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The relationship between oil prices and the BRICS stock markets before and after the onset of Covid-19 pandemic

Differences in oil importing and oil exporting countries

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ABSTRACT:

The purpose of this study is to examine the relationship between the BRICS stock markets and global oil prices. The paper investigates how the fluctuations in oil prices impact the stock returns in BRICS countries before and after the onset of Covid-19 pandemic. The BRICS countries have become an important part of the global financial markets, and they are among the fastest growing economies in the world. Hence it is essential for market participants to understand the influence of different global factors, such as oil price, on these markets. In addition to their importance for the global financial markets, the BRICS countries include some of the most important oil exporters and oil importers in the world. Therefore it will be interesting to examine whether there are differences in the oil price-stock market relationship between the oil importing and oil exporting BRICS economies.

The study uses the daily MSCI index returns of each BRICS stock market as well as the Brent and WTI oil prices. The daily returns are analyzed over a period from November 19, 2014 to January 30, 2023. This study utilizes a multiple linear regression model in order to empirically examine whether there is a significant relationship between the global oil prices and the BRICS stock returns during the study period. In order to control the macroeconomic circumstances, exchange rate and interest rate changes are added to the model as control variables, in addition to the global market returns.

The empirical analysis finds evidence that, in general, there is a significant relationship between the BRICS stock returns and global oil prices. The degree of the relationship is not consistent through the whole study period, and it varies between oil importing and oil exporting countries. Oil exporting countries have a positive and generally stronger relationship with the oil price movements, whereas in oil importing countries, the relationship is mostly negative. Additionally, in contrast to previous studies, not much evidence is found of a stronger relationship since the onset of the Covid-19 pandemic.

KEYWORDS: Oil prices, stock returns, BRICS, emerging economies, Covid-19 pandemic

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TIIVISTELMÄ:

Tämän tutkimuksen tarkoituksena on tutkia BRICS osakkemarkkinoiden ja globaalien öljyn hintojen välistä yhteyttä. Tutkimus selvittää, kuinka heilunnat öljyn hinnassa vaikuttavat osaketuottoihin BRICS maissa ennen koronapandemian alkua sekä sen jälkeen. BRICS maista on tullut tärkeä osa globaaleja rahoitusmarkkinoita ja ne ovat maailman nopeiten kasvavien talouksien joukossa. Sen vuoksi markkinaosapuolille on tärkeää ymmärtää globaalien muuttujien, kuten öljyn hinnan, vaikutus näillä markkinoilla. Sen lisäksi, että BRICS mailla on merkittävä vaikutus globaaleihin rahoitusmarkkinoihin, nämä maat ovat yksiä maailman tärkeimpiä öljyn viejiä ja tuojia. Niinpä on mielenkiintoista tutkia onko öljyn hinnan ja osakemarkkinoiden välisessä suhteessa eroja niiden BRICS maiden välillä, jotka ovat öljyn tuojia ja niiden, jotka ovat öljyn viejiä.

Tutkimus käyttää päivittäisiä MSCI indeksituottoja jokaiselta BRICS osakemarkkinalta ja lisäksi Brent ja WTI -öljyjen hintoja. Päivittäisiä tuottoja analysoidaan ajanjaksolla, joka alkaa 19. marraskuuta, 2014 ja päättyy 30. tammikuuta, 2023. Tämä työ hyödyntää usean muuttujan lineaarista regressioanalyysia tutkiakseen empiirisesti, onko globaalien öljyn hintojen ja BRICS osaketuottojen välillä merkittävää suhdetta tutkimusajanjakson aikana. Jotta makroekonomisia olosuhteita voidaan kontrolloida, valuuttakurssi- ja korkokurssimuutokset lisätään regressioon kontrollimuutujiksi, globaalien markkinatuottojen lisäksi.

Empiirisen analyysin tulokset osoittavat, että yleisesti BRICS osaketuottojen ja globaalien öljyn hintojen välillä on merkittävä suhde. Suhteen aste ei ole yhtenäinen koko tutkimusjakson ajan ja se vaihtelee öljyn tuonti- ja öljyn vientimaiden välillä. Öljyn viejämailla on positiivinen ja yleisesti vahvempi suhde öljyn hintojen kanssa, kun taas öljyn tuojamailla suhden on enimmäkseen negatiivinen. Lisäksi, verrattuna aiempiin tutkimuksiin, vahvemmasta suhteesta koronapandemian alkamisen jälkeen ei juurikaan löydetty todisteita.

AVAINSANAT: Oil prices, stock returns, BRICS, emerging economies, Covid-19 pandemic

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1 Introduction

Oil has been the world's most traded commodity since 2000 and its importance in our society is well known. Oil is one of the key facilitators of our life as it is needed for numerous different purposes. Crude oil is used, for example, in transportation, heating and electricity generation as well as in the production of different plastics, chemical products and synthetic materials. Since oil is such an essential commodity, it has a significant influence on the global economy, and it is considered as an important driver of the economic and industrial activity. Therefore, movements in oil prices are closely followed by both policymakers and investors. (Ali, Mensi, Anik, Rahman and Kang, 2020; Aloui, Nguyen and Njeh, 2012.) Furthermore, some previous studies provide evidence that oil prices negatively affect economic growth through different channels, such as inflation, rising production cost, and investor confidence (Lardic and Mignon, 2008; Killian, 2008; Hamilton 2003). Therefore, it could be assumed that there is at least some degree of interdependence also between oil prices and stock market returns.

The correlation between oil prices and stock returns might be either negative or positive. For example, because oil is an important input for many firms, increasing oil prices are reflected in companies as increased production costs, which leads to decreasing stock returns. However, crude oil prices often reflect market expectations regarding future macroeconomic variables, like for example, aggregate demand, implying that increases in oil prices lead to increases in demand (Heinlein, Legrenzi and Mahadeo, 2021). Kollias et al. (2013:744) also note that investors often associate higher oil prices with a booming economy, implying stronger business performance. These assumptions, on the other hand, are drivers of a positive correlation between stock returns and oil prices.

When assessing the relationship between oil prices and stock returns, one should distinguish between oil importing and oil exporting countries. Wang et al. (2013) have found that the magnitude, duration, and even direction of stock markets' response to oil price shocks are highly dependent on whether the country is oil importer or exporter. Increases in oil prices could be expected to have positive effects on stock returns in countries which are oil exporters, because higher oil prices will increase the country's income. On the other hand, in oil importing countries, increased oil prices could be expected to have a negative effect on stock returns, as oil is one of the main inputs of production.

For global investors, who are seeking for international diversification benefits by including assets of emerging markets into their portfolios, new information about the effects of oil on the assets' risk-return profile in these markets is especially important as they can better manage the risk incorporated to their portfolios (Aloui et al., 2012). Further, assessing the impacts of oil price fluctuations on emerging stock market returns is important for number of reasons. As a result of financial liberalization and increased integration, emerging markets, and especially the BRICS markets, have become a significant part of global financial markets. Therefore, it is important for market participants to understand the influence of various global financial and economic factors on these markets, given especially that investment, risk diversification and speculation opportunities may arise. (Mensi et al., 2014; Kocaarslan et al., 2017.)

The BRICS markets are the fastest growing economies, China and India being the top two countries in the world, measured by the GDP (Brennan, 2020). During the 2008-09 global financial crisis, economic growth of emerging countries outperformed economic growth in developed countries. The statistics of International Monetary Fund show that in 2009 the GDP of developed countries decreased -3.6% on average, whereas the GDP in emerging economies increased by 1.7% on average. Furthermore, it has been predicted that emerging economies will account for approximately 50% of the global GDP by 2050 and be the primary driving force for the global economic growth. (Cheng et al., 2007; Aloui et al., 2012.) In addition to this rapid economic growth in emerging economies, especially in the BRICS countries, global oil demand grew annually by an average of 1,153 million barrels per day over the period 2001-2010.

The impact of higher oil prices is found to be stronger in emerging stock markets than in those of developed markets. Bhar and Nikolova (2009) explain that this is mainly because of the energy intensiveness of emerging economies as they experience rapid economic growth and, in general, use energy less efficiently. Therefore, given the oil intensity of the BRICS economies and the growing capital inflow and international investment in these markets, it is essential for global investors and other market participants to have a better understanding of the relationship between oil prices and the BRICS stock markets.

On April 20^{th}, 2020, price of the West Texas Intermediate (WTI) crude oil fell into negative levels for the first time in history. Likewise, the price of Brent dropped under 20 dollars per barrel against the average price of 64 dollars in 2019. Before this, on March 11^{th}, 2020, the World Health Organization had announced the outbreak of the Covid-19 pandemic. Shortly after, strict lockdowns, travel restrictions and social distancing were imposed by many governments around the world. These efforts to control the spread of the disease disrupted also the global supply chains and reduced aggregate demand (Vidya and Prabheesh, 2020). Consequently, oil consumption dropped substantially as well as the crude oil prices, as described above.

After the oil demand had returned to its normal levels, another crisis took place. First, the rapid economic growth after the pandemic outpaced energy supply globally. Then, in 2022, Russian invasion of Ukraine began on February 24, and it has been since ongoing. As a result, the Western countries' demand of Russian oil dropped, and ultimately also sanctions towards Russia were issued, including an embargo on Russian seaborne crude oil. On the other hand, Russia reduced its gas deliveries to Europe. Together all these actions caused energy prices to reach record high levels, leading to a global energy crisis in 2022.

In addition to its impacts on energy prices as well as on oil demand and supply, the Russian-Ukrainian war has notable effects on financial markets. As described by Adekoya et al. (2023), the war has increased the price of oil, the most traded commodity in the world, which is further impacting the economic performance of both oil exporting and oil importing countries. Therefore policymakers and market participants want to understand the changes happening in market dynamics due to the war in order to hedge their investments and maximize future opportunities in such cases. (Adekoya et al., 2023.)

1.1 Purpose of the study

This study aims to investigate the relationship between oil prices and the BRICS stock markets before and after the Covid-19 pandemic. Furthermore, this study distinguishes between oil exporting and oil importing countries when assessing that relationship. The relationship between oil prices and stock markets has been studied before, but a vast majority of these studies are focusing on developed countries. Moreover, within these previous studies, the results have been rather inconclusive, and that might be due to country specific factors, such as, different industrial structures, the state of countries' financial markets and levels of dependence on oil imports and exports. Therefore, it is essential to distinguish between these country specific factors, like for example, the fact whether the country is an oil importer or oil exporter. Considering these country specific factors and their importance in assessing the relationship between oil prices and the stock markets, not many previous studies differentiate between oil exporting and importing countries or do a comparison between them.

Since the onset of the Covid-19 pandemic, the world faced an unexpected situation when lockdowns were announced worldwide and transportation, especially air traffic, plunged. This had obvious consequences on oil demand and further oil prices. Previous literature has shown that global financial crisis has had a significant influence on the correlations between oil prices and the BRICS stock markets. Therefore, this study aims to find whether there are similar changes in the correlations between these markets, caused by the onset of the Covid-19 pandemic. Furthermore, it will be interesting to examine what kind of differences there might be between the oil exporting and oil importing countries, as the BRICS countries include both, oil exporters and oil importers. Finally, this study's scope will also include the Russian-Ukrainian war. At the beginning of the war, as a result of the disruption of crude oil supply from Russia, global oil prices reached the highest levels in 8 years as. As a critical factor in the global financial markets, this significant increase in oil prices could have an impact on the performance of other financial assets, such as stocks (Adekoya et al., 2022).

1.2 Research hypothesis

The main objective of this thesis is to investigate the relationship between the BRICS stock markets and oil price in periods before and after the Covid-19 pandemic. Furthermore, the aim is to investigate the impacts of the Covid-19 pandemic on the dependence between the oil prices and the BRICS stock markets. And finally, this thesis investigates whether the degree and/or structure of the dependence differs for oil importing and oil exporting countries. Therefore, the hypothesis of this thesis are:

H1: There is significant relationship between oil prices and the BRICS stock markets during the study period.

H2: The onset of the Covid-19 pandemic has made the relationship between oil prices and the BRICS stock markets stronger.

H3: The degree and/or structure of the dependence is different for oil importing and oil exporting countries.

1.3 Structure of the study

This paper is divided into ten main chapters. The first chapter gives an introduction and presents the purpose of the study as well as the research hypothesis. That is followed by a chapter that presents the most relevant finance theories, including the efficient market theory as well as some common stock market pricing models. Next, the study moves on to discuss about the oil markets and their growing complexity and introduce the main factors affecting in oil price fluctuation.

In the fourth chapter the theoretical relationship between oil prices and stock returns are introduced. The chapter will discuss transmission mechanisms, such as the cash flow hypothesis, through which the oil price movements can influence the behavior of stock returns. Next, the fifth chapter will go through previous studies and discuss about their main findings. Following that, the thesis continues by introducing the data and providing the summary statistics of the data. This is followed by the introduction of the used methodology in chapter seven. Then the results of the empirical research are introduced and discussed in more detail. Finally, this study ends with a conclusion, which shortly discusses about the main topics covered in the study and presents ideas for future research as well as the most relevant findings and implications of the results.

2 Financial theory background

2.1 The efficient market hypothesis

In 1953 Maurice Kendall examined the behavior of stock market prices over time and found that there are no predictable patterns in stock price movements. On the contrary, prices seemed to move randomly. At first, Kendall's findings were ignored in the finance world, but later on they became labelled as the random walk model. (Bodie et al., 2013:350; Dimson and Mussavian, 1998.) The argument that stock prices should follow a random walk, relies on the notion that price movements should be random and unpredictable. Moreover, if prices are rationally determined, only new information will cause them to move. Consequently, prices that always reflect all current and available information would follow the random walk. (Bodie et al., 2013:350-351.)

The efficient market hypothesis was introduced by Fama (1970), and it has since become one of the cornerstones of financial theories. According to Fama (1970), markets are efficient when all available information is reflected in the asset prices. In his seminal paper (1970) Fama reviews the early random walk literature and introduces the three forms of market efficiency, which are the weak form, semi-strong form and strong form. These three forms of market efficiency differ by their notions of what is meant by the term "all available information." (Bodie et al., 2013:352-353.)

According to the weak form efficiency, all historical information of stock prices is incorporated in the current stock prices. This type of information includes, for example, data of past prices, trading volumes and short interest. The weak form of the hypothesis is the most tested one and has received a wide support in the academic world (Fama, 1970). It relies on the notion that past stock price data is publicly available and virtually free and therefore, all investors have already exploited the possible signals of future performance (Bodie et al., 2013: 253).

The semi-strong form of efficiency states that all publicly available information is already reflected in the stock prices. Furthermore, it indicates that stock prices respond to new information, such as earnings announcements and stock splits, rapidly and accordingly. (Brealey et al., 2020: 343; Bodie et al., 2013: 354.). Ball and Brown (1968) and Fama (1969) study the reaction of stock markets to company announcements and find that the market seems to be anticipating the information, and the majority of price adjustment is done even before the news is released to the market (Dimson and Mussavian, 1998).

Finally, the strong form of the efficient market hypothesis denotes that stock prices fully reflect all relevant information to the firm, including also the private information available only to company insiders (Bodie et al., 2013: 354). In theory, this means that there should not be a way that one could outperform the market consistently, because all available information is incorporated into the stock prices.

All versions of the efficient market hypothesis states that, at given time, using current information, it should not be possible outperform the market due to the fact that stock prices already reflect all available information. It is pointed out, however, by Bodie et al. (2013), that the degree of efficiency may vary between various markets. For instance, emerging markets are often less efficient due to the fact that their financial markets are not as developed, they are not as heavily analyzed compared, e.g., to the US markets, and they usually have not as strict accounting disclosure requirements. Therefore, in these markets, some stocks might be less efficiently priced than others, or they might not react to new information as quickly. (Bodie et al., 2013: 352.)

2.2 Stock market pricing

In order to examine the impact of oil price on stock market returns, we need to understand the concept of share valuation, i.e., how the stock is priced. Valuation of stocks is one of the most essential aspects of investing, making it also a popular subject for examination and analysis. Fundamentally, stock valuation is a process of determining the intrinsic value of a stock. Intrinsic value refers to a value that is theoretical in nature, meaning that the value is not affected by its market price. The importance of stock valuation develops from the fact that the intrinsic value of a stock can be different from its current market price. By determining a stock's intrinsic value, an investor can define whether the stock is over- or undervalued at its current market price.

Essentially, stock valuation methods can be divided into two different types, which are absolute valuation and relative valuation. Absolute stock valuation relies only on the company's fundamental information, and it is used to calculate the intrinsic value of the stock. Absolute valuation methods utilize various financial information, such as, the company's cash flows, growth rates and dividends, which can be found from the company's financial statements. Popular absolute stock valuation techniques include, for example, the discounted cash flow model (DCF) and the dividend discount model (DDM).

Relative stock valuation, on the other hand, uses ratio analyses and compares the potential investment to other companies. This method calculates multiples of similar companies and tries to derive a target company's stock's value through these multiples. The two main types of valuation multiples are equity multiplies and enterprise value multiples. The most often used equity multiple is price-to-earnings ratio, also known as P/E ratio, and it represents the company's profit-making capability. Another commonly used multiple is price-to-book ratio, or P/B ratio, which is used to compare a company's current market value to its book value. It should be considered, however, that companies have different amounts of debt which ultimately influence equity multiplies. Therefore, it is sometimes more appropriate to use enterprise value multiples, as they eliminate the impact of debt financing. The most commonly used enterprise value multiple is the EV/EBITDA ratio. It compares the company's enterprise value (EV) to its earnings before interest, taxes, depreciation and amortization (EBITDA) and it is often used as a valuation method to compare the relative value of different companies. (CFI, 2022.)

Above, only the few most commonly used valuation methods and ratios are discussed. In addition to those, valuation methods can consider, for instance, debt, operating performance, liquidity and other profitability and cash flow measures. In addition, when valuing stocks, one needs to be able to filter the relevant information from all of that information available and use a variety of investment valuation ratios in order to achieve the most accurate results. Next, this paper moves on to present some of the most commonly used asset pricing models in order to provide more in detail information about the essential financial theory background for this study.

2.2.1 Capital asset pricing model

The capital asset pricing model, often referred to as the CAPM, is a fundamental piece of modern financial theory. Even though it is not fully supported by empirical tests, it is widely used because of its simplicity and the insight it offers in a variety of situations. It gives us an accurate prediction of the relationship we should expect to see between a systematic risk of an asset and its expected return. (Bodie, Kane and Marcus, 2013:291.) Using Harry Markowitz (1952) portfolio theory as a foundation, William Sharpe (1964) and John Lintner (1965) developed the capital asset pricing model, which marks the birth of asset pricing theory (Bodie et al., 2013; Fama and French, 2004.) Decades later, the CAPM is still broadly used in different applications, like for example, evaluating the performance of managed portfolios and estimating the cost of capital for companies. The popularity of the CAMP relies on the fact that it offers robust predictions about how to measure risk and the relationship between risk and expected return. (Fama and French, 2004.)

The model considers the asset's sensitivity to market risk, also known as non-diversifiable or systematic risk, which is often represented by beta (β), in addition to the expected return of the market and the expected return of a theoretical risk-free asset. In other words, the CAPM is based on the relationship between an asset's beta, the equity risk premium, and the risk-free rate. In the CAPM, risk and return go hand in hand: higher risk leads to a higher return, whereas lower risk comes with lower returns. The results of the capital asset pricing model are plotted in the security market lane, SML, for all the different betas.

In Markowitz's model of portfolio choice, an investor chooses a portfolio at time $t - 1$ that produces a stochastic return at t. The model presumes that investors are risk averse and, when choosing between portfolios, they care only about the mean and variance of their one-period investment return. Therefore, investors choose "mean-variance-efficient" portfolios, in the sense that the portfolios 1) minimize the variance of portfolio return, given the expected return, and 2) maximize expected return, given variance. The portfolio model generates an algebraic condition on asset weights in mean-variance-efficient portfolios. In the CAPM, this algebraic condition is further developed into a testable prediction about the relationship between risk and expected return by identifying a portfolio that must be efficient if asset prices are to clear the market of all assets. (Fama and French, 2004.)

In order to derive conditions for equilibrium in the capital market, Sharpe (1964) and Lintner (1965) add two key assumptions to the Markowitz's model. First, there is borrowing and lending at risk-free rate, which is the same for all investors and is not dependent on the amount borrowed or lent. Secondly, investors are assumed to have homogeneous expectations: investors agree on the prospects of different investments, such as the expected values, standard deviations and correlation coefficients. (Sharpe, 1964.)

Given the assumption that there is risk-free borrowing and lending, the expected return on assets that are uncorrelated with the market return $E(R_M)$, must equal the risk-free rate R_f. Consequently, the relationship between expected return and beta then becomes the Sharpe-Lintner CAPM equation, which can be denoted as follows (Sharpe, 1964; Fama and French, 2004):

$$E(R_i) = R_f + \beta_i\left[E(R_M) - R_f\right] \quad (1)$$

where:

$E(R_i)$ = expected return of an asset

R_f = risk-free rate

β_i = beta of an asset

$E(R_M)$ = expected return of the market

$[E(R_M) - R_f]$ = market risk premium

Even though the CAPM is widely used, it has also been a subject of criticism since its release, mostly due to the unrealistic assumptions it requires to be derived. These assumptions include, for example, market equilibrium, the ability to borrow or lend at a common risk-free rate, no transaction costs, all information is publicly available, and that investors are rational, mean-variance optimizers and have homogeneous expectations (Brealey et al., 2020: 212; Bodie et al., 2013:304; Levy, 2010). One example of theoretical criticism is the prospect theory by Kahneman and Tversky (1979), which shows that typical investors are not always rational and risk-averters (Levy, 2010). In addition, in their regression approach Fama and French (1992) find that size and book-to-market ratio contribute to the explanation of average stock returns associated with the market beta. Based on their findings, Fama and French (1993, 1996) suggest a new model for asset pricing. This model will be presented in the next section of this paper.

2.2.2 Factor models

One of the simplest asset pricing models is the single-index model (SIM), developed by William Sharpe in 1963. It is commonly used to measure both the risk and the return of an asset. The single-index model assumes that only one macroeconomic factor causes systematic risk and therefore affects the stock returns. More precisely, this model uses the market index, such as the S&P 500, to proxy for the common macroeconomic factor. (Bodie et al., 2013:256-259.)

To estimate systematic risk, the single-index model utilizes past return rate data on market indexes, like for example, the S&P 500. The model denotes the market index by *M*, with excess return of $R_M = r_M - r_f$, and standard deviation of σ_M. Given the linearity of the single-index model, the sensitivity (or beta) coefficient of a security on the index can be estimated by using a single-variable linear regression. The excess return of a security, $R_i = r_i - r_f$, can be regressed on the excess return of the index, R_M. In order to estimate the regression, a historical sample of paired observations, $R_i(t)$ and $R_M(t)$, where t denotes the time of each observation, will be collected. Consequently, the regression equation of the single-index model can then be denoted as follows (Bodie et al., 2013:259)

$$R_i(t) = \alpha_i + \beta_i R_M(t) + e_i(t) \tag{2}$$

where:

$R_i(t)$ = the excess return of a security at time t.
α_i = the expected excess return of a security when the market excess return is zero.
β_i = the security's sensitivity to the index: It is the amount by which the security return increases or decreases for every 1% increase or decrease in the return on the index.
$R_M(t)$ = the excess return of the index at time t.
$e_i(t)$ = the unexpected residual: Firm specific surprise in the security return at time t.

Given that $E(e_i) = 0$, the expected return-beta relationship of the single-index model can be obtained as follows:

$$E(R_i) = \alpha_i + \beta_i E(R_M) \tag{2.1.}$$

From the above equation it can be seen that a security's risk premium, $E(R_i)$, consists of two parts. Part of it is due to the risk premium of the index. The market risk premium, $E(R_M)$, is multiplied the relative sensitivity, or beta, of the individual security. It is called also the *systematic* risk premium, because it is derived from the risk premium that characterizes the entire market, and which is used as a proxy for the condition of the full economy. The other part of the risk premium is denoted by the first term of the equation, alpha (α), which is a nonmarket premium. (Bodie et al., 2013:260.)

As mentioned earlier, Fama and French (1992) pointed out some failures of the CAPM in their analysis. Fama and French (1993) argue that while the size and book-to-market factors are not state variables themselves, the high book-to-market stocks and higher average returns on small stocks reflect unidentified state variables that generate undiversifiable risks in returns, which are not captured by the market return and are separately priced from the market betas (Fama and French, 2004). Based on their findings, Fama and French (1993, 1996) propose a new asset pricing model, the three-factor model, which incorporates three factors that appear to determine a security's expected returns. These factors are the market factor (the systematic risk factor), the size factor and the book-to-market factor. (Brealey et al., 2013; Fama and French, 2004.) The three-factor model for expected returns can be denoted as follows:

$$E(R_{it}) = R_{ft} + \beta_1 \left[E(R_{Mt}) - R_{ft} \right] + \beta_2 SMB_t + \beta_3 HML_t \tag{3}$$

Where:

$E(R_{it})$ = the expected return for an asset i
R_{ft} = the risk-free return rate
R_{Mt} = the market portfolio return
$\left[E(R_{Mt}) - R_{ft} \right]$ = the market risk premium
SMB_t = the size factor (small minus big)
HML_t = the value factor (high B/M minus low B/M)
$\beta_{1,2,3}$ = the beta coefficients of the factors

One implication of the three-factor model's expected return equation presented by Fama and French (2004) is that the intercept α_i is zero for all assets in the time-series regression:

$$R_{it} - R_{ft} = \alpha_i + \beta_1 \left(R_{Mt} - R_{ft} \right) + \beta_2 SMB_t + \beta_3 HML_t + \varepsilon_{it} \tag{3.1}$$

In the above equation the error term is denoted by ε_{it}. With the criterion on this equation, that the intercept is zero, Fama and French (1993, 1996) find that model captures a lot of the variation in average return for portfolios that are formed on book-to-market equity, size and other price ratios that are found to be problematic for the CAPM. The three-factor model has become widely used equation in empirical research when a model of expected returns is needed. (Fama and French, 2004.)

3 World oil markets

Oil has been the world's most important source of energy for many years now. In 2019 oil accounted for 33% of the global energy needs, with coal 27% and natural gas 24% as its nearest rivals (BP, 2021).

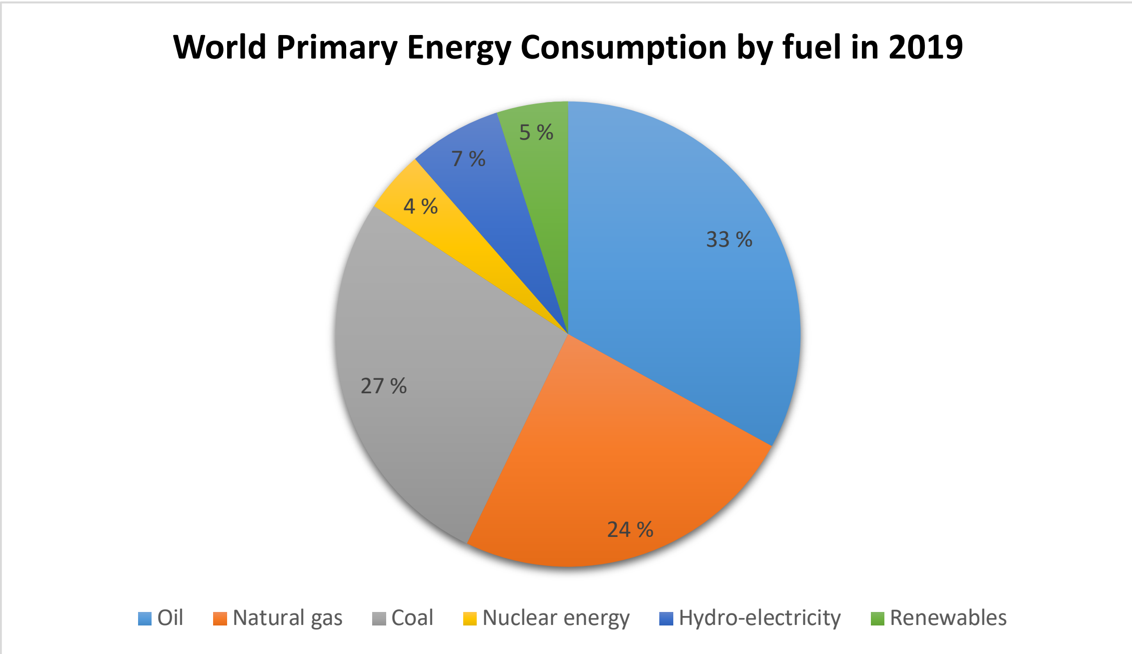

Figure 1. World Primary Energy Consumption by fuel in 2019 (BP Statistical review, 2021)

As a result, oil has become the world's largest traded commodity, measured both by volume and value. For instance, the physical crude oil market would be worth about 3.3 trillion US dollars per year if we were to assume a constant reference price of USD 100 per barrel applied to 2012 global demand of approximately 90 million barrels per day. Accordingly, for a market with this wide global reach and financial/physical size, the oil price reflects the interaction of countless considerations around supply and demand fundamentals as well as other risk factors. Moreover, it must be noted that in the recent years the market has become a lot more complex, due to the role of financial investors in particular, leading to debate the relationship between physical fundamentals and commodity prices. (Deutsche Bank, 2013.)

In addition to the growing complexity, oil markets have been through a notable turmoil due to the Covid-19 pandemic. The combination of the pandemic and the actions that occurred in order to limit its impact had an unprecedented effect in the global oil demand, as lockdowns around the world decimated the transport-related oil demand. The total primary energy consumption fell by -4.5% in 2020, which is the largest decline since the second world war. The drop was driven mostly by oil, which accounted for almost three-quarters of the net decline. Oil consumption alone declined by a record 9.1 million barrels per day, or total -9.3% to its lowest level since 2011. Similarly, also the oil production saw its largest drop since the second world war, -6.6 million barrels per day over the whole year. Oil prices followed these declines accordingly. Brent reached a low of under $20 per barrel, whereas the US WTI prices dropped to negative levels for the first time in history. The oil price (Dated Brent) averaged at its lowest level since 2004, at USD 41.84 per barrel. (BP, 2021.)

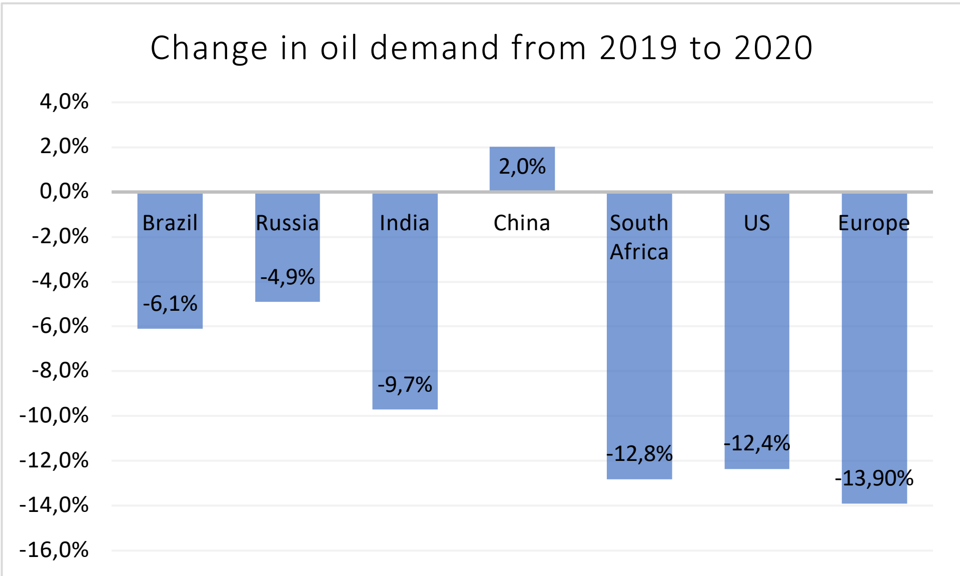

Figure 2. Change oil demand from 2019 to 2020 (BP Statistical review, 2021.)

It is essential to note that China was virtually the only country in the world where oil demand increased in 2020. The above figure shows the percentage change in oil demand in 2020 compared to 2019 in the BRICS countries as well as in the US and Europe. It is also worth noting that on average, the oil demand in the BRICS countries fell by -6.3%

on average, whereas in the US and Europe the average decline was over -13%. This can be explained, at least partly, with the energy intensiveness of the BRICS countries and emerging economies in general – these countries have high demand for oil and other energy sources due to their rapid economic growth and less efficient use of energy. Furthermore, OPEC forecast states that non-OECD countries, which includes all the BRICS countries, will drive oil demand growth in the future, whereas the OECD oil demand is expected to decrease by over 10 million barrels per day between 2021 and 2045 (OPEC, 2022).

Looking at the year 2021, when Covid-19 restrictions began to loosen and economic activity recovered, also the oil demand increased, however, remaining still below 2019 levels. This is mostly explained by the aviation-related oil demand, which remained 33% below 2019 levels in 2021, initially due to its slower recovery from the Covid-19 pandemic (BP, 2022; OPEC, 2022). In 2021 also the oil prices increased to the second highest level since 2015, averaging at USD 70.91 per barrel (BP, 2022).

The Covid-19 pandemic had an unseen impact on the global oil markets, as the above shortly describes the main effects. Given the significant fluctuations in the oil market, including the consumption as well as the production and price fluctuations, it is essential to examine in more detail the numerous different components of oil markets and how they ultimately impact the oil price. Next section of this thesis will introduce and go through the most important factors as well as some recent literature examining the influence of these factors on the oil price changes.

3.1 Oil price determination

As mentioned, oil is the world's most important commodity. As an essential source of energy as well as a financial investment tool, oil has a vital role in both modern industry and economic development. In addition, crude oil prices are the most widely monitored commodity price indicator in the world. The notable fluctuations in oil prices have a significant impact on the world economy. (Zhao, 2022; Ji and Guo, 2015.) As a result, there is a large amount of academic research that focuses on the crude oil prices and the factors affecting them.

Recent papers by Razek and Michieka (2019) and Zhao (2022) examine the influence of some of the main factors, such as, supply, demand, inventories and the US dollar exchange rate on the crude oil price volatility. Zhao (2022) states that supply and demand are still the most influential factors of oil price changes. Razek and Michieka (2019) examine the OPEC's influence on the global oil market as the recent decrease in OPEC's spare capacity has resulted analysts to question OPEC's ability to influence oil prices. Their empirical results reveal that OPEC still has an essential role in balancing oil markets, and especially in longer time horizons, it explains a large portion of the fluctuations in oil prices. These results are similar to those of Coleman (2012), who finds that OPEC market share has the most economically significant impact on long-term oil price. Regarding the other factors, Zhao (2022) finds that inventories and US dollar exchange rate both are relatively influential factors of crude oil price volatility.

3.1.1 Supply

Oil markets and oil production in particular cannot be discussed without highlighting the importance of the Organization of the Petroleum Exporting Countries, familiarly known as the OPEC (EIA, 2022). OPEC crude oil production can be described as centrally coordinated and controlled mainly by national oil companies. Non-OPEC production on the other hand, is performed primarily by independently operating, international investor-owned oil companies. These non-OPEC oil production companies consider economic factors when making investment decisions, aiming to increase shareholder value. Therefore, their investment and future supply capabilities are mainly functions of market conditions and are able to respond to changes in market conditions more readily. Even though some OPEC oil companies operate in a similar manner, their objectives also include building infrastructure, increasing revenues and providing employment to benefit their economies in a broader sense. (EIA, 2022; Razek & Michieka, 2019.)

Crude oil production by OPEC has a significant impact on oil prices, mostly due to the fact that it sets targets to manage oil production in its member countries. Historically, crude oil prices have increased in times when OPEC's production targets are mitigated (EIA, 2022). Below figure shows how changes in Saudi Arabia's crude oil production result in changes in WTI crude oil prices.

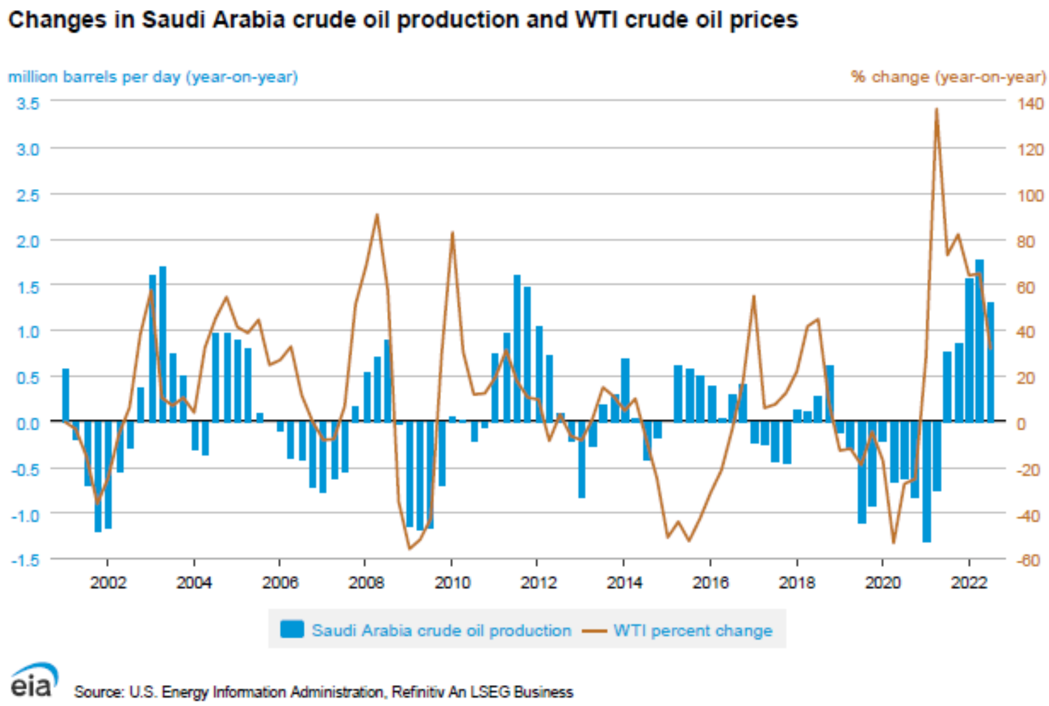

Figure 3. Changes in Saudi Arabia crude oil production and WTI crude oil prices

OPEC member countries account for about 40 percent of the world's crude oil production, whereas OPEC's oil exports comprise about 60 percent of the total global crude oil exports. Market shares this large, both in production and exports, give OPEC an influential role in the world's oil market. Projections of OPEC production fluctuations, especially in Saudi Arabia, cause changes in oil prices, mirroring the role of expectations in driving oil prices. Unexpected interruptions, the extent and duration of disruption as well as the uncertainty of reverting the output have significant impact on oil prices. It is also worth noting that OPEC adjusts its production to changes in market conditions with a delay to ensure it responses to permanent shocks rather than to momentary shocks.

Furthermore, regardless of OPEC's aims to manage production and maintain target price levels, member countries do not always comply with the production targets set by the organization. Such unwillingness to maintain certain production levels can also affect the oil prices. (EIA, 2022.)

The level of utilization of OPEC member countries' available production capacity reflects the global oil market's ability to react to possible oil supply disruptions and the extent to which OPEC is exploiting its upward influence on prices. Spare capacity is defined by EIA (2022) as "the volume of production that can be brought on within 30 days and sustained for at least 90 days". In the past, Saudi Arabia had the largest spare capacity of about 1.5-2 million barrels per day, which, together with other OPEC countries' spare capacities, could be used to respond to potential crises that reduce oil supplies. Hence, a rising risk premium is often incorporated into the oil prices when OPEC spare capacity reaches low levels. Between 2003 and 2008, OPEC's total spare capacity remained approximately at 2 million barrels per day or under, thus limiting its capability to increase its supply in case of quickly rising demand. (EIA, 2022; Razek & Michieka, 2019.)

Oil production from non-OPEC countries currently represents about 60 percent of global oil production. The most important producers within non-OPEC include North America, former Soviet Union regions and the North Sea, in addition to South American countries Brazil, Columbia and Argentina. Typically, non-OPEC producers are price takers, meaning that they respond to market prices instead of trying to influence them. Hence, they usually produce at or near full capacity and have limited spare capacity. Decreasing non-OPEC supply has an upward pressure on prices by decreasing total global supply and intensifying the demand for OPEC supply and hence further increasing OPEC's ability to influence prices. On the other hand, increases in non-OPEC production contribute to lower oil prices whereas unplanned outages in non-OPEC production add the uncertainty in the markets, causing increasing levels of price volatility. (EIA, 2022.)

In comparison to OPEC production, non-OPEC production often occurs in rural areas, such as deep water offshores, that have relatively high finding and production costs, whereas the majority of lower cost conventional oil resources are located in OPEC member countries. Therefore, non-OPEC producers have pursued unconventional sources, like for example, oil sands. In order to reduce their production cost disadvantage compared to the OPEC production, non-OPEC producers are developing new production technologies. In the short term this may result in the development of higher-cost supplies whereas in the long term, when technology advances, costs often fall which ultimately leads to lower oil prices. (EIA, 2022.)

3.1.2 Demand

Another important factor driving the oil prices is demand. Similar to supply, also demand is often viewed from the perspective of two groups of countries. Countries can be divided into developed and developing countries, or OECD and non-OECD countries. The Organization of Economic Cooperation and Development (OECD) consists of the United States, big part of Europe and other developed countries. (EIA, 2022.) OECD countries can be grouped together because their economic infrastructure is fundamentally more advanced and extensive in comparison to the non-OECD countries. In addition, differences in energy infrastructure and in the amount of energy that the countries consume, are seen as divisive factors between OECD and non-OECD countries. Non-OECD countries include, for example, all the BRICS countries and other emerging economies.

Oil consumption in OECD countries has been decreasing constantly since the early 2000s whereas consumption in non-OECD countries has been increasing considerably in recent years. Between 2000 and 2010, non-OECD oil consumption increased over 40 percent, with China, India and Saudi Arabia having the greatest impact on this growth. Increasing oil consumption is driven by rapid economic growth in non-OECD countries. Both current and expected levels of economic growth have an impact on global oil demand as well as in oil prices. (EIA, 2022.)

Furthermore, each economy's structural conditions influence the relationship between economic growth and oil prices. Usually, non-OECD economies are more driven by the manufacturing industries, using more oil and hence being more energy intensive than service industries. Even though transportation sector is much smaller in non-OECD countries than in OECD countries, the use of transportation oil is expected to increase rapidly as growing economies increase the need to move people and goods. In addition, vehicle ownership per capita is strongly correlated with higher incomes, and is expected to grow in the future in non-OECD countries as incomes increase. Finally, it must be noted that also energy policies have an impact in the relationship between oil consumption and economic activity. For example, many developing countries subsidize end-use price, therefore limiting consumer response to changes in market prices and increasing the importance of economic growth as the primary driver of non-OECD demand. Together with high population growth, these factors implicate the significance of non-OECD countries in driving the oil prices. (EIA, 2022.)

On a contrary to non-OECD countries, even in times of strong economic growth, the growth in oil consumption often tends to be slower in OECD countries, mostly due to economic conditions and policies. In OECD countries, oil use in transportation sector is usually much larger than in non-OECD countries, and therefore economic conditions and policies that affect transportation have a significant impact on total oil consumption in OECD countries. For instance, many OECD countries have relatively high fuel taxes and policies that increase the use of biofuels. This notably slows down the increase in oil consumption in developed countries. Furthermore, OECD countries' economies have larger service sectors relative to manufacturing, which requires less oil and therefore strong economic growth does is not reflected in oil consumption in a similar manner as it is in non-OECD countries. Lastly, as OECD countries usually have fever subsidies on end-use prices, changes in market oil prices are usually quickly reflected in consumer prices. (EIA, 2022.)

3.1.3 Inventories

Inventories are maintained as a balancing point between supply and demand. During periods when production exceeds demand, oil can be stored in refineries and storage terminals. Inventories help to prepare for seasonal fluctuations, unexpected weather and refinery maintenance periods. Since inventories satisfy both current and future demand, their level responds to the relationship between the current and future oil prices. If market expectations indicate relative increase in future demand or lower future supply, prices for future contracts will increase, creating a contango effect. On the other hand, a positive unexpected shock to current consumption associated with a negative shock to current supply will often push up spot prices relative to futures prices, encouraging inventory draw downs in order to meet the current demand, creating a backwardation effect. (EIA, 2022; Razek & Michieka, 2019.)

Additionally, the relationship between inventories and prices allows for effects in either direction. If futures prices increase to a higher level relative to the current spot prices, there is an incentive to store oil and sell it later at higher expected price. On the contrary, increasing inventories could indicate that current supply exceeds current demand which would cause current spot prices to decrease in order to rebalance demand and supply. Therefore, physical inventory levels and price spreads over time are used as signals between current market participants and those with long-term exposures. However, it is worth noting that inventory data is not always available on timely basis, or not available at all. The lack of complete inventory information creates additional uncertainty in the world's oil market, which can further influence oil prices. (EIA, 2022.)

3.1.4 Financial markets

In addition to physical quantities, market participants also trade future oil contracts and other energy derivatives in order to hedge against risk and inflation, profit from price changes and diversify portfolios. As measured by the New York Mercantile Exchange (NYMEX), open interest on exchange-traded crude oil futures has been increasing significantly over the past decades. Given the notable size and the role of futures markets in price discovery, they have influence also in oil prices.

Traditionally, stocks have been the largest investment market. In response to economic conditions, stock and commodity (i.e., oil) prices move together, which has an impact on corporate earnings and further, also on the demand for commodities as raw materials. Between 2008 and 2010, the level and appetite for risk changed dramatically. Over the past few decades, crude oil has shown similar risk and return characteristics to stocks. Hence, in times where risks are significantly increasing (in financial crisis) and then adapting (risks are decreasing) stocks and crude oil prices might move in the same direction. (EIA, 2022; Razek & Michieka, 2019.)

The negative correlation between crude oil prices and the US real effective exchange rate (REER) may be a reflection from the fact that oil benchmarks are traditionally priced in US dollars. When the value of US dollar decreases, the effective price of crude oil outside the US drops, hence potentially increasing consumer demand and creating upward pressure on prices. In addition, since depreciation of the US dollar decreases the returns on dollar-denominated assets once converted into foreign currencies, foreign market participants may aim to maintain higher oil prices. (EIA, 2022.) During downturns, there is a deeper negative relationship between the exchange rate and the oil prices due to risk shocks and the financialization of oil prices (Fratzscher et al., 2014).

4 Theoretical relationship between oil prices and stock returns

Literature has investigated and tested the different transmission mechanisms by which oil price fluctuations can affect the behavior of stock returns. One of the most commonly tested is the cash flow hypothesis, suggested by Jones and Kaul (1996), which assumes that stock prices are determined by expected discounted cash flows. In other words, oil prices influence stock markets directly through the stock valuation channel. To simply explain this requires two equations: firstly we define stock returns ($R_{i,t}$) as the first log difference as follows:

$$R_{i,t} = \log\left(\frac{P_{i,t}}{P_{i,t-1}}\right) \tag{4}$$

where $P_{i,t}$ denote the firm's i stock price at time t. Secondly, finance theory assumes that current stock prices reflect the discounted future cash flows of a certain stock (Degiannakis, Filis and Arora, 2018). This can be denoted as:

$$P_{i,t} = \sum_{n=t+1}^{n} \left(\frac{E(CF_n)}{(1+E(r))^n}\right) \tag{5}$$

where CF_n denotes the cash flow at time n and r is the discount rate. E is the expectation operator. Equations 4 and 5 show that stock returns are impacted by the expected cash flows and/or discount rate, which in turn are affected by factors such as oil prices. (Degiannakis et al., 2018.) According to the cash flow hypothesis, oil price changes can affect a firm's future cash flows either negatively or positively, depending on whether the firm is an oil producer or an oil consumer. For an oil producer, increasing oil prices will result in higher profit margins and therefore, higher expected cash flows and stock returns.

Two channels imply a negative relationship. First, since for an oil-consuming firm, oil is one of the major inputs, higher oil prices will increase the production costs, which will lower profit levels and therefore future cash flows, earnings and dividends, and lastly, stock returns. (Degiannakis et al., 2018; Smyth and Narayan, 2018.) Secondly, increasing oil prices can lead to an overestimation of expected inflation and higher real interest rates. As mentioned, increasing oil prices lead to higher production costs for oil consuming firms. Consequently, these costs will be transferred to consumers through higher retail prices and therefore, higher inflation expectations. The discount rate, that is used to discount expected future cash flows, is at least partially composed of expected real interest rates and expected inflation (Mohanty and Nandha, 2011). Therefore, higher oil prices can decrease future cash flows, and ultimately the stock returns, through inflation and interest rates.

Another possible reason for a positive relationship between oil prices and stock returns is that, as noted by Kollias, Kyrtsou and Papadamou (2013), investors may associate higher oil prices with a booming economy. Therefore, increasing oil prices could be seen as a reflection of stronger business performance and the concomitant influence on stock markets (Smyth and Narayan, 2018). Furthermore, Hamilton (2009) suggests that, before the global financial crisis, increasing oil prices reflected growth in developing markets in addition to high level of business confidence. Chen, Cheng and Demirer (2017), argue that stock market momentum and oil price volatility are positively correlated. They use China as a case study and argue that this correlation is driven by time-varying investor sentiment, in which investors react to oil price volatility associated with uncertainty by putting upward demand pressure on winner stocks.

On a contrary to Kollias et al., (2013), Brown and Yucel (2002), suggest that increasing oil prices will lead to higher uncertainty in the real economy, due to the effect on inflation and production costs, among others. Therefore, according to Brown and Yucel (2002), higher oil prices will decrease firms' demand for indelible investments, which in turn, will lower the expected cash flows. It is argued that uncertainty is transmitted also to households, which will reduce their consumption of durable goods (Pindyck, 2004). According to Edelstein and Kilian (2009), increasing uncertainty regarding the future oil prices will increase the incentives of households to save rather than consume.

Degiannakis et al. (2018), add that as uncertainty increases due to higher oil prices, the value of postponing consumption and investment decisions will get higher, whereas the incentive to consume or invest today decreases, which hence weakens the economic growth prospects and thereby stock market returns.

5 Literature review

Even though fluctuations in the crude oil prices are considered as an essential factor for understanding changes in stock prices, and the relationship between oil price and stock markets has been studied quite a lot, there is still no consensus among economists about the relationship between crude oil prices and the stock markets. One reason for this could be the fact that oil prices did not float freely until 1973, when oil price was liberated from regulations. For this reason, the academic world has not had that long of a time to fully research the relationship between oil prices and stock markets. Since then, during the past four decades, a growing literature has appeared, analyzing the impacts of oil price fluctuations on different macroeconomic and financial variables. Especially the 2008 surge in oil prices, when the price of oil reached the 100 dollars per barrel mark for the first time in history, began an extensive interest in oil market research. (Smyth and Narayan, 2018.) This section of the thesis will go through the most relevant previous studies in order to provide a better understanding about the various methods used and the inconsistencies between different papers and their results.

Bhar and Nikolova (2009), analyze the price discovery and volatility transition between the oil market and BRIC stock markets over a period of 1995-2007. They were one of the first ones to distinguish between oil exporting and oil importing countries when examining the oil price-stock market relationship. Accordingly, the authors conclude that the relationship between oil prices and stock markets depends on the extent to which those countries are oil exporters or oil importers. Unlike the other BRICS countries, Russia has historically been an oil exporter and therefore the Russian economy is strongly dependent on oil exports, making it vulnerable to oil price fluctuations. Bhar and Nikolova (2009) find in their analysis, that there is a strong relationship between Russian equity returns and global oil prices. For the other BRIC countries there are no significant correlations found. Bhar and Nikolova (2009) note, however, that in case Brazil becomes a net oil exporter, similarly to Russia, it would make Brazil's stock markets more responsive to the changes in the global oil prices.

Fang and You (2014), study the dynamic interactions between oil prices and stock returns of three large emerging countries, namely Russia, China and India, over the period of 2001-2012. Their study utilizes the structural vector autoregressive model (SVAR) originally proposed by Kilian and Park (2009), and examines how precise structural shocks affect the stock market returns in India, China and Russia. To represent the oil demand and supply shocks, Fang and You (2014) use the change rate of global oil production, global real activity and real oil price. They justify the use of the change rate of variable with the fact that it has more economical meanings and is thus more meaningful from an economics perspective. For instance, the import oil price change can be associated with the specific oil demand shock, which is driven mostly by the preventive demand for crude oil. From an investor perspective this means that the economy is expected to weaken, and the firms' profit rates are expected to decrease as the oil price increases. This leads investors to sell their stocks in order to prevent capital losses. On the other hand, the export oil price is used to capture the oil supply specific effect, which from the investor perspective means that the oil exporter's, in this case the Russian, economy will grow and due to the higher export oil prices, the firms' profits will also increase.

The basic statistics of Fang and You's (2014) study indicate that Russian stock returns are higher than those for India and China. In addition, Russia's oil supply change rate is a lot higher than the global oil supply change rate, and therefore it can be stated that a large proportion of Russian stock returns are caused by the high change rate of Russian oil export prices. In contrast to Russia, China and India are net oil importers and increasing oil prices often lead to higher costs of non-oil-producing companies and furthermore decrease the stock returns due to the reduced profits. Hence, this is one of the reasons for notably lower stock returns in India and China than those in Russia, due to the increasing oil prices in the time of Fang and You's (2014), study period.

Fang and You (2014) find that the impact of global oil production shock is insignificant in comparison to the impact of oil-specific demand shock and the impact of aggregate demand shock. This finding is in line with the argument of Kilian and Park (2009) that the response of aggregate stock returns might be different depending on the causes of the oil shock, and global oil production shocks are less significant. Even though Russia is a major oil exporter in the world and the whole energy industry has an essential role in the Russian economy, Fang and You (2014), find that global oil demand shocks lead to a significant decrease in the Russian stock returns in the first period. The authors explain this with the notion that even though Russia is the main oil supplier in the world, not every oil company always benefits from high oil prices. Since the oil companies will bear a heavy tax burden as the oil prices increase, they usually prefer oil prices to remain stable or have only small increase. Notable oil price fluctuations might cause the oil companies to fail to react to the changes in time. Consequently, the global demand oil shocks have only a temporary significant negative effect on the Russian stock returns. On the other hand, as expected, oil price shocks driven by Russian oil supply, have a significant positive impact on the Russian stock returns. Fang and You (2014) conclude that in the case of oil exporters, like Russia, the impact on stock returns varies depending on what causes the oil shock.

As mentioned earlier in this paper, the energy efficiency of emerging countries is low compared to that of developed countries. Out of the countries incorporated in the study of Fang and You (2014), China has the lowest energy efficiency and that is one of the reasons why the China-specific oil demand-driven oil shocks have a significant negative impact on the Chinese stock market. Moreover, Fang and You (2014), find that oil shock driven by global demand have insignificant impact on China’s stock returns. This could be explained by the fact that the Chinese financial market is still under heavy regulation and is characterized by a lack of transparency. A few notable features of the Chinese stock markets are that foreign investors can buy only small amounts of China’s stocks and that the shares held by legal persons and the state cannot be circulated. Accordingly, Chinese stock returns reflect only the demand from domestic investors who have only few ways to invest. Therefore, Fang and You (2014) argue that the insignificant impact of global demand-driven oil price shocks on Chinese stock returns is at least partly due to the incomplete nature of China’s stock market.

In the case of India, Fang and You (2014) find that Indian stock market reacts positively to its oil-specific demand shock only during the first month. This indicates that these demand shocks in India should be seen as an indicator of development speed instead of precautionary demand caused by the uncertainty about the oil supply shortfalls. In addition, it is found that oil price shocks caused by the global demand have a notable negative impact on the Indian stock returns only at the first month. This indicates that the Indian stock market is not able to reflect the positive spillover effect from global economic expansion. Fang and You (2014) conclude that as long as the oil price is not driven by the growing oil demand of India, the oil prices always have a negative impact on India’s stock market.

Another study employing the structural VAR analysis proposed by Kilian and Park (2009) is done by Wang, Wu and Yang (2013). Wang et al. (2013) study the relationship between oil prices and stock markets over a period of 1999-2011 in major oil importing and exporting countries, such as, Saudi Arabia, Russia, Norway, Germany, US, India, and China, among others. They section oil price shocks into oil supply shocks, aggregate demand shocks, and other oil-specific shocks. Wang et al. (2013) find that the driving force of the oil price shocks as well as the net position of the country in global oil market have an impact on the relationship between oil price changes and stock market returns. Moreover, their results show that the contributions of oil price changes to stock return fluctuations are overall larger in oil exporting countries than in oil importing countries. Wang et al. (2013), suggest that this could be at least partly due to the greater importance of crude oil for oil exporting economies.

Investigating the response of stock market returns to oil price shocks, Wang et al. (2013), find that in most cases the response to oil supply shocks is insignificant. They argue that this result can be explained by the insignificant impact of oil supply shocks on oil prices, which, however, is a contradictory to the results of some other studies (e.g., Kilian and

Park, 2009; Basher et al. 2012), which find that the impact of oil supply shocks on oil prices is significant and persistent.

When assessing the impacts of demand shocks, Wang et al. (2013) find that the response of stock markets is much stronger and more persistent in oil exporting countries than what it is in oil importing countries. It is generally suggested that oil demand shocks lead to higher oil prices, therefore causing the industry costs to rise as well, which further affect the stock market negatively. In addition, increasing oil demand will also result in a transfer of wealth from oil importing countries to oil exporting countries. Hence, the positive effect of demand shocks is greater and more persistent on the stock returns in oil exporting countries.

Wang et al. (2013) point out, however, that the positive effect of demand shocks is quite strong and persistent in China and India in comparison to the other oil importing countries. They argue that this is due to the relatively high economic growth rates in these two emerging economies. On the other hand, when looking at the oil exporting countries, the positive effects of demand shocks on stock markets are less persistent in Russia, Mexico and Saudi Arabia than in the other exporting countries included in their study. A probable explanation is that these countries consume greater amounts of crude oil, which leads to a stronger negative effects of high oil price on national economy, hence offsetting the positive impacts.

On a contrary to previous studies by Kilian and Park (2009) and Jung and Park (2011), Wang et al. (2013) find that the impact of precautionary demand shocks on stock returns is insignificant in oil importing countries, with China as an exception. The earlier literature suggest that the effect is highly significant. Inconsistent results may be due to the more recent dataset and larger number of countries included in the study of Wang et al. (2013). Furthermore, many studies show that the impact of oil price shocks on macroeconomic variables has become less significant during the years Wang et al. (2013) carried out their research. The impacts of precautionary demand shocks on the Chinese stock market become significant after nine months. This lacking response can be explained by the inefficiency of the Chinese stock market, which causes late information transmission from crude oil market to the stock market.

Nguyen and Bhatti (2012) employ nonparametric chi- and K-plots and parametric copula models in order to study the dependence structures and/or tail dependence between Chinese and Vietnamese stock markets and oil price changes. The tail dependence allows to better determine whether the two variables move together in the same or opposite directions. Nguyen and Bhatti (2012) find that there is relatively strong left tail dependence between the oil price changes and the Vietnamese stock market, indicating that if the oil prices decrease, Vietnam's stock market will also decrease. In the case of China, however, Nguyen and Bhatti (2012), do not find any tail dependence between the Chinese stock market and oil price changes. Therefore, the results suggest that the Chinese stock market is independent from the oil price changes during the study period of 2000-2009. Nguyen and Bhatti (2012) suggest that this might be due to the strong growth of the Chinese economy during that period, meaning that the negative impacts of oil prices are absorbed by the growth of the Chinese economy. On a contrary, the Vietnamese stock market has a smaller market capitalization and is more likely to be affected by the fluctuations in the global oil prices.

Study by Gupta and Modise (2013), investigates the dynamic relationship between the South African stock market and different oil price shocks. These different shocks are oil supply shock, an aggregate demand shock and speculative demand shock. They employ the structural VAR model over a study period from 1973 to 2011. According to Gupta and Modise (2013), a negative oil supply shock, which results in declining oil production and higher oil prices, has a negative impact on the South African stock returns. This result is consistent with other studies, as oil supply shock generally has a negative impact on stock returns in oil importing countries (Park and Ratti, 2008).

An aggregate demand shock driven by improved global activity results in increasing oil prices, increased global real activity and rising oil production. Gupta and Modise (2013) find that this type of global demand shock has a positive impact on the South African stock markets. This result is opposite to some of the other studies and general assumptions, as it is often assumed that oil importing countries respond negatively to oil demand shocks, because the importing costs will rise. Gupta and Modise (2013) argue that their differing results can be explained by South Africa being a commodity exporter, as it is one of the major exporters of platinum, gold and other mining products. Similar responses are found for example in the Russian stock markets (Fang, 2010), and even though South Africa does not export oil like Russia, the general increase in global commodity prices driven by a positive global demand shock results in the same responses for the two countries.

A negative speculative demand shock leads to a general decline in world oil production, in real global activity and an overall drop in the stock returns, whereas the oil price increases following such a shock. Similarly to some previous studies (e.g., Gunter, 2013), Gupta and Modise (2013), find that even though impact is positive for the first months, the overall effect of a speculative demand shock is negative on South African stock returns. This can be explained with the increasing oil prices, with no increase in the other commodity prices, which will have an inflationary effect in South Africa and hence reducing household wealth.

Using a quantile regression approach, introduced by Koenker and Bassett (1978), Mensi et al. (2014) examine the dependence between BRICS stock markets and different global factors, oil prices being one of them. Furthermore, they study how the global financial crisis has affected this relationship. Their results for the period from 1997 to 2013 show that the oil prices display a symmetric independence with the BRICS stock markets, except for South Africa. However, Mensi et al. (2014) find that the global financial crisis has significantly increased the co-movements of oil prices and all the BRICS stock markets. As these results differ from some of the other studies, it is essential to note that Mensi et al. (2013) do not identify the driving forces behind the oil price shocks nor do they differentiate whether the country is an oil importer or exporter. In addition to the different methodology, these might be reasons for the inconclusive results.

Paper by Zhu, Li and Li (2014) investigates the dynamic dependence between stock returns in ten countries in the Asia-Pacific region and crude oil prices over the period of January 2004 – March 2012. They use unconditional and time-varying copula-GARCH models to study the dependence structure between stock returns and crude oil prices. Furthermore, they investigate whether there are changes in this dependence in periods before and after the global financial crisis. Hence, Zhu et al. (2014) divide their study period into two subperiods, referred as pre-crisis and post-crisis. Their results show that, generally, the dependence between oil prices and stock returns is weak pre-crisis, with correlations close to zero. On the contrary, their empirical evidence for the post-crisis period indicates that the dependence between oil prices and stock returns increased significantly in all markets, with India showing the strongest dependence on crude oil prices.

Caporale, Ali and Spagnolo (2015) study the time-varying effect of oil price uncertainty on sectoral stock returns in China. The authors use weekly data on ten sectoral indices over the study period from January 1997 to February 2014. In their study, they estimate a bivariate VAR-GARCH with a DCC specification, allowing for mean effects. Moreover, they take a time-varying approach, differentiating between periods characterized by different types of oil price shocks, as introduced originally by Kilian and Park (2009). The results of Caporale et al. (2015) show, that oil price uncertainty has a positive impact on stock returns during periods characterized by demand side shocks, for all sectors except the Consumer Services, Financial and Oil and Gas sectors. The last two sectors are found to react negatively to oil price volatility during periods of supply side shocks. Furthermore, the effect of oil price uncertainty seems to be insignificant during periods characterized by precautionary demand shocks. Overall, these results are in line with those of

Kilian and Park (2009) and others, who found that the impact of oil price changes on stock returns and the correlation between the two depend on the type of oil shock.

Paper by Mensi, Hkiri, Al-Yahyaee and Kang (2018) examines the co-movements between the BRICS stock markets and both crude oil and gold prices. Their results based on the wavelet squared coherence analysis between the BRICS stock market and oil returns show a strong co-movement across frequencies and over time, suggesting a strong relationship between the markets. Furthermore, Mensi et al. (2018) find that this tendency is stronger during the onset of the global financial crisis, as their results show a pronounced co-variation between the BRICS stock markets and oil prices between 2007 and 2013 at high frequencies.

A recent study by Wang, Ma, Niu and He (2020), propose an extreme Granger causality analysis model to examine the relationship between extreme fluctuations in crude oil prices and BRICS stock markets. Over the study period from 2000 to 2007, Wang et al. (2020), employ weekly price data from the WTI crude oil and the BRICS stock indexes. They find that the impact of crude oil on the BRICS stock markets is heterogeneous, which is in line with previous literature. Overall, their results imply that the effect of oil price changes on the BRICS stock markets is stronger under extreme circumstances compared to normal circumstances.

Since the onset of the Covid-19 pandemic, a growing body of literature has emerged to investigate the impacts of the pandemic on different macroeconomic variables as well as on the financial markets. Heinlein et al., (2021) examine how the onset of the Covid-19 pandemic has impacted the relationship between crude oil and stock markets returns. They focus on a heterogeneous group of oil importing and oil exporting countries in advanced, emerging and small economies. Using the local Gaussian correlation and the contagion testing with high frequency intraday data, Heinlein et al. (2021) find significantly higher correlations between oil and stock market returns for all countries in their sample since the onset of the Covid-19 pandemic. Furthermore, they find that oil exporting countries' stock markets tend to have more robust correlations with oil returns, in comparison to those of oil importing countries, both during the crisis and non-crisis period. Heinlein et al. (2021) suggest that this can be a sign of relatively higher vulnerability to adverse shocks as well as a decrease in portfolio diversification benefits for investors holding assets both in oil and stocks of these oil-exporting countries.

Heinlein et al. (2021) find the most apparent difference in the oil-stock market correlations between China and Russia. China experienced the lowest correlation in the Covid-19 crisis, while Russian stock market exhibited the highest correlation. Heinlein et al. (2021) argue that it is possible to explain the high correlation between Russian stock markets and the crude oil with its country specific factors, such as that it is one of the largest oil exporters in the world. These results are also consistent with previous studies (e.g., Bhar and Nikolova, 2009.) On the other hand, Heinlein et al. (2021) find that China was the only country in their sample that did not exhibit higher correlations during the crisis. They suggest that this may be due to the comparatively better position the Chinese stock market has, in comparison to the other stock markets, to withstand oil price fluctuations during a crisis period. This finding is also consistent with previous evidence (e.g., Fang and You, 2014) on the resilience of the Chinese stock market to fluctuations in both global financial markets as well as in oil markets.

A novel strand of literature has emerged since the Russian war in Ukraine started in February 2022. Izzeldin et al. (2023) investigates how the Russian-Ukrainian war impacts global financial markets and commodities markets. They compare whether the markets respond differently to the war than to the Covid-19 pandemic and global financial crisis. Overall they find that stock markets react to the Russian invasion of Ukraine almost immediately, whereas the reaction to the Covid-19 pandemic and global financial crisis occurred with a lag. Izzeldin et al. (2023) argue that this is because investors interpreted the war as “real news”. Markets had not discounted an actual invasion and it was considered unlikely until it happened. On the other hand, the intensity of the Russian-Ukrainian war on the markets is found to be less severe in comparison to the other two crisis. It is possible, according to Izzeldin et al. (2023), that investors are underestimating the actual implications of the war. Prior warlike experiences have been notably different as they have not been happening on the European continent and/or they often involve terrorist attacks. Hence it is possible that investors are wrongly drawing insights from these past events. Regarding the commodities, Izzeldin et al. (2023) find that specific commodities are affected differently in each of the crisis. Oil markets are most affected by the onset of the Covid-19 crisis.

Another recent study by Adekoya et al. (2023) investigates the multifractality and cross-correlations between oil prices and European and non-European stock markets before and during the Russian invasion of Ukraine. Their results reveal a strong multifractal behavior in the stock and oil markets. They find that the war has a stronger direct impact on the constancy of the oil and the European stock markets. On the other hand, it has a greater indirect impact on the constancy of the non-European stock markets, namely the US, China and Japan, through oil prices.

In a prior study, Adekoya et al. (2022) study how oil connects with significant financial assets, such as stocks, bonds and US dollar, before and during the Russian-Ukrainian war. In short, their results show that overall connectedness is stronger during the war in comparison to before it. They also find that the war changes the spillover direction of some assets and increases it for others. For instance, oil becomes a net transmitter of spillover, indicating its significant effect on other assets. In addition, Adekoya et al. (2022) find that the connectedness is time varying, being the strongest at the beginning of the war. Finally, they find that the war makes oil a safe-haven instrument against risks in other markets, due to its net transmitting status.

6 Data and summary statistics

This study empirically examines the relationship between the BRICS stock markets and crude oil prices over the daily period from November 19, 2014 to January 30, 2023. The MSCI (Morgan Stanley Capital International) database is used to obtain the data for the BRICS stock markets. The data consist of daily closing index prices on each individual emerging market. This study uses the MSCI country indexes for each of the BRICS economies. In addition, the MSCI world index is used to act as a proxy of global stock markets. MSCI country indexes are designed to measure the performance of the large and mid-cap segments of the corresponding market. Each index covers approximately 85 percent of the free float-adjusted market capitalization in each country. Furthermore, all data is expressed in US dollars in order to measure their homogeneous features and to avoid the possible effect of currency risks on empirical results. The stock returns are computed by taking the difference in the logarithm between two consecutive prices. As for oil data, this study employs daily spot prices of West Texas Intermediate (WTI) and Brent crude oils, available from the US Energy Information Administration (EIA). For each price series, this study computes the returns (r_t) by taking the difference in the logarithm between two consecutive prices:

$$r_t = 100\ x \log\left(\frac{P_t}{P_{t-1}}\right) \tag{6}$$

In order to avoid distortions in the oil-stock market relationship caused possibly by the global financial crisis, the period 2008-2010 will be excluded in this study. This will also allow the study to have a more recent dataset compared to the previous similar studies, and to emphasize the importance of the onset of the Covid-19 pandemic. As mentioned, the aim of this study is to examine whether the dependence structure between the BRICS stock returns, and the global oil prices has changed since the onset of the Covid-19 pandemic. To achieve this, the study period will be divided into two subperiods referred to as pre-crisis period (November 19, 2014 to March 11, 2020) and crisis period (March 12, 2020 to January 30, 2023), respectively. March 11, 2020 is chosen as the turning point, because it is the day when the World Health Organization announced the outbreak of the Covid-19 pandemic. Furthermore, since the crisis period includes also the Russian invasion of Ukraine, which started on the 24th of February 2022, the crisis period will be further divided into two sub-periods, first one from March 12, 2020 to February 23, 2022 and the second one from February 24, 2022 to January 30, 2023. The turning point between the crisis periods is chosen to be February 24, 2022, because it is the day when Russia started the invasion of Ukraine. This way it is possible to differentiate between the two crisis and examine the effects of Covid-19 pandemic as well as the Russian invasion of Ukraine, separately. It is essential to assess these effects separately, since the impacts on stock and oil markets have been different during the two crises. Nevertheless, the crisis period will be examined also as a full period in order to do a proper comparison.

As a result of the Russian invasion of Ukraine, the Russian equity market became not investable and MSCI reclassified its Russia indexes from emerging markets to standalone market status. Thus, the study period for Russia is shorter and ends on February 28, 2022. The crisis period therefore includes 459 daily observations for the Russian market, whereas the other markets have 673 daily observations in the crisis period. Furthermore, Russia will not be included in the second crisis period, which starts on February 24, 2022, because it would not be meaningful to study the oil price-stock market relationship based on only a few days.

Descriptive statistics of the stock indexes and oil returns are reported in the table 1 for the pre-crisis period and full crisis period. In the pre-crisis period the average daily BRICS stock returns are positive in China and Russia and negative in Brazil, India and South Africa, ranging from -0.019% (South Africa) to 0.021% (China). Also the average oil returns are negative, -0.069% for WTI and -0.046% for Brent. It is worth noting that China and Russia's average returns are higher than that observed for the world market index (0.015%). During the crisis period, the Chinese mean return drops into negative (-0.021%). The lowest average return is observed within the Russian stock returns (-

0.079%), whereas the highest returns in the crisis period are associated to the oil markets, with average daily returns of 0.307% for WTI and 0.106% for Brent.

Overall, during the full study period, the stock markets in oil exporting countries (Brazil and Russia) tend to be riskier in comparison to the stock markets in oil importing countries. Over pre-crisis period, the highest standard deviation, which is an indicator of the risk level, is associated to the oil markets with values of 2.60% (WTI) and 2.42% (Brent). Brazilian market is the riskiest out of the BRICS markets with a standard deviation of 2.06% followed by the South African and Russian stock markets. All the BRICS markets exhibit higher volatility than the world market index, as indicated by their high standard deviations compared to the world market (0.78%). During the crisis period, the standard deviations increase for all markets. Oil markets experience the greatest growth with values of 7.57% (WTI) and 4.59% (Brent). Within the BRICS markets, the highest standard deviation in the crisis period is observed in Russia, 3.62%, whereas India is the least risky BRICS market with a standard deviation of 1.59%.

All the return series exhibit negative Skewness in the pre-crisis period, indicating that the tail is on the left side of the distribution. During the crisis period, majority of the return series get even more negative values, with the Chinese and WTI returns as an exception, as their skewness turns positive. Highest skewness in the crisis period is associated to the WTI returns (8.93) and the lowest to the Russian stock returns (-6.15). Excess kurtosis, as compared to the value of the normal distribution, is observed for all return series in the pre-crisis period, with lowest values in China and South Africa. During the crisis period, all the return series exhibit higher values of excess kurtosis compared to pre-crisis. These high degrees of kurtosis indicate that the probability of observing extreme values is much higher relative to a normal distribution. Moreover, the Jarque-Bera test for normality is performed. According to the results, the null hypothesis of normality is strongly rejected for all return series in both subperiods. Finally, the null hypothesis of a unit root is tested using the augmented Dickey and Fuller (1979) test. The null hypothesis of the presence of unit root is rejected for all return series in the pre-crisis and crisis periods, indicating that they are stationary.

Table 1. Descriptive statistics

Nov 19, 2014 - Mar 11, 2020	*Brazil*	*Russia*	*India*	*China*	*South Africa*	*WTI*	*Brent*	*World*
Mean	-0.0123	0.0175	-0.0117	0.0207	-0.0189	-0.0691	-0.0461	0.0146
Standard Deviation	2.0622	1.8146	1.0624	1.2539	1.8631	2.6040	2.4207	0.7841
Kurtosis	6.5784	9.4837	3.8239	2.3609	2.0680	12.8448	11.4350	10.2695
Skewness	-0.6926	-0.3869	-0.6463	-0.2657	-0.2785	-0.9034	-0.7482	-1.4529
Range	26.8961	26.8342	12.5585	12.4542	17.7589	42.3143	36.5877	10.7092
Minimum	-15.8517	-13.2533	-7.4791	-6.6060	-9.4182	-28.1382	-25.5175	-7.4317
Maximum	11.0444	13.5808	5.0794	5.8483	8.3407	14.1761	11.0701	3.2774
Jarque-Bera	2310.5***	4628.8***	833.0***	299.4***	234.5***	8601.9***	6799.6***	5823.5***
ADF	-19.8183***	-20.4372***	-19.1873***	-19.3361***	-20.0401***	-19.2430***	-18.4947***	-18.7363***
Mar 12, 2020 - Jan 30, 2023 (until Feb 28, 2022 for Russia)								
Mean	-0.0310	-0.0791	0.0553	-0.0211	0.0426	0.3065	0.1057	0.0361
Standard Deviation	2.5585	3.6153	1.5860	1.8987	2.0615	7.5714	4.5858	1.3462
Kurtosis	11.9234	83.5019	19.2316	5.4883	5.1858	197.8539	70.7337	12.7895
Skewness	-1.0972	-6.1484	-1.8466	0.4111	-0.7639	8.9286	-3.5299	-1.0005
Range	34.5914	71.4565	24.7932	22.1107	20.1873	212.6133	105.5721	18.8403
Minimum	-19.4332	-47.9816	-15.6226	-8.5344	-12.3459	-70.2930	-64.3699	-10.4270
Maximum	15.1581	23.4749	9.1706	13.5763	7.8414	142.3203	41.2023	8.4133
Jarque-Bera	4121.7***	136242.1***	10753.8***	863.6***	819.6***	1106665.5***	141697.3***	4699.1***
ADF	-15.8016***	-9.1385***	-15.6546***	-15.1460***	-16.4245***	-17.8281***	-16.4153***	-16.9476***

***significant at 1% level

Table 2 reports the descriptive statistics for the two separated crisis periods. During the first crisis period the average daily returns were positive for all the return series with Brazilian stock returns as an exception, where the average return is -0.08%. The highest returns during this period are associated to the WTI returns, with an average of 0.51%. During the second crisis period, which includes the Russian invasion of Ukraine, the average returns are negative for all the series, except for the Brazilian stock returns and Brent oil returns. Russia has the lowest daily returns during the second crisis period, with an average of -1.86%.

During the first crisis period, which includes the onset of the Covid-19 pandemic, Brazilian stock market is the only one to have negative mean returns, whereas during the second crisis period all the daily mean returns are negative. The riskiest stock markets during the Covid-19 crisis are the Brazilian and Russian stock markets, with a standard deviations of 2.73% and 2.16% respectively. Both of the oil returns exhibit high standard deviations, 8.94% for WTI and 5.15% for Brent. Comparing to the second crisis period, the

Chinese stock market is the only one to exhibit a higher standard deviation than in the first crisis period. On the other hand, the riskiness of oil markets has decreased notably from the first crisis period. Standard deviation for both WTI and Brent is little over 3%, whereas for Chinese stock market the standard deviation is 2.45% during the second crisis period. This indicates that for the oil markets, and also for the BRICS markets with China as an exception, the Covid-19 related crisis period caused more fluctuations and made the markets riskier. On the other hand, the Chinese stock market is found to be more riskier during the second crisis period in comparison to the first period.

Excess kurtosis is observed during the first crisis period for all return series, with China having the lowest and India the highest level of excess kurtosis within the BRICS markets. Both of the oil returns have very high excess kurtosis levels during the first crisis period. Over the second crisis period, highest excess kurtosis is observed in the Chines stock returns. Results of the Jarque-Bera test indicate that the null hypothesis of normality can be rejected for all returns series in the first crisis period and for all returns except for South Africa and World returns in the second period. Finally, the null hypothesis of the presence of unit root can be rejected for all return series in both periods.

Table 2. Descriptive statistics for the two crisis sub-periods

Mar 12, 2020 - Feb 23, 2022	***Brazil***	***Russia***	***India***	***China***	***South Africa***	***WTI***	***Brent***	***World***
Mean	-0.0375	0.0439	0.1103	0.0093	0.0912	0.5186	0.1956	0.0641
Standard Deviation	2.7277	2.1589	1.7135	1.5684	2.0880	8.9368	5.1459	1.3349
Kurtosis	13.2741	6.3966	20.6247	1.5200	7.3087	149.6786	65.9378	19.5400
Skewness	-1.3527	-0.9558	-2.1037	-0.3610	-1.0975	7.9770	-3.6702	-1.5435
Range	34.5914	21.1569	24.7932	11.0338	20.1873	212.6133	105.5721	18.8403
Minimum	-19.4332	-12.2327	-15.6226	-6.0908	-12.3459	-70.2930	-64.3699	-10.4270
Maximum	15.1581	8.9242	9.1706	4.9430	7.8414	142.3203	41.2023	8.4133
Jarque-Bera	2310.5***	4628.8***	833.0***	299.4***	234.5***	8601.9***	6799.6***	5823.5***
ADF	-13.0417***	-13.4295***	-13.2140***	-13.3791***	-13.7931***	-14.7418***	-13.6532***	-14.4775***
Feb 24, 2022 - Jan 30, 2023								
Mean	-0.0175	-	-0.0602	-0.0850	-0.0596	-0.1394	-0.0832	-0.0227
Standard Deviation	2.1661	-	1.2731	2.4552	2.0054	3.1333	3.0969	1.3709
Kurtosis	1.4804	-	2.5745	5.0766	0.2738	0.9792	1.4224	0.4359
Skewness	0.0686	-	-0.5432	0.8411	0.0111	-0.4513	-0.5650	0.0570
Range	16.1328	-	9.6543	22.1107	13.0073	20.9912	21.4688	8.6652
Minimum	-6.3259	-	-6.4496	-8.5344	-6.3093	-12.7771	-13.3124	-3.7270
Maximum	9.8069	-	3.2048	13.5763	6.6980	8.2141	8.1564	4.9382
Jarque-Bera	20.0***	-	70.6***	258.6***	0.7	16.0***	29.8***	1.8
ADF	-8.2168***	-	-7.8171***	-8.1033***	-8.6186***	-8.9204***	-8.7384***	-8.6117***

***significant at 1% level

7 Methodology

In order to analyze the relationship between the BRICS stock returns and global oil price changes, this study employs a multiple linear regression model. It has been previously used in the literature to assess the impact of oil price changes on stock returns in studies such as Jones and Kaul (1996), Hammoudeh and Li (2004), Sharif et al. (2005), Nandha and Faff (2008) and Scholtens and Yurtsever (2012). The model used in this paper is based on the standard market model that is augmented with the oil price factor. Two-factor model as such can be underspecified because the exchange rate between the US dollar and the home currency as well as bond yields are not included (Sadorsky, 2001). Therefore, in this study, to better control the macroeconomic circumstances and to increase the explanatory power and accuracy of the model, interest rate and exchange rate changes will be added as control variables to the model, since those two factors are often measured in the dependencies between oil price and stock returns.

In this study the regression model is formed so that stock returns are used as the dependent variable and oil price changes, global market returns, exchange rate changes, and interest rate changes as independent variables. Each country's 3-month government bond yields are used to express the interest rates. As for the global market returns, this study uses the MSCI world index returns. The multiple linear regression model can therefore be denoted as follows (Wooldridge, 2013):

$$R_{st} = \alpha + \beta_o R_{ot} + \beta_m R_{mt} + \beta_x R_{xt} + \beta_{irc} R_{irct} + \varepsilon_t \quad (7)$$

Where:

α = The constant

R_{st} = BRICS stock returns

$\beta_o R_{ot}$ = Beta and daily returns of oil

$\beta_m R_{mt}$ = Beta and daily returns of global stock market

$\beta_x R_{xt}$ = Beta and daily changes of exchange rate

$\beta_{irc}R_{irct}$ = Beta and daily changes of interest rate (3-month government bond yield)

ε_t = The error term

8 Empirical results

In order to ensure that there is not a too high correlation between the independent variables, i.e., multicollinearity, in the multiple regression model, correlation matrices have been conducted for each country and each period. It is not fully clear what is too high level of correlation, but usually correlations over 0.7 are considered strong, and those should be avoided between the independent variable. Correlations close to or over the 0.7 are observed only between the two oil prices, Brent and WTI. However, since the regressions are done separately, using WTI as the oil price variable in the other model and Brent in the other, this high level of correlation will not be an issue. The results for the correlation matrices are presented in appendixes 1-4.

Tables 3 and 4 reports results of the multiple linear regression model during the pre-crisis period. All the regressions are done separately with WTI and Brent as the independent oil price variable. Overall, during this pre-crisis period, there is a significant relationship between Brent and/or WTI price changes and all the BRICS stock market returns except for India. Tables 5-10 present the results for the full crisis period from Mar 12, 2020 to Jan 30, 2023 as well as for the two separate crisis periods, from mar 12, 2020 to Feb 23, 2022 and from Feb 24, 2022 to Jan 30, 2023. Looking at the full crisis period, the results show a significant relationship between the Brent prices and the Brazilian and South African stock returns. Indian stock returns have a significant relationship with the WTI price changes. In the first, Covid-19 pandemic related crisis period, a significant relationship between the oil prices and stock returns is observed only for India. Finally, during the later crisis period, the significant relationships between stock returns and oil prices are associated to South Africa and Brazil.

Table 3. Results for the multiple regression model with Brent in pre-crisis period.

	Brazil	Russia	India	China	South Africa
Brent	0.1057*** (5.8193)	0.1378*** (8.1721)	0.0020 (0.6590)	-0.0129 (-0.9409)	0.0986*** (5.7874)
Gov bond	-0.0876 (-1.5711)	-0.1007*** (-3.7415)	0.0261 (1.0703)	-0.0113 (-0.2284)	-0.0069 (-1.0851)
FX rate	0.9999*** (24.5853)	0.6643*** (21.1980)	1.3913*** (18.9103)	0.6672*** (4.9049)	0.8101*** (20.0195)
World	0.8366*** (14.3434)	0.5178*** (9.8303)	0.3382*** (9.4880)	0.7951*** (18.4892)	0.7439*** (12.9489)
R square	0.5316	0.5161	0.3449	0.2791	0.4949
Adjusted R square	0.5300	0.5145	0.3427	0.2767	0.4932

Notes: The numbers in parantheses are the t Stat values.
***significant relationship at 1% level
** significant relationship at 5% level
* significant relationship at 10% level

Table 4. Results for the multiple regression model with WTI in pre-crisis period.

	Brazil	Russia	India	China	South Africa
WTI	0.1023*** (6.0123)	0.0592*** (3.5433)	0.0048 (0.4650)	-0.0309** (-2.4251)	0.0445*** (2.7662)
Gov bond	-0.0853 (-1.5318)	-0.1090*** (-3.9689)	0.0266 (1.0900)	-0.0117 (-0.2368)	-0.0067 (-1.0362)
FX rate	0.9795*** (23.9537)	0.6868*** (20.5697)	1.3899*** (18.9034)	0.6702*** (4.9427)	0.8041*** (19.6005)
World	0.8383*** (14.4719)	0.5919*** (11.0948)	0.3409*** (9.5673)	0.8202*** (19.0357)	0.8086*** (14.0347)
R square	0.5324	0.4948	0.3448	0.2820	0.4843
Adjusted R square	0.5309	0.4932	0.3426	0.2797	0.4826

Notes: See the notes of table 3.

Table 5. Results for the multiple regression model with Brent in full crisis-period.

	Brazil	Russia	India	China	South Africa
Brent	0.0393*** (2.7157)	-0.0285 (-1.1235)	0.0029 (0.2452)	0.0159 (1.0524)	0.0299** (2.3431)
Gov bond	-0.0345 (-1.0879)	0.4548*** (4.9878)	0.1652*** (4.1460)	0.0485 (0.6238)	-0.0068 (1.5640)
FX rate	1.0659*** (19.2066)	1.6943*** (17.5857)	1.1749*** (7.0394)	1.6040*** (6.8977)	0.9740*** (14.9407)
World	0.8177*** (15.9825)	0.4668*** (4.6417)	0.3969*** (8.9548)	0.3788*** (7.0935)	0.5016*** (10.1627)
R square	0.5862	0.4841	0.2694	0.1829	0.5037
Adjusted R square	0.5837	0.4795	0.2650	0.1780	0.5007

Notes: See the notes of table 3.

Table 6. Results for the multiple regression model with WTI in full crisis-period.

	Brazil	Russia	India	China	South Africa
WTI	0.0083 (0.9773)	-0.0001 (-0.0069)	-0.0157** (-2.2760)	-0.0003 (-0.0295)	0.0020 (0.2648)
Gov bond	-0.0288 (-0.9023)	0.4447*** (4.8934)	0.1687*** (4.2599)	0.0534 (0.6864)	-0.0064 (-1.4601)
FX rate	1.0655*** (19.0779)	1.6804*** (17.5401)	1.1769*** (7.0846)	1.6094*** (6.9158)	0.9747*** (14.8858)
World	0.8535*** (17.2004)	0.4348*** (4.5013)	0.4020*** (9.3757)	0.3936*** (7.6324)	0.5294*** (11.0055)
R square	0.5823	0.4826	0.2749	0.1816	0.4996
Adjusted R square	0.5798	0.4781	0.2706	0.1766	0.4966

Notes: See the notes of table 3.

Table 7. Results for the multiple regression model with Brent in first crisis-period.

	Brazil	Russia	India	China	South Africa
Brent	0.0085 (0.5288)	0.0143 (0.9663)	-0.0075 (-0.5495)	0.0025 (0.1886)	0.0124 (0.8770)
Gov bond	-0.0284 (-0.8825)	-0.1104 (-1.6212)	0.2039*** (4.4234)	0.0195 (0.2616)	-0.0064 (-1.4318)
FX rate	0.9468*** (14.1520)	1.29021*** (14.1727)	1.3222*** (6.3052)	1.2004*** (4.2982)	0.9095*** (11.5450)
World	1.1781*** (18.5061)	0.4321*** (6.9874)	0.4954*** (8.7386)	0.4648*** (8.6905)	0.6131*** (10.0819)
R square	0.6347	0.5368	0.3298	0.2315	0.5100
Adjusted R square	0.6315	0.5327	0.3239	0.2246	0.5056

Notes: See the notes of table 3.

Table 8. Results for the multiple regression model with WTI in first crisis-period.

	Brazil	Russia	India	China	South Africa
WTI	0.0071 (0.8132)	0.0013 (0.1606)	-0.0168** (-2.2852)	-0.0021 (-0.2912)	-0.0016 (-0.2051)
Gov bond	-0.0258 (-0.8009)	-0.1034 (-1.5202)	0.2057*** (4.4968)	0.0218 (0.2924)	-0.0063 (-1.4071)
FX rate	0.9439*** (14.1107)	1.3090*** (14.6410)	1.3215*** (6.3543)	1.1984*** (4.2907)	0.9113*** (11.5541)
World	1.1893*** (19.7931)	0.4448*** (7.3154)	0.4867*** (8.9872)	0.4684*** (9.2709)	0.6283*** (10.8002)
R square	0.6350	0.5359	0.3371	0.2315	0.5092
Adjusted R square	0.6318	0.5318	0.3312	0.2247	0.5048

Notes: See the notes of table 3.

Table 9. Results for the multiple regression model with Brent in second crisis-period.

	Brazil	India	China	South Africa
Brent	0.0522* (1.8613)	-0.0051 (-0.1924)	0.0605 (1.1917)	0.0955*** (3.0619)
Gov bond	-0.0320 (-0.1725)	-0.0175 (-0.2167)	0.1555 (0.8235)	-0.0145 (-0.5561)
FX rate	1.3957*** (18.0412)	0.8442*** (3.2384)	1.9585*** (4.6410)	1.1466*** (10.0469)
World	0.1255* (1.9055)	0.2041*** (3.0592)	0.2340* (1.9625)	0.2810*** (3.3663)
R square	0.6797	0.1461	0.1583	0.5207
Adjusted R square	0.6736	0.1300	0.1424	0.5117

Notes: See the notes of table 3.

Table 10. Results for the multiple regression model with WTI in second crisis-period.

	Brazil	India	China	South Africa
WTI	0.0481* (1.7187)	0.0019 (0.0712)	0.0332 (0.6561)	0.0756** (2.4237)
Gov bond	-0.0364 (-0.1961)	-0.0172 (-0.2128)	0.1628 (0.8606)	-0.0122 (-0.4663)
FX rate	1.3952*** (17.9278)	0.8421*** (3.2201)	1.9872*** (4.6946)	1.1458*** (9.9601)
World	0.1229* (1.8620)	0.2050*** (3.0501)	0.2358** (1.9678)	0.2807*** (3.3249)
R square	0.6789	0.1460	0.1544	0.5130
Adjusted R square	0.6729	0.1299	0.1384	0.5039

Notes: See the notes of table 3.

Looking at the results for Brazil is interesting, because it is one of the largest oil consumers in the world and the largest in South America. In addition, Brazil is an important oil producer and for the past decade, it has been a net oil exporter. The results for the pre-crisis period are as expected based on the previous literature. Both Brent and WTI prices show positive significant relationship with the Brazilian stock returns during the pre-crisis period. The model shows these significant relationships at the 1% level. The results indicate that 1 percent increase in WTI prices increases stock returns by 0,1% in the pre-crisis period, whereas 1 percent increase in Brent prices creates a 0,11% increase in the stock returns. In the crisis periods, the oil price related relationships were significant for Brent during the full crisis period and for both WTI and Brent in the second crisis period. However, the coefficients are smaller in comparison to the pre-crisis period, indicating that the impact of oil price changes on the Brazilian stock returns is weaker during crisis.

As for the 3-month government bond yield, no significant relationships with the Brazilian stock markets are found during the whole study period. On the other hand, exchange rate changes and the global stock returns show significant relationship with the Brazilian stock markets in all periods. All the relationships are significant at the 1% level except for the global stock returns during the second crisis period, which are significant at the 10% level. The highest beta coefficient for the exchange rate (1.40) is observed in the second crisis period and for the global stock returns (1.19) in the first crisis period. These betas are notably higher than those observed for the oil price changes, indicating that exchange rates and global stock returns have a greater impact to the Brazilian stock returns in comparison to oil prices. Finally, the adjusted R squares for Brazil are relatively high, over 0.53 in all periods. It can be also noted that during the two separate crisis periods, adjusted R square is between 0.63 and 0.67, which indicates that the model better explains the variance in Brazilian stock returns during the crisis periods.

Russia is the third largest oil producer in the world, after United States and Saudi Arabia. It is also the second largest oil exporter behind Saudi Arabia. Since the Russian invasion of Ukraine, the Western countries have imposed numerous sanctions towards Russia, including an embargo on Russian seaborne crude oil. According to the European Central Bank, Russia’s oil exports to the EU dropped by almost 70% after the invasion of Ukraine. However, Russia has since redirected those exports mainly to Asia, India and China being the largest importers (ECB, 2023). Due to the importance of the oil exports for Russian economy, it could be expected that there is a relatively strong dependency between the oil prices and the Russian stock returns.

During the pre-crisis period there is a significant positive relationship between both Brent and WTI prices and Russian stock returns, at 1% significance level. The relationship is stronger with Brent, every one percent increase in Brent prices increases the stock returns by 0.14%. However, during the crisis periods, there is not any evidence of significant relationship between the Russian stock returns and oil prices. Similarly to the other BRICS countries, there is a significant relationship between Russian stock returns and both the exchange rate changes and the global stock returns. Global stock returns’ beta coefficient is greater in the pre-crisis period, whereas the FX rate’s coefficient increases during the crisis period. Furthermore, Russian stock market is the only market that has a significant relationship with the government bond yield in the pre-crisis period. During the full crisis period that relationship remains significant, but it becomes positive.

India is one of the biggest oil importers in the world. Therefore, it could be expected that there is a negative relationship between oil prices and the Indian stock returns, because of the increased importing costs. Relationship like this is found in the full crisis period, where the relationship between WTI prices and stock returns is significant at the 5% level. Every one percent increase in WTI prices decreases the Indian stock returns by -0.016%. The negative relationship is even stronger during the first crisis period but is not significant anymore during the second crisis period. In the pre-crisis period, there is no significant relationship found. This indicates that the oil price changes have more power on explaining the stock returns during a crisis period, and especially during the Covid-19 pandemic. The highest coefficient betas are again associated to the exchange rate changes and global stock returns, in all periods.

China is the second largest oil importer in the world, following the European Union. Nevertheless, previous studies have found that there is often very little impact of the global market movements and oil price fluctuations on the Chinese stock markets. This is explained by the incomplete nature of the Chinese markets as well as the restrictions there are for foreign investors. Results of this study at least partly support these previous findings. The only significant relationship between oil price movements and Chinese stock returns is observed during the pre-crisis period. The relationship between WTI prices and the stock returns is negative and significant at the 5% level. Negative relationship is consistent with the theory, as China is a net oil importer, similarly to India. Furthermore, in support of the resilience of the Chinese stock markets to the oil price changes and global stock returns, is the small R square in all periods. The highest adjusted R square is 0.28, which is observed in the pre-crisis period, whereas the lowest one is 0.14 during the second crisis period. Hence, even though there is a significant relationship between the Chinese stock markets and the global stock returns in all periods, the overall explanatory power of this regression model is very small in the case of China. This indicates that these variables do not have much power in explaining the changes in Chinese stock returns.

Despite the fact that South Africa is a net oil importer, like China and India, the results of this study indicate that there is a positive relationship between the oil price changes and stock returns in South Africa. In the pre-crisis period the relationship between Brent prices and stock returns is significant at the 1% level, with a beta coefficient of 0.10. During the full crisis period this relationship decreases but is still significant at the 5% level and has a coefficient of 0.03. During the Covid-19 related crisis period the relationship is insignificant, whereas during the second crisis period it is significant at the 5% level with a 0.10 coefficient. There is a significant relationship also with the WTI prices during the pre-crisis period and the second crisis period, with smaller coefficients in comparison to the ones observed with Brent. These results indicate that oil price movements have strong positive impact on the South African stock returns before the crisis and during the second crisis period. In fact, South African stock markets experience the strongest relationship with the oil prices during the Russian-Ukrainian war.

Positive relationship between oil prices and stock returns is usually not associated with oil importers, such as South Africa. Some previous studies have found similar results and argue that even though South Africa does not export oil, it is a major commodity exporter of many mining products, such as gold and platinum. Therefore, a general increase in global commodity prices could have a positive impact on the South African stock markets. Furthermore, the R squares for South Africa are much higher in comparison to India and China, indicating that this model with these variables explains the changes in South African stock returns quite well, and much better than for the other two oil importing countries. The adjusted R squares range between 0.48 and 0.51 for South Africa. The 3-month government bond yield does not have a significant relationship with the stock returns in any period, whereas FX rate and the global stock returns have a significant positive relationship with the South African stock returns during all the periods. Global stock returns have the strongest impact during pre-crisis period with beta coefficients of 0.81 and 0.75, and the exchange rate changes during the second crisis period, with coefficient of 1.15.

Overall, these results reveal that stock markets in oil exporting countries tend to have a stronger, positive relationship with global oil price movements. In oil importing countries, on the other hand, the impact is generally negative and weaker. The exception here is South Africa, as described above. Regarding the first hypothesis (H1) of this study, which states that there is a significant relationship between the oil price changes and the BRICS stock markets, the results are mixed. In the pre-crisis period the relationship is significant for all the countries except for India. During the different crisis-periods, a significant relationship is observed for all the countries at least in one of the crisis-period, with China as an exception. Therefore the H1 can be partially accepted.

The second hypothesis (H2) states that the onset of the Covid-19 pandemic has made the relationship between oil prices and the BRICS stock markets stronger. The results of this study show very little evidence supporting this. Regression for India is the only one that shows a stronger relationship during the full crisis-period and the Covid-19 related crisis-period in comparison to the pre-crisis period. For the other BRICS countries, the relationship is no longer significant (China) or is weaker than before the onset of the Covid-19 pandemic (Brazil, Russia and South Africa). Hence, the H2 can be accepted only in the case of India.

Finally, the third hypothesis (H3) argues that the degree and/or structure of the relationship is different for oil importing and oil exporting countries. The results observed from the multiple regressions are supporting the acceptance of hypothesis. For the oil exporting countries, Brazil and Russia, the relationship between oil prices and stock returns is positive, whereas in the case of the oil importing China and India, the relationship is negative. Furthermore, the beta coefficients for the oil price changes are greater in the regressions for Brazil and Russia, indicating that oil price changes have a bigger impact on the stock returns in oil exporting countries, than those in oil importing countries. The only exception here is South Africa, as even though it is a net oil importer, the relationship between oil prices and South African stock returns is positive. These differing results could be explained by the fact that South Africa is a major commodity exporter, top exports of South Africa being platinum and gold. Overall, this makes South Africa a net commodity exporter. Increasing commodity prices in general could therefore have a positive effect on the South African stock markets, similar to those of oil exporting countries. Hence, as a conclusion, the H3 can be fully accepted for Brazil, Russia, India and China. Regarding South Africa, the H3 can also be accepted with an exception that it is a commodity exporter, but an oil importer.

9 Conclusion

The main purpose of this study was to investigate the relationship between global oil price changes and the BRICS stock market returns. Moreover, the paper examined whether there has been changes in the abovementioned relationship, caused by the onset of the Covid-19 pandemic. Since the study period includes also the onset of the Russian invasion of Ukraine, this paper differentiated between the two crisis periods in order to better analyze the possible effects on stock returns and oil prices. Finally, this study compared the results of oil importing and oil exporting countries in order to see whether the stock markets of these countries react differently to oil price changes.

First, the importance of oil to the global economy and its many implications were discussed. Today, oil is the most traded commodity in the world, and it is an essential driver of the economic and industrial activity. As a result, movements in oil prices are followed closely by investors and policymakers. Recent studies examining the impact of the main factors affecting the oil price conclude, that supply and demand are still the most important factors of oil price volatility. In addition, it is found that OPEC still has an important role in balancing oil markets, and especially in a long turn, it is able to influence oil prices. Also, US dollar exchange rate and inventories are found to be quite influential factors of oil price movements.

Secondly, different stock pricing models and the efficient market hypothesis were introduced. The efficient market hypothesis suggests that all relevant and available information is reflected in stock prices. Therefore, according to the efficient market theory, if oil price movements have an impact on a profitability of a company, they should also impact the stock returns of these companies. In addition, this paper presented the different methods through which oil price changes can affect stock returns. The most common theory is the cash flow hypothesis, which assumes that stock prices reflect the expected discounted cash flows. According to the theory, oil prices can affect both the cash flows and the discount rates, hence influencing the stock markets directly through the stock valuation.

Previous studies have provided somewhat inconclusive results. Some common findings include, for example, that there is difference in the oil price-stock market relationship between oil exporting and oil importing countries. Oil exporting countries tend to experience stronger and more positive relationship in comparison to oil importing countries. Many studies have also found that there is relatively small or even non existing impact of oil price changes on the Chinese stock markets. Finally, studies comparing non-crisis periods and crisis-periods find that the relationship between oil prices and stock returns is often stronger during crisis-periods.

The findings of this paper differ from the previous studies in some parts, but are partly similar, leaving also room for further research. Firstly, this study finds that there generally is a significant relationship between the BRICS stock returns and oil price changes. However, the relationship is not consistent throughout the whole study period for all countries. For instance, when examining India, a significant relationship is observed only during the crisis-period, but not during the pre-crisis period. For China, there is a significant relationship only in the pre-crisis period. South Africa and Brazil were the only countries to experience a significant oil price-stock return relationship during the second crisis period. Hence, due to these mixed results, the H1 was only partially accepted.

Regarding the second hypothesis, which argues that the relationship between oil prices and stock returns is stronger after the onset of Covid-19 pandemic, the results were quite different in comparison to the previous studies. As mentioned, earlier papers have found that during crisis periods the oil price-stock market relationship tends to be stronger. However, the results of this study show a weakening in that relationship for all the other countries except for India. Therefore, the H2 was accepted only in the case of India and rejected for the other BRICS countries.

Finally, regarding the third objective of this study, which was to compare the results of oil importing and oil exporting countries to see if there are differences in the oil price-stock market relationship between these two groups. And for this part, the results were consistent with the theory and previous studies. In BRICS countries, Brazil and Russia are considered as oil exporters, whereas the other three are oil importers. In case of the oil exporting countries, the observed relationship was positive, and for the most parts also stronger. For India and China, the two major oil importing countries of the world, the relationship between oil price changes and stock returns was negative and also weaker in comparison to the exporting countries. The only exception here was South Africa, as was described at the end of chapter 8. Accordingly, the H3 was accepted with an exception that South Africa is a commodity exporter.

The findings of this paper indicate that there often is a significant relationship between the oil price changes and the BRICS stock returns, but the degree and direction of that relationship differs between oil importing and oil exporting countries. There is not much evidence that the onset of the Covid-19 pandemic has made the relationship stronger, which is in contrast to the previous literature. One reason for these differing results regarding the crisis period could be the methodology that was used in this study. Multiple linear regression is quite simple model, and it is not the best suited to study the complex market environment and the oil price-stock market relationship.

It could be useful to do a similar study using a more complex methodology, such as the quantile regression model. It would be able to better test whether there is a crisis-specific change in the degree or structure of dependence between oil prices and stock returns. Another possibility for future research could be specifying between the types of oil price shocks. In this case, VAR model could be employed. This would give a more detailed picture of the relationship between oil price changes and stock returns in the BRICS countries. It would also be interesting to study the oil price-stock market relationship from emerging markets' sectoral perspective. This would reveal implications for market participants about different equity sectors. In addition, the study could be extended to a larger group of emerging countries and to some developed countries as well, enabling a wider comparison between different markets. The impacts of the Covid-19 pandemic as well as the Russian invasion of Ukraine are not yet fully discovered, so extending the study period in the future could also provide more information.

Nevertheless, even with its limitations, this study provides a good overview of the latest relationship between oil prices and BRICS stock returns, which has been affected quite a lot during the recent years. The results of this study have some useful implications for investors, policymakers as well as to other market participants. First, the effects of oil price changes on stock returns vary between the pre-crisis period and crisis periods. This means that market participants need to account for the changing market conditions in their decisions. Secondly, both the significance and the direction of the relationship between oil prices and stock returns depends on whether the country is oil importer or oil exporter. Generally stronger and positive relationship between oil exporting countries' stock returns and oil price changes decreases the attractiveness of crude oil in portfolio diversification in cases it includes also equities from oil exporting countries. Hence, portfolio managers and investors need to find other ways to diversify their portfolios.

Appendix

Appendix 1. Correlation matrices for pre-crisis period

	Brazil	*WTI*	*Brent*	*World*	*BRL to USD*	*Gov. Bond*
Brazil	1					
WTI	0.3704	1				
Brent	0.3280	0.6895	1			
World	0.5253	0.3995	0.3950	1		
BRL to USD	0.6303	0.2270	0.1532	0.3102	1	
Gov. Bond	-0.0854	-0.0208	-0.0066	-0.0050	-0.1021	1

	Russia	*WTI*	*Brent*	*World*	*RUB to USD*	*Gov. Bond*
Russia	1					
WTI	0.4291	1				
Brent	0.4614	0.6895	1			
World	0.4931	0.3995	0.3950	1		
RUB to USD	0.6489	0.4821	0.3853	0.4097	1	
Gov. Bond	-0.1185	-0.0280	-0.0525	0.0039	-0.0726	1

	India	*WTI*	*Brent*	*World*	*INR to USD*	*Gov. Bond*
India	1					
WTI	0.1580	1				
Brent	0.1514	0.6895	1			
World	0.3907	0.3995	0.3950	1		
INR to USD	0.5325	0.0992	0.0769	0.2922	1	
Gov. Bond	0.0325	0.0126	0.0390	0.0268	0.0009	1

	China	*WTI*	*Brent*	*World*	*CNY to USD*	*Gov. Bond*
China	1					
WTI	0.1551	1				
Brent	0.1887	0.6895	1			
World	0.5144	0.3995	0.3950	1		
CNY to USD	0.2289	0.1171	0.1405	0.2213	1	
Gov. Bond	-0.0045	-0.0020	0.0012	0.0023	-0.0008	1

	South Africa	*WTI*	*Brent*	*World*	*ZAR to USD*	*Gov. Bond*
South Africa	1					
WTI	0.3067	1				
Brent	0.3348	0.6895	1			
World	0.5603	0.3995	0.3950	1		
ZAR to USD	0.6107	0.2420	0.1836	0.4332	1	
Gov. Bond	-0.0124	0.0066	0.0019	-0.0293	0.0411	1

Appendix 2. Correlation matrices for the full crisis-period

	Brazil	*WTI*	*Brent*	*World*	*BRL to USD*	*Gov. Bond*
Brazil	1					
WTI	0.0692	1				
Brent	0.2377	-0.0570	1			
World	0.5931	0.0272	0.2766	1		
BRL to USD	0.6289	0.0621	0.0988	0.2870	1	
Gov. Bond	-0.0038	-0.0616	0.0418	-0.0018	0.0424	1

	Russia	*WTI*	*Brent*	*World*	*RUB to USD*	*Gov. Bond*
Russia	1					
WTI	0.0335	1				
Brent	0.1537	-0.1551	1			
World	0.3613	0.0067	0.3284	1		
RUB to USD	0.6558	0.0600	0.1974	0.3214	1	
Gov. Bond	-0.0477	-0.0399	0.0347	-0.0658	-0.3207	1

	India	*WTI*	*Brent*	*World*	*INR to USD*	*Gov. Bond*
India	1					
WTI	-0.0583	1				
Brent	0.1492	-0.0570	1			
World	0.4419	0.0272	0.2766	1		
INR to USD	0.3992	0.0127	0.1528	0.4225	1	
Gov. Bond	0.1208	0.0295	0.0599	-0.0433	-0.0107	1

	China	*WTI*	*Brent*	*World*	*CNY to USD*	*Gov. Bond*
China	1					
WTI	0.0141	1				
Brent	0.1387	-0.0570	1			
World	0.3492	0.0272	0.2766	1		
CNY to USD	0.3318	0.0257	0.0998	0.2827	1	
Gov. Bond	0.0138	0.0451	0.0426	-0.0506	0.0155	1

	South Africa	*WTI*	*Brent*	*World*	*ZAR to USD*	*Gov. Bond*
South Africa	1					
WTI	0.0355	1				
Brent	0.2224	-0.0570	1			
World	0.5762	0.0272	0.2766	1		
ZAR to USD	0.6374	0.0371	0.1423	0.4899	1	
Gov. Bond	-0.0544	-0.0380	0.0274	-0.0315	-0.0068	1

Appendix 3. Correlation matrices for the first crisis-period

	Brazil	*WTI*	*Brent*	*World*	*BRL to USD*	*Gov. Bond*
Brazil	1					
WTI	0.0431	1				
Brent	0.2326	-0.1564	1			
World	0.6873	0.0077	0.3327	1		
BRL to USD	0.5624	0.0335	0.0621	0.2526	1	
Gov. Bond	-0.0088	-0.0664	0.0431	-0.0050	0.0447	1

	Russia	*WTI*	*Brent*	*World*	*RUB to USD*	*Gov. Bond*
Russia	1					
WTI	0.0770	1				
Brent	0.3163	-0.1564	1			
World	0.5564	0.0077	0.3327	1		
RUB to USD	0.6878	0.1216	0.3625	0.4994	1	
Gov. Bond	-0.1109	-0.0609	0.0460	-0.1537	-0.0342	1

	India	*WTI*	*Brent*	*World*	*INR to USD*	*Gov. Bond*
India	1					
WTI	-0.0734	1				
Brent	0.1734	-0.1564	1			
World	0.4904	0.0077	0.3327	1		
INR to USD	0.4275	0.0195	0.2062	0.4171	1	
Gov. Bond	0.1743	0.0358	0.0720	0.0008	0.0171	1

	China	*WTI*	*Brent*	*World*	*CNY to USD*	*Gov. Bond*
China	1					
WTI	-0.0108	1				
Brent	0.1558	-0.1564	1			
World	0.4467	0.0077	0.3327	1		
CNY to USD	0.2908	-0.0132	0.0836	0.2666	1	
Gov. Bond	-0.0141	0.0538	0.0451	-0.0773	0.0286	1

	South Africa	*WTI*	*Brent*	*World*	*ZAR to USD*	*Gov. Bond*
South Africa	1					
WTI	0.0117	1				
Brent	0.2324	-0.1564	1			
World	0.6018	0.0077	0.3327	1		
ZAR to USD	0.6154	0.0311	0.1689	0.4613	1	
Gov. Bond	-0.0636	-0.0433	0.0228	-0.0356	-0.0073	1

Appendix 4. Correlation matrices for the second crisis-period

	Brazil	*WTI*	*Brent*	*World*	*BRL to USD*	*Gov. Bond*
Brazil	1					
WTI	0.2896	1				
Brent	0.2687	0.9139	1			
World	0.3654	0.1470	0.1137	1		
BRL to USD	0.8177	0.2709	0.2401	0.3598	1	
Gov. Bond	0.0629	0.0553	0.0383	0.0238	0.0840	1

	India	*WTI*	*Brent*	*World*	*INR to USD*	*Gov. Bond*
India	1					
WTI	0.0277	1				
Brent	0.0309	0.9139	1			
World	0.3220	0.1470	0.1137	1		
INR to USD	0.3240	-0.0397	-0.0268	0.4311	1	
Gov. Bond	-0.0663	0.0221	0.0182	-0.1633	-0.0731	1

	China	*WTI*	*Brent*	*World*	*CNY to USD*	*Gov. Bond*
China	1					
WTI	0.1181	1				
Brent	0.1435	0.9139	1			
World	0.2381	0.1470	0.1137	1		
CNY to USD	0.3646	0.1776	0.1623	0.3164	1	
Gov. Bond	0.0544	0.0061	0.0350	0.0066	-0.0036	1

	South Africa	*WTI*	*Brent*	*World*	*ZAR to USD*	*Gov. Bond*
South Africa	1					
WTI	0.1907	1				
Brent	0.2016	0.9139	1			
World	0.5211	0.1470	0.1137	1		
ZAR to USD	0.6845	0.0820	0.0617	0.5462	1	
Gov. Bond	-0.0193	0.1038	0.1112	-0.0280	-0.0065	1

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