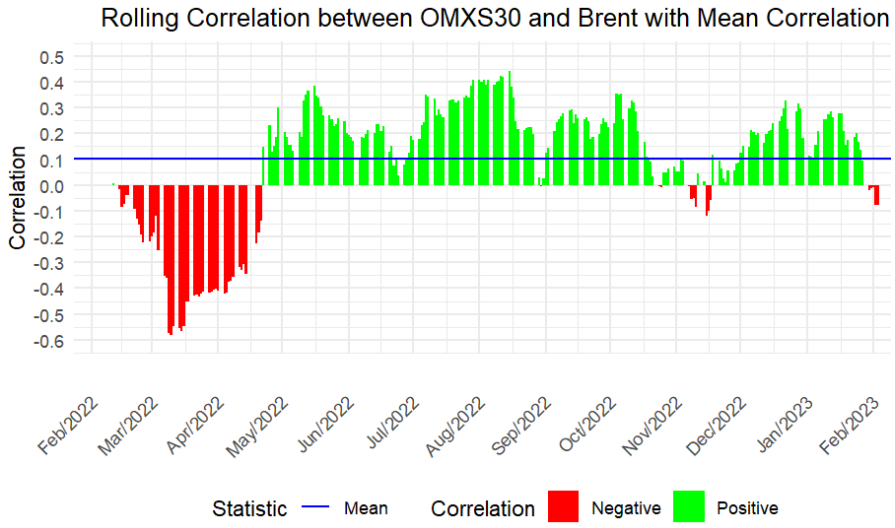

Figure 28: 30-day rolling correlation between OMXS30 and Brent during the war period

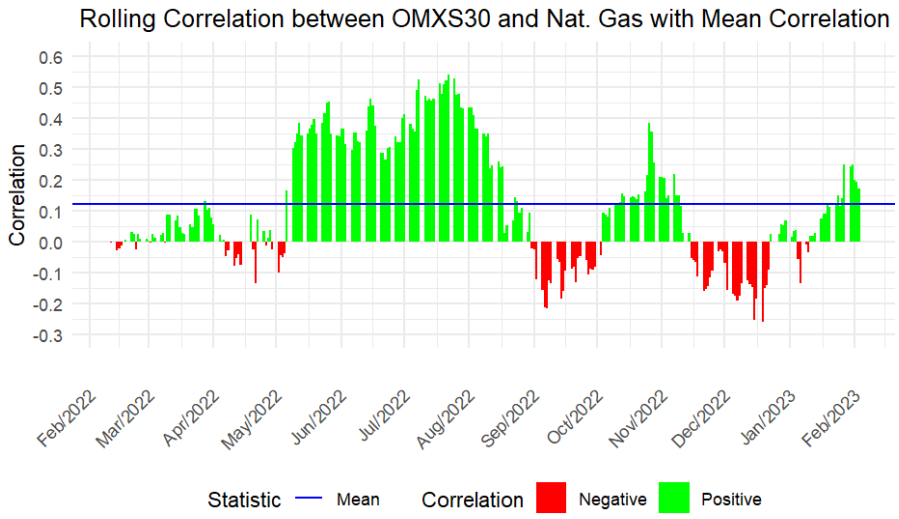

Figure 29: 30-day rolling correlation between OMXS30 and Nat. Gas during the war period

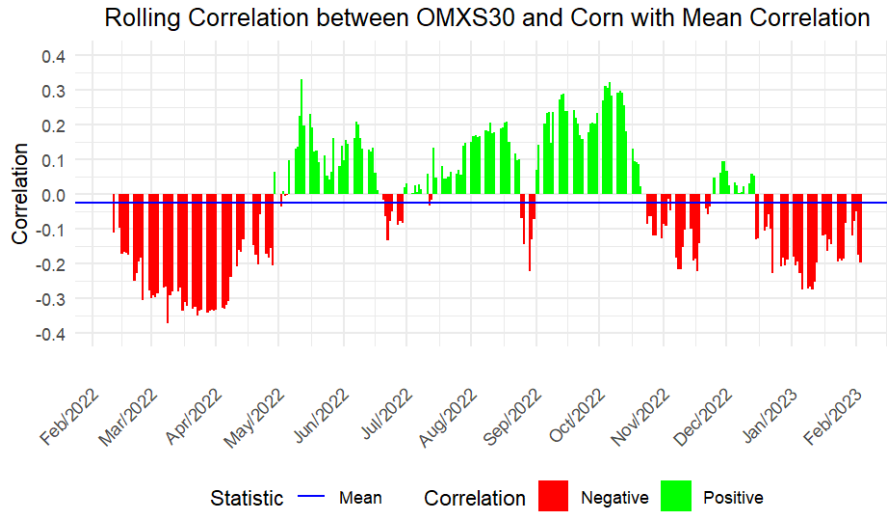

Figure 30: 30-day rolling correlation between OMXS30 and Corn during the war period