Bachelor Thesis

"Dynamic correlation between oil and the stock market. Does the status of the market and the origin of the shock matter?"

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PLAGIARISM STATEMENT

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Abstract

This paper investigates the time varying correlation between oil and the stock market in five oil importing and five oil exporting countries. A DCC-GARCH-GJR model similar to the one proposed by Engle (2009) is employed. The estimation output of the selected model suggests that the time-varying correlation does not differ for oil-importing and oil-exporting economies and that the correlation increases positively (negatively) in respond to important aggregate demand-side (precautionary demand) oil price shocks, which are caused due to imbalances in the global financial and economic activity or world turmoil such as wars. Regarding supply-side oil price shocks the results imply that only the recent "Oil Glut" in 2014 significantly (positively) contributed in the dynamic correlation between oil and the stock market. All the other supply-side shocks seemed not to affect essentially the relationship between the two markets.

JEL: C5 ; G1; Q4

Keywords: oil prices; oil price shocks; stock market returns; DCC-GARCH; dynamic correlation; oil crisis episodes; stock market crushes

1. Introduction

During periods of economic turmoil when the possibility of a financial crisis is profound financial markets constitute a source of instability and in many cases do not operate rationally. The price of many assets falls quickly and deeply, central banks cut their policy rates drastically and the overall situation is characterized by a great amount of uncertainty. The recent financial crisis, as well as, other crises episodes resulted in a significant persistent recession that directly indicated the existence of a close relationship between the financial system and the real economy. The stock market is the “heart” of the financial system. Without the availability of stocks and the development of financial markets, there would not have been substantial growth in the business sector or the overall growth in the economy. It is therefore important for everyone to understand that there is a close and direct relationship between the stock market and the real economy. Since oil prices can affect the economy, they are probably capable of affecting the stock market. This is the reason that enabled us to investigate the dynamic correlation between oil and the stock market.

This paper investigates the time-varying correlation between stock market prices and oil prices for oil-importing and oil-exporting countries. In order to provide a spherical explanation regarding the relationship between the two markets we decided to take into consideration the origin of oil price shocks. Intuitively we consider Kilian’s (2009) and Hamilton’s (2009) origins of oil price shocks (aggregate demand-side shock, precautionary demand shock, and supply-side shock). Despite the enormous literature concerning the relationship of the oil market with the real economy, the literature upon the correlation of the oil market with the financial system is not very large. To specify it, even more, the number of papers that are concerned with the investigation of the dynamic correlation between the two markets is relatively small and with this study, we wish to contribute in the current bibliography.

The DCC approach was firstly introduced by Engle and Sheppard in 2001. However, the significant specification of the model and the correct interpretation of its estimation measures was conducted by Engle in 2002. There is a big interest among experts in enhancing the performance of DCC approaches by proposing several improvements upon its structure because after its development the explanation of time-varying correlation is necessary in many cases. Cappielo et al. (2006) employed the asymmetric generalized DCC (AG-DCC) process. The innovation of this process is that it considers the impact of series-specific news and smoothing parameters and it also allows for conditional asymmetries in correlation dynamics. This DCC approach facilitates the investigation of correlation dynamics among different asset classes and the existence of asymmetry in conditional variances.

Billio and Caporin (2006) proposed a generalization for the approaches of Engle (2002) and Cappielo et.al (2006) by imposing a new parsimonious approach with a block structure in parameter matrices that allows for interdependence with a reduced number of parameters. Hafner and Franses (2009) also suggested a generalization of the DCC model introduced by Engle (2002). In their model, the authors took under consideration asset-specific correlation sensitivities in order to summarize a large number of asset returns. Their results implied that this approach enhances the performance of the DCC model of Engle (2002) and can be applied in a variety of different asset classes.

In 2009 Colacito, Engle and Ghysels proposed a DCC approach with short- and long-run component specification, in order to extract a long-run correlation component via mixed data sampling. Based on this approach, Urbina (2013) examined whether the recent financial crisis that initiated in the US spread in the entire world through contagion or interdependence. He realized that there is a necessity to employ a DCC- MIDAS approach in order to interpret the estimation of the data under consideration when testing for long-term interdependence and cross-correlations. Engle and Kelly (2012) proposed a new covariance matrix in the estimation procedure of the traditional DCC model assuming that in every period all cross-correlations are the same. Their innovative approach was called DECO and the results indicated that it offers consistent parameter estimates even when the equal cross-correlation assumption is violated.

One of the most important studies considering the dynamic nature in the correlation between oil and the stock market was conducted by Ewing and Thomson in 2007. In their methodology, cyclical components of oil and stock prices were included to examine whether stock market prices precede oil prices in the economic cycle. Their findings implied that oil prices present a pro-cyclical behavior and that stock market prices precede oil prices in the economic cycle by six months. In another study, Hammoudeh & Li (2005) concluded that on a daily basis the stock and the oil market interact with each other in a dynamic fashion and are negatively correlated.

Later on, Büyükşahin, Haigh, and Robe (2008) examined whether the dynamic correlation between commodities and the stock market has increased substantially over the period 1993-2008. Their findings implied that there is no increase in the correlation between the returns on commodity and equity investments during periods of asymmetric fluctuations of returns. In a study focusing on the Russian stock market, Bhar and Nikolova (2010) investigated the dynamic correlation between the stock market and oil prices in Russia using a bivariate EGARCH model. The outcome of their research was that the terrorist attack in 2001, the war in Iraq that took place in 2003 and the civil war in Iraq in 2006 led to a significant interdependence between the stock and the oil market in Russia.

Lee and Chiou (2011) applied a univariate regime-switching model in order to examine the relationship between oil prices and S&P500 returns. They concluded that when significant fluctuations in oil prices exist, the asymmetric price changes lead to a negative impact on stock returns. However, their findings suggest that this result is not valid in the case of low oil price fluctuations. Filis et al. (2011) examined the time-varying correlation between stock market prices and oil prices in three oil importing and three oil exporting countries using a DCC-GARCH-GJR approach. Their findings indicated that the supply side oil price shocks have no impact on the relationship between the two markets. In contrast, they found that important aggregate demand-side (precautionary demand) oil price shocks contribute positively (negatively) on the increase of correlation.

Zhu, Rong Li and Sufang Li (2012) conducted research upon the dynamic dependence between crude oil prices and stock markets in ten countries across the Asia-Pacific region. Their study implied that the dependence between crude oil prices and the Asia-Pacific stock market returns significantly increased in the aftermath of the recent financial crises. Awartani & Maghyereh (2013) examined the dynamic spillovers between crude oil and the stock market in GCC countries. Their results implied that there exists a bi-directional relationship between oil and the stock market, though asymmetric since the impact of oil price shocks on the stock market tends to be more significant than the impact of stock market shocks on the oil market. Jain and Biswal (2016) examined the relationship between gold, crude oil, exchange rates, and stock market returns. The authors employed a DCC-GARCH approach and suggested that a drop in crude oil prices can force a downward movement of the Indian stock market.

In this study we decided to employ an asymmetric version of the GARCH family that takes into account the time-variation of time series. To the best of our knowledge the DCC-GARCH-GJR model has been applied before only once by Filis et.al (2011) in order to investigate the time-varying correlation between oil and stock market prices, considering the origin of the oil price shock. The data chronology of our analysis begins from 1989Q4 and terminates in 2018Q4 and includes five oil importing and five oil exporting countries: Canada, Mexico, Russia, Norway and Saudi Arabia regarding the exporters, and USA, UK, France, Japan and China regarding the importers. With this paper we intend to contribute to the limited financial literature regarding the time varying correlation between oil prices and stock markets.

2. Background

Oil is a natural, non-renewable resource that contributes significantly to the operation of financial markets. Crude oil can be used to produce gasoline, diesel, and other petrochemicals. Since it is a non-renewable resource, its supply is limited. Back in the 1970s, an unexpected problem arose and that was the fact that the price of oil became more important than the question of supply, because there was no profound danger of running out of oil shortages. This resulted to a primary financialization of the oil market since the oil price began to be determined endogenously in the market and immediately after that, it became a product of trade between market participants like any other commodity. An undeniable fact is that when the price oil fluctuates, everything linked to oil prices also fluctuates (i.e. the price of outputs that require the oil usage). Consequently, a situation like this is capable of causing a considerable impact on the overall economic activity since it affects important economic components, and thus seems to be a determinant factor in the production of recessions. The truth is that after the oil crises episodes in the 1970s the interest of the scientific community on the correlation among oil price, the economy and the stock market was considerably diminished due to a long period of oil-price stability and non-interaction with the overall activity.

However, during the past decade on the aftermath of the recent financial crisis, the subsequent economic downturn and the following recovery alongside with the advanced financialization of commodities have brought sharp movements in crude oil and stock prices and thus the interest about the dynamic interaction between oil prices and equity returns rose again. The relationship between the two markets has drawn considerable attention among experts because of its implications for portfolio selection, risk management, and international asset allocation. Oil and stock markets are systems characterized by complexity since they are consisting of heterogeneous agents. These market participants differ in a variety of terms such as trading strategies, investment horizons, risk profiles, etc. Thereafter, it seems logical to assume that the degree of connection between oil prices and stock market returns may vary over time and across countries.

Although many authors suggest that oil prices are mutually correlated with the stock market a distinction needs to be drawn between the primary drivers of oil prices and the drivers of stock prices. Oil prices are determined by the supply and demand for petroleum-based products. Their prices might rise as a result of increased consumption or they might fall as a result of increased production. On the other hand, stock prices rise and fall based on future corporate earnings reports, investor risk tolerances and a large number of other factors. It is very possible that oil prices affect certain sectors much more dramatically than they affect others. It can be stated that these markets are too complex to expect one commodity to drive all business activity in a predictable way.

The renewed interest in the relationship between oil and the stock market enabled us to examine whether oil price changes are able to affect the stock market. However, our desire is to avoid producing specification errors and conclude to significant, time-varying estimations in order to contribute essentially to the existing literature. Oil prices are expected to have both a direct and indirect negative influence on stock market performance. The direct effect can be explained by the fact that oil price shocks can be considered as a risk factor for financial markets and thus a positive oil price shock may induce a decrease in share prices (Jones and Kaul 1996). Moreover, increased oil prices imply higher production costs for firms, which will attempt to pass these onto consumers by raising their prices. In contrast to the direct effects, this cost effect has an influence on core inflation. On the other hand, an indirect negative effect can be also justified since higher oil prices lead to higher inflation, which, in turn, causes a negative effect on the stock market. This negative relationship between oil prices and stock returns has been documented by Filis (2010), Chen (2010), Miller and Ratti (2009), Driesprong et al. (2008), O'Neill et al. (2008), Park and Ratti (2008), Bachmeier (2008), Ciner (2001) and Gjerde and Sættem (1999). Similar findings are reported by Malik and Ewing (2009), who also observe that the oil price volatility causes negative effects on stock market returns. Oberndorfer (2009) also supports this specific opinion in his study regarding the effect of oil price volatility on European stock markets.

Our primary concern regarding the dynamic correlation between the two markets is to classify the changes in oil prices as demand driven (demand shocks) or supply driven (supply shocks). It seems that oil producing firms are likely to benefit from increases in oil demand, but may have a natural hedge against shocks to oil supply. If oil becomes more difficult to produce, producers will sell less, but at higher prices. If this is the case, oil producer returns can be used as a control to separate shocks to demand and supply. The world's dependence on oil has rapidly changed since the mid-1900s. Countries depend on the supply of crude oil for economic growth. Increased oil prices have a definite impact on the world economy through employment, rising inflation, decrease in dollar value all of which combine to the economic slowdown. Any massive increase or decrease in crude oil has an impact on the condition of stock markets throughout the world.

2.1 Oil Prices: Fundamentals and Historic Events

2.1.1 DEMAND

Demand is determined by expectations that coincide with the global business cycle and uncertainty related to unexpected declines in supply levels. Thereafter, we can conclude that the global business cycle is the driving force of the alteration in the desire of customers for consumption. Increased economic growth is supposed to be the most important factor for rising levels of oil consumption. Another characteristic of oil demand is that people respond to changes in oil prices slowly which means that any imbalances in the economic activity due to fluctuations in oil demand do not happen simultaneously. An important study in support of the above-mentioned conclusion was conducted by Hamilton (2009), providing evidence that in the short run the driving force of oil demand is the personal income rather than prices. More specifically, if personal incomes remain stable then the demand for oil will not drop if temporary fluctuations in oil prices occur.

2.1.2 SUPPLY

Countries like Saudi Arabia, Iraq, Iran and others in the Middle East possess massive supplies of oil and consequently constitute the world's leading oil exporters. Other countries such as the USA, Russia, and Venezuela also have considerable amounts of oil in their inventories. However, the control of oil production is under the supervision of the Organization of the Petroleum Exporting Countries (OPEC) which possesses approximately 82% of the global oil production and therefore is capable of changing the supply of oil in order to achieve the desired price levels. A supply shock is a situation in which the availability of crude oil either increases or decreases and as we mentioned above the OPEC can regulate the direction of these changes to cause fluctuation in oil prices. Respectively to the demand side of oil, the supply side is neither subject to significant fluctuations whenever price changes occur. An undeniable fact is that oil supply is directly affected by the expectations related to the future ability of production since it is well known that crude oil and fossil fuels are non-renewable sources that will become extinct in the future. Furthermore, exogenous shocks like war can significantly reduce the supply of oil. For example, as Smith (2009) supports in his study, the US invasion in Iraq led to a 2.2 mb/day decrease from April to July of 2003.

2.1.3 Oil price determinants

1) One of the most important factors linked to the fluctuations of oil prices is the demand and supply of oil-based products. The concept of supply and demand is fairly straightforward. As demand increases (or supply decreases) the price should go up. As demand decreases (or supply increases) the price should go down. For example, by restricting production, OPEC could force prices to rise, and theoretically enjoy greater profits than if its member countries had each sold on the world market at the going rate. Regarding the financial markets, the futures market with which oil prices are directly connected includes two types of traders, hedgers, and speculators. This means that the price of oil is based on the expectations of those traders over its movements. As a result market sentiment has a direct impact on oil prices. For instance, the belief that oil demand will increase at some point in the future could be a determinant factor of a huge increase in oil prices in the present as speculators and hedgers would sharply grab futures contracts

2) Reports on production figures, spare capacity, target pricing, and investments can be a crucial factor in the setting of crude oil prices. Some of the most keenly followed reports are the OPEC Monthly Oil Market Report, International Energy Agency (IEA) Oil Market Report, American Petroleum Institute (API) Inventory Report, US Energy Information Administration's (EIA) Reports on Crude Oil Stockpile, Short-Term Energy Outlook, Annual Energy Outlook, Monthly Energy Review, and International Energy Outlook.

3) Political events and crises. War, natural disasters, political turmoils, and new government leaders are factors influencing crude oil pricing. For example, the "Arab Spring" unrest in 2011 pushed oil prices to a peak of $113 a barrel as unrest and protests rocked Egypt, Libya, and Tunisia. They then returned to under $100 per barrel as things calmed down in June. Hurricane Katrina caused a large price increase in 2005 when it destroyed hundreds of oil and gas platforms and pipelines. Moreover, when a large storm hits, it usually brings lower temperatures and increases the heating demand of each home

4) The price of the US dollar against foreign currencies. A devalued US dollar gives foreign investors more money to buy crude oil contracts and a stronger US dollar discourages foreign investment in crude oil contracts.

5) In the long run, the cost of production is a critical variable because the market price cannot deviate from it by very much for very long. When the market price falls below the cost of production, the industry does not earn a profit, as it must in order to invest in new equipment and engage in exploration activities. Producers with the highest costs will drop out of the industry, reducing supply and putting upward pressure on prices. When, on the other hand, the market price is higher than the cost of production for any appreciable length of time, the new capital will flow into the industry, increasing supply and exerting downward pressure on prices. In the long run, therefore, the market price gravitates around the cost of production at the highest-cost production sites, the output of which remains necessary to satisfy demand.

2.1.4 Differentiation of oil shocks

According to Kilian (2008), it is necessary to differentiate the cause of oil shocks whether it is a demand or supply driven oil shock. In his study the author defines three types of shocks: oil supply shocks which are related to unexpected innovations in the production of crude oil, aggregate oil demand shocks which are driven by the global business cycle and oil market specific demand shocks, which are directly connected with an overall uncertainty regarding the convenience yield that is reflected by the expected supply. Kilian & Park (2008) investigated whether oil price shocks can directly affect overall economic activity and stock market behavior. Their findings provided evidence that global economic activity does not significantly respond to oil market demand shocks. The impulse responses further showed that oil supply shocks fail to produce significant responses on the aggregate stock returns. However, it seems that aggregate demand shocks are capable of causing a persistent increase in stock market returns.

Apergis and Miller (2009) suggested that oil-supply shocks, aggregate global demand shocks, and oil-market idiosyncratic demand shocks contribute significantly in explaining stock-market returns in most countries during the periods of shocks but not on their aftermath. Lippi & Nobili (2008) concluded it is necessary to clarify the nature of the oil shock (i.e. supply or demand shock) in order to make clear both the direction and the magnitude of the correlation between oil price fluctuations and the performance of the overall economic activity in the US.

Cashin et al (2014) found that the economic consequences of a supply-driven oil-price shock are very different from those of an oil-demand shock driven by global economic activity, and vary for oil- importing countries compared to energy exporters. The findings of Baumeister & Peersman (2013) indicated that oil supply shocks more recently account for a smaller fraction of the variability of the real price of oil, implying a greater role for oil demand shocks. Zhao et al (2016) found that four types of oil price shocks exist. Supply-side shocks are driven by political events in OPEC countries, other oil supply shocks, aggregate shocks to the demand for industrial commodities, and demand shocks that are specific to the crude oil market.

2.1.5 Oil crises episodes

An oil shock is defined as an unexpected and dramatic change in the price of oil. Sharp increases in oil prices can be the primary factors of various, negative, economic consequences. In many cases, it is suggested that these shocks have an asymmetric and non-linear effect on the economic performance a topic that was extensively investigated during the 1970s and 1980s. The reason behind the increased interest on this topic is that the rising oil prices as a result of the 1970s oil crisis led to a high inflation and unemployment rate. As a result, a negative relationship between oil price increases and the overall economic activity was established.

In the past 50 years, five significant oil price shocks took place. The first one started in October 1973 when members of the OAPEC proclaimed an oil embargo to many western countries including the US because of the help they provided to Israel during the Yom Kippur War. By the end of the embargo in March 1974, the price of oil had increased as much as four times compared to the initial point in October from US$3 to US$12 per barrel. In US production, the disruption of oil prices led to intensive recessions and excessive inflation rates that persisted on the aftermath of the oil embargo and consequently resulted in slower economic growth. Many academic and financial experts suggest that this oil crisis was one of the principal components of the preceding stock market crash a situation that caused considerable, negative effects on the financial system such as uncertainty and a significant drop in the prices of many equities.

The second episode was the Islamic Revolution in Iran in 1979. The outcome of this turbulence was an increase in the price of crude oil from US$15.85 to US$39.50 after twelve months. The truth is that neither the persistence nor the magnitude of this episode was the same as the 1973 oil embargo however it contributed in a significant short-term rise in recession levels inside the US. The third episode was the 1990s Iraqi invasion in Kuwait.

Lasting only nine months, the price spike was less extreme and of shorter duration than the previous oil crises of 1973–1974 and 1979–1980, but the spike still contributed to the recession of the early 1990s. The average monthly price of oil rose from $17 per barrel in July to $36 per barrel in only 2 months from the initiation of the turbulence. However, after the U.S. military success against Iraqi forces, concerns about long-term supply shortages eased and prices began to fall. (Sourced: Wikipedia, Investopedia)

The fourth episode was the energy crisis of the 2000s. According to Hamilton (2009), this episode was caused by strong demand and confronting stagnating world production. Another possible cause of the crisis episode was the "financialization" of commodities since investors bought oil not as a commodity but as a financial asset and adopted specific trading strategies to exercise influence on its price, a technique that introduced a speculative bubble in the price of oil. The last significant oil price shock during the past 50 years was the "Oil Glut" of 2014 in which the price of oil dropped from $100 to $40 in 4 months. The main causes behind the spurious decline of oil prices in this episode were the massive oversupply of oil from the US and Canada, China's slow growth that couldn't satisfy the expectations of oil demand and geopolitical rivalries between members of OPEC.

2.2 The impact of oil price shocks on oil-importing, oil-exporting countries and the industrial sector

2.2.1 Oil importing and oil exporting countries

The economic theory suggests that asset prices should be determined by their expected discounted cash flows. Therefore, it seems logical to assume that any disturbance capable of altering the expected discounted cash flows is also capable of imposing a significant impact on asset prices. In general, oil price increases are supposed to result in rising levels of costs, profits and a decrease in shareholders' value. Thus, oil price increases should be accompanied by a decrease in stock prices. The question is whether this outcome is the same for oil importing and oil exporting countries.

It is generally supposed that an oil price increase is positively related to the performance of oil exporting countries and negatively related to oil importing countries. On the contrary, oil price decreases favor oil importing countries whereas they are expected to worsen the performance of oil exporting countries. Arouri and Rault (2012) concluded that a positive oil price shock in an oil exporting country can produce a positive impact on the stock market performance. Similar results are documented by Bashar (2006). Al Fayoumi (2009) found no evidence of a significant impact from oil price shocks on the stock market of oil exporting countries. Countries that export non-oil forms of energy could be affected by oil price shocks in a different way. Peersman and Van Robays (2009) suggested that oil importing countries that produce and export other forms of energy (not oil) could potentially benefit from soaring oil prices through increased demand for their oil substitutes.

It seems that the role of other forms of energy could also lead to cross-country differences regarding the dynamic effects of crude oil shocks. The prices of non-oil sources of energy, such as natural gas, typically move closely with oil prices. This is clearly the case when the oil price shift is driven by an expansion of worldwide economic activity which triggers a general surge in demand for commodities. For exogenous oil supply and oil-specific demand shocks, the magnitude of this effect will depend on the substitutability of oil with other sources of energy. Hence, an oil-importing country that produces and exports other forms of energy could therefore still benefit from an adverse oil shock via increased demand for alternative sources of energy. According to Baumeister et.al (2009), an unfavorable oil supply shock directly affects the performance of oil and energy-importing countries. This impact though seems to be insignificant or even positive in energy-exporting countries. Filis & Chatziantoniou (2014) investigated the impact of oil price changes on the stock market of oil importing and oil exporting countries. Their findings implied that the stock market of oil exporting countries generally benefits from oil price increases. However, this regime does not hold when taking into consideration oil importing countries, since they seem to be negatively affected by oil price shocks.

The results of Bjørnland (2009) indicated that a 10% increase in oil price can result in a 2.5% increase in stock prices in Norway, an oil-exporting country. Park and Ratti (2008) also found that rising oil prices have positive effects on the Norwegian stock market, in contrast to those in oil-importing countries on which increases in oil prices have negative effects. Jung and Park (2011) compared the significance of response to oil supply and demand shocks by stock markets in an oil-exporting country (Norway) and an oil-importing country (Korea). Their findings suggested that the response of stock market returns to oil price shocks in these two countries significantly differed. Wang, Wu & Yang (2013) found that the response of stock market returns to oil price shocks depends on whether the country is a net importer or exporter, and whether changes in the oil prices are driven by supply or aggregate demand. In a similar study, Filis, Degiannakis & Floros (2011) investigated the dynamic correlation between oil price and the stock market in oil importing and oil exporting countries and found that oil demand-side shocks generally exhibit a negative effect in all stock markets, regardless the origin of the oil price shock.

Kang & Ratti (2013) suggested that positive oil demand-side shocks negatively affect the stock market returns of oil importing countries. Cunado & de Gracia (2014) examined the impact of oil price shocks on stock returns in 12 oil importing European economies by. The authors concluded that oil price changes are capable of producing a negative and significant impact on the performance of European stock markets. Creti, Ftiti and Guesmi (2014) suggested that interdependence between the oil price and the stock market is more evident in oil exporting rather than in oil importing countries. Wang and Liu (2015) investigated the dynamic correlation between oil and the stock market in oil importing and oil exporting countries. The authors concluded that the dynamic correlation between the two markets depends on the net position of the country under examination.

2.2.2 Industrial sectors

The truth is that oil is a very valuable resource for the rational operation of industries since it participates in most of its functions. One of the first studies that focused on this topic was conducted by Lee and Ni (2002). The authors suggested that concerning industries with a high-cost share of oil, oil shocks can produce a significant drop in the amount of supply. However, on industries like the automobile industry these shocks were proved to be related to a drop in the amount of demand. Herrera (2008) took a sample of 21 US manufacturing industries during the period 1958 to 2000. The estimates of the study presented evidence that oil price shocks are capable of causing a decrease in the industrial output. Scholtens & Yurtsever (2012) employed a VAR model and a multivariate linear regression model and took a sample of 38 European industries for the period 1983-2007. The results of their study implied that for the majority of the sample’s industries the magnitude of change due to negative oil price fluctuations was larger and more significant than the corresponding one due to positive price changes. Jimenez & Rodriguez (2008) investigated whether oil price shocks can produce dynamic effects on the production of the main industries in six OECD countries. The study implied that the responses of the industrial production to oil price shocks were not similar among the specific countries.

Nandha & Faff (2008) investigated whether oil price shocks can affect the returns of 35 industries in a monthly panel from 1983 to 2005. The results of their study implied that oil price shocks exhibit a significantly negative impact on the returns of almost all sectors except mining, oil and gas industries who are supposed to exhibit a positive relationship with oil prices. In another study, Gogineni (2009) examines 14 U.S. industries with regard to their sensitivity to oil price changes. The results of the study suggested that for industries with a high negative relationship between the stock market and oil prices, the industries' sensitivity to oil prices increases with a rise in cost-side dependence. Guidi, F. (2009) conducted a study regarding the relationship between oil prices and the UK's manufacturing and services sector performance. The estimation outputs implied that declining oil prices play a more important role than rising oil prices in the performance of the services sector.

El-Sharif, Brown, Burton, Nixon, & Russell (2005) investigated the relationship between UK equity values and oil prices while focusing on the oil and gas sector equity. The results presented a significant positive relationship between oil and gas sector equity with oil prices. However, coefficients of the other sectors were found to be insignificant. Bjørnland (1998) analyzed the economic effects of energy booms on the manufacturing output in two energy producing countries. The first one is Norway and the second the United Kingdom. The results indicated that there was only weak evidence for such a case in the UK and also that higher oil prices benefit the manufacturing sector in Norway. Hutchison (1994) examined whether the development of the oil and natural gas sector in Norway, the Netherlands and the UK has influenced the manufacturing sector. The author concluded that the decline in the percentage of total value added devoted to the manufacturing sector is not systematically related to energy booms.

Sadorsky (2003) investigated the impact of oil prices on U.S. technology stock prices using daily and monthly data from 1986 to 2000. The estimates implied that technology stock prices do not respond significantly to uncertainty in macroeconomic conditions, which is caused by oil price volatility. Cong, Wei, Jiao and Fan(2008) examined whether oil price fluctuations affect sectors of the Chinese economy. The results indicated that oil price shocks appear to affect significantly the manufacturing index, the indexes of two oil companies and the mining and petrochemicals index. Arouri and Nguyen (2010) provided roots of a negative effect from oil price changes on sectors such as Food and Beverages, Health Care and Technology and a positive effect on the Financial, Oil & Gas, Basic Materials and Personal and Household Goods sectors.

In the results of their study, Narayan and Sharma (2011) suggested that sectors such as Supply, Manufacturing, Food, Chemical, Medical, Computer, Transportation, Real Estate and General Services respond negatively to positive oil price changes. Hammoudeh and Li (2005) concluded that oil price changes are capable of causing a negative impact on the Transportation sector. Elyasiani et al. (2011) reported that positive oil price changes directly and positively affect US oil-related and oil-substitute sectors (i.e. Electric Services, Gas Services, Oil Refineries, etc.). However, they concluded that there is a negative and indirect effect on oil-using sectors (such as Buildings, Chemicals, Industrial Machinery, Transport Equipment, and Air Transportation) and financial industries.

Boyer and Filion (2007) included in their sample 105 Canadian oil and gas firms and suggested that firms' stock returns respond positively to rising oil prices which can be attributed to the fact that Canada is an oil-exporting country. Henriques & Sadorsky (2008) investigated how sensitive is the financial performance of alternative energy companies to changes in oil prices. The results of the study indicated that technology-firm stock prices and oil prices Granger cause the stock prices of alternative energy companies. Furthermore, simulation results suggested that a shock to technology stock prices can produce a more significant impact on alternative energy stock prices than a shock on oil prices can.

3. Literature Review

One of the earliest studies on the area between the economy and the oil market was conducted by Hamilton (1983). He concluded that oil price changes exercise a significant impact on economic activity in the US. In his study, Kling (1985) concluded that crude oil price increases are associated with stock market declines. Chen et al. (1986), in contrast, suggested that oil price changes have no effect on asset prices. In his study, Taneko (1995) employed a VAR model to test whether economic variables (including oil price changes) affect the stock market returns in Japan and the US. He concluded that only the Japanese stock market is sensitive to oil price fluctuations since no significant results were found regarding the US market and oil prices.

Jones and Kaul (1996) found that changes in oil prices that preceded most economic series caused a lagged negative effect on stock returns in the United States, Canada, Japan, and the United Kingdom during the post – Second World War period. Huang, Masulis, & Stoll (1996) investigated whether stock markets are efficiently linked to oil futures markets. The results of their study indicated that there exists a significant relationship between the oil futures index and stock market index. Sakellaris (1997) examined whether oil price shocks cause significant fluctuations in the excess returns of the stock market. The author concluded that oil shocks that can affect the input factor and output prices of a specific firm can significantly contribute to the variation of excess returns. Ciner (2001) conducted research over the dynamic linkages between oil prices and the stock market. Relying on nonlinear causality tests, the author found evidence that oil shocks affect stock index returns. Wei (2003) tested the relationship between energy prices, stocks markets, and business investment. The results implied the existence of transmission channels generated by the supply side of energy and more specifically by the input side to the stock market.

Hammoudeh & Li (2005) concluded that on a daily basis there is a negative bi-directional dynamic relationship between the oil futures price growth and the return of the world capital market as represented by MSCI. Basher and Sadorsky (2006) investigated the impact of oil price changes on a large set of emerging stock market returns. The estimation outputs suggested oil price shocks impact stock price returns in emerging markets. Ågren (2006) conducted a study over the volatility spillover from oil prices to stock markets by employing an asymmetric BEKK model. The author found strong evidence of volatility spillover from oil shocks to all stock markets of the sample, except the Swedish, in which only weak evidence was implied.

Buyuksahin, Haigh & Robe (2008) found that no significant change between the returns of commodities and stock market indices has occurred in the last fifteen years. Using dynamic correlation and recursive cointegration techniques they also found no increase in commodity and stock market comovement during turmoil periods. The results of Sujit & Kumar (2011) indicated that during times of oil price uncertainty, oil investments emerged as a risk deterrent in the context of inverse relationship with stock market movement. Park & Ratti (2008) suggested that oil price shocks have a statistically significant impact on real stock returns in the same month of the episode occurrence or within one month. Mollick & Assefa (2013) examined the relationship between oil and the stock market. The authors employed GARCH and MGARCH-DCC models and divided their sample into three sub-periods. In subsamples, I and II U.S. stock returns were not significantly related to oil price fluctuations. However, in subsample III the relationship between stock market returns and oil prices became positive and statistically significant.

Chang et al (2013) examined the volatility spillovers between crude oil returns and stock index returns. After employing a CCC-GARCH model the authors concluded that the estimated conditional correlations for returns across markets were very low and in some cases, they were not even statistically significant. However, when the authors employed the DCC-GARCH model they found that either for the same market or across markets, the conditional correlations were always statistically significant. Dhaoui & Khraief (2014) examined whether oil prices are capable of affecting stock market returns and their volatility. Their findings indicated that stock market returns and oil prices are negatively correlated and that oil price changes increase the volatility of returns. Diaz et.al (2016) examined the relationship between oil price volatility and stock returns in the G7 economies. They found a negative response of G7 stock markets to an increase in oil price volatility.

Aloui & Jammazi, (2009) found that increases in oil prices play a significant role in determining both the volatility of stock returns and the probability of transition across regimes. Mensi et al. (2013) suggested that significant correlation and volatility transmission across commodity (crude oil, gold) and equity markets exist. Similar findings are implied in the paper of Bampinas & Panagiotidis (2017) who examined four different crises episodes by employing a local Gaussian correlation approach and used daily data for the market indices.

Their research indicated the existence of nonlinear and asymmetric dependence between oil and stock markets during all financial crisis periods. The findings led the authors to further conclude that contagion between US stock markets and all the benchmark crude oil markets in the study exists.

Arouri (2009) investigated the short-run relationships between oil prices and GCC stock markets by taking into account both linear and nonlinear relationships. His findings implied that for some countries there are significant links between oil and the stock market, while for others there are not. In a similar study, Fayyad & Daly (2011) suggested that oil prices affect GCC markets, as well as the UK and the USA. Mohanty et.al (2011) also examined the relationship between crude oil prices and equity returns in GCC. Their findings indicated that except for Kuwait, stock markets have significant positive exposures to oil price shocks. Cong et.al (2008) investigated the effects of oil prices changes on Chinese stock market returns. The estimation output suggested that there isn't any significance in the predictive power of oil price fluctuations regarding China's stock market returns. Wen, Wei, & Huang (2012) found a significantly increasing dependence between crude oil and stock markets after the failure of Lehman Brothers. Zhu et al (2014) concluded that the dependence between crude oil prices and Asia-Pacific stock market returns is generally weak.

Aloui et.al (2012) conducted research with respect to the impact of world oil price changes on emerging stock markets. The findings implied that during periods of rising oil prices the sensitivity of stock returns is asymmetric and particularly significant, especially for emerging markets that are positively correlated with oil price movements. Asteriou and Bashmakova (2013) focused on emerging stock markets and found that stock market returns in the Central and Eastern European Countries (CEEC) economies respond negatively to positive innovations of oil prices. In a similar study, Basher et.al (2012) examined the dynamic relationship between oil price changes and the stock market performance regarding emerging markets. The findings provided roots of the bi-directional relationship between oil prices and the stock market in emerging economies.

Table 1

Author(s)	**Findings**
Hamilton (1983)	Significant Relationship between Oil & Economy
Kling (1985)	Negative Relationship between Oil & Stock Market
Chen et al. (1986)	No Relationship between Oil & Stock Market Returns
Taneko (1995)	Japanese stock market sensitive to oil price fluctuations. US market not
Jones and Kaul (1996)	Oil price changes → lagged negative effect on stock market returns of US, UK, Canada & Japan.
Huang, Masulis, & Stoll (1996)	Significant relationship between oil futures index and stock market index
Sakellaris (1997)	Oil shocks that can affect the input factor and output prices of a specific firm can significantly contribute to the variation of excess returns
Ciner (2001)	Significant relationship between oil shocks & stock index returns
Wei (2003)	Transmission channels from energy price shocks to stock market returns
Hammoudeh & Li (2005)	Negative bi-directional dynamic relationship between oil futures price growth and the return of the world capital market
Basher and Sadorsky (2006)	Oil price shocks significantly affect stock price returns of emerging markets
Ågren (2006)	Strong evidence of volatility spillover from oil shocks to most stock markets of the sample
Buyuksahin, Haigh & Robe (2008)	No significant change between the returns of commodities and stock market indices in the last fifteen years
Cong et.al (2008)	No significance in the predictive power of oil price fluctuations on China's stock market returns
Park & Ratti (2008)	Oil price shocks → Statistically significant impact on real stock returns in the same month of the episode occurrence or within one month
Arouri (2009)	For some countries of the sample there are significant links between oil and the stock market, while for others there are not
Aloui & Jammazi, (2009)	Increases in oil prices play a significant role in determining the volatility of stock returns
Sujit & Kumar (2011)	During times of oil price uncertainty, oil investments emerge as a risk deterrent in the context of inverse relationship with stock market movement
Fayyad & Daly (2011)	Oil prices shocks affect the stock markets of GCC countries, US and UK
Mohanty et.al (2011)	For all GCC countries except for Kuwait, stock markets have significant positive exposures to oil price shocks
Wen, Wei, & Huang (2012)	Significantly increasing dependence between crude oil and stock markets after the failure of Lehman Brothers
Aloui et.al (2012)	During periods of rising oil prices the sensitivity of stock returns is asymmetric and particularly significant, especially for emerging markets that are positively correlated with oil price movements
Basher et.al (2012)	Bi-directional relationship between oil prices and the stock market in emerging economies.
Mollick & Assefa (2013)	In some periods no relationship between oil and the stock market. In other periods positive and statistically significant relationship between the two markets
Chang et al (2013)	Statistically significant relationship between oil and

	the stock market when employed DCC-GARCH
Asteriou and Bashmakova (2013)	Stock market returns in the Central and Eastern European Countries (CEEC) economies respond negatively to positive innovations of oil prices
Mensi et al. (2013)	Significant correlation and volatility transmission across commodity (crude oil, gold) and equity markets
Zhu et al (2014)	The dependence between crude oil prices and Asia-Pacific stock market returns is generally weak.
Dhaoui & Khraief (2014)	Negative correlation between oil prices and stock market returns
Diaz et.al (2016)	Negative response of G7 stock markets to an increase in oil price volatility
Bampinas & Panagiotidis (2017)	Existence of nonlinear and asymmetric dependence between oil and stock markets during all financial crisis periods

4. Methodology

We employ a DCC-GARCH-GJR approach to produce robust results about the time varying correlation between oil prices and stock markets. DCC-GARCH is a generalization of the CCC (constant conditional correlation) model which was introduced by Bollerslev in 1990, but in contrast it allows the correlation matrix to depend on the time. The assumption of the CCC model that conditional correlations are fixed over time is not always a rational consideration since many disturbances can cause a fluctuation on the level of interdependence between two variables. Furthermore, by employing the DCC-GARCH we can overcome the lack of temporal dynamics in the correlations. The DCC-GARCH model has clear computational advantages in that the number of parameters to be estimated in the correlation process is independent of the number of series to be correlated. Thus potentially very large correlation matrices can be estimated. It is not linear but can often be estimated very simply with univariate or two step methods based on the likelihood function. It is shown that it performs well in a variety of situations and provides sensible empirical results. The idea of the models in this class is that the covariance matrix, H_t can be decomposed into conditional standard deviations, D_t and a correlation matrix, R_t. In the DCC-GARCH model both $D_t$and $R_t$are designed to be time-varying.

4.1 Auto-Regressive Conditionally Heteroscedastic (ARCH) models

A very important non-linear model with a widespread usage in finance is the ARCH model. It represents a realistic version of a non-linear model with practical application in financial time series because it takes into consideration that the variance of errors is not constant over time, though in contrast it states that variance is evolving with the passage of time. Moreover, it is directly related to the so called "volatility clustering" a situation implying that the current level of volatility tends to be positively correlated with its level in immediately preceding periods.

A full ARCH model takes the following form:

$$y_t = \beta_1 + \beta_2\chi_{2t} + \beta_3\chi_{3t} + \ldots \beta_q\chi_{qt} + u_t \qquad u_t \sim \mathrm{N}(0, \sigma^2) \; (1)$$

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + a_2 u_{t-2}^2 + \ldots a_q u_{t-q}^2 \; (2)$$

4.2 GARCH models

Although ARCH models are very useful in modeling heteroscedasticity in financial time series they are subject to considerable limitations. Firstly σ_t^2 denotes a conditional variance and therefore its value must always be positive. For an ARCH(q) model an equation similar to (2) above must meet a certain condition which supposes that all a_i should be greater than or equal to zero. However, in an ARCH model ceteris paribus, an extremely large number of parameters in the equation of conditional variance implies a great possibility for negative values for some of the parameters. Furthermore, the number of lags of the squared errors that are necessary to capture all the dependence in the conditional variance might be very large thus leading in a variance model which is over fitted.

To overcome some of these drawbacks related to the ARCH models, Bollerslev and Taylor in 1986 developed an extension of the ARCH model, the Generalised ARCH (GARCH model). GARCH models are tools for forecasting and analyzing volatility of time series when volatility varies over time. Their main advantage against their ARCH counterparts is that a GARCH model is more parsimonious requiring less parameters to determine the current conditional variance without processing less flexibility. A GARCH(p,q) model takes the following form: $\sigma_t^2 = a_0 + \sum_{i=1}^{q} a_i u_{t-i}^2 + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^2$ (3)

However, in most cases a GARCH (1,1) model is sufficient to capture the volatility clustering in the data.

4.3 The GJR model

In this study one of our primary considerations is to produce robust results in every outcome that is extracted based on the methodology and the econometric applications that we employ. This motivated us to try detecting whether any asymmetric effects that occur regarding the relationship of oil and the stock market, and include them in our final interpretation of results. More specifically, we employed the GJR model which is an extension of GARCH. The conditional variance is the same plus the additional term $\{\gamma u_{t-1}^2 I_{t-1}\}$that accounts for possible asymmetries.

$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta\sigma_{t-1}^2 + \gamma u_{t-1}^2 I_{t-1}$(4) ,where $I_{t-1} = 1$ if $u_{t-1} < 0$ or I_{t-1}=0 if $u_{t-1} \geq 0$. If $\gamma > 0$ we there is an indication for a leverage effect or if $\gamma < 0$ we have an asymmetric effect.

4.4 Multivariate GARCH models

The function of multivariate GARCH models is similar to that of univariete. However, the former models are supposed to be more complex and difficult to be estimated because they are primarily concerned with the evolution of covariances over time which is a complicated procedure not conducted by univariate models. They are extremely useful because of their ability to predict the dependence in the co-movements of asset returns. In this study we are examining a dynamic time-varying correlation between oil prices and the stock market and therefore we considered it necessary to model the dynamics for correlations directly. We concluded that a multivariate process that will facilitate our study, help us to interpret the results and at the same time offer us with robust outcomes is the dynamic conditional correlation GARCH (DCC-GARCH) model which is an extension of the constant conditional correlation GARCH model (CCC-GARCH).

4.5 Two – Step estimation models

CCC-GARCH

The CCC-GARCH models consider the correlations between disturbances to be fixed over time. The idea behind the constant conditional correlation was first proposed by Bollerslev in 1990 and it supposed that conditional covariances are pegged with the variances. More specifically this model supposed that the conditional variances are similar to univariate GARCH specifications and are modelled as follows.

$h_{ii,t} = c_i + a_i e_{i,t-i}^2 + \beta_i h_{ii,t-1}$ (5), i= 1….N

The conditional correlation matrix does not vary over time and it is formed in a very specific way. $H_t = D_t R D_t$ (6), R= $[\rho_{i,j}]$ is the positive definite correlation matrix. The off-diagonal elements of H_t, $h_{ij,t}$ are defined through the correlations ρ_{ij}. The estimation equation is: $h_{ij,t} = \rho_{ij} h_{ii,t}^{1/2} h_{jj,t}^{1/2}$ (7), i, j = 1…N. i < j. A major drawback of the

CCC-GARCH model when examing a time varying correlation between two classes is that it assumes constant correlations that do not evolve over time. Bera and Kim (2012) and Tse (2000) conducted two different mathematical tests and concluded that stock returns do not imply constant correlations over time and thus it does not seem appropriate in the field of our research. This was the reason that forced us to reject the specific model for our analysis, since our primary consideration is to capture the time-varying correlation between oil and the stock market, and not their simultaneous relationship.

Dynamic Conditional Correlation (DCC-GARCH) model

DCC-GARCH models were firstly introduced by Engle and Sheppard (2001) and their primary objective was to model the conditional correlation between a variety of different classes including stock market and oil indices. In this models the correlation matrix R_t indicated that there can be a time-variation in the correlations. DCC-GARCH models are defined as:

$H_t = D_t R_t D_t$ (8)

$r_t = \mu_t + \alpha_t$ (9)

$\alpha_t = z_t H_t^{1/2}$(10)

where $r_t$is a n x 1 vector of log returns of n assets at time t, α_t is a n × 1 vector of mean-corrected returns of n assets at time t indicating that E[α_t] = 0 and Cov [α_t] = H_t, μ_t is a n × 1 vector of the expected value of r_t, H_t n × n matrix of conditional variances of α_t, $H_t^{1/2}$is any n × n matrix at time t such that H_t is the conditional variance matrix of α_t, D_t is a n × n, diagonal matrix of conditional standard deviations of α_t at time t, R_t is a n × n conditional correlation matrix of α_t at time t and z_t is a n × 1 vector of iid errors such that E[z_t] = 0 and E[$z_t z_t^T$] =I. The diagonal matrix D_t is consisted of standard deviations that are extracted from univariate GARCH models.

4.6 Specification of the DCC-GARCH model

To specify a DCC model there are three general steps. At first the volatilities must be estimated in order to construct the desirable standardized residuals a process called "DE-GARCHING''. On the second stage it is necessary to estimate the quasi correlations in a dynamic way based on the standardized residuals constructed from the first stage. The existing bibliography proposes integrated, mean reverting and asymmetric models as the most appropriate for the specification procedure. A stochastic process is proposed for the quasi correlation matrix (Q_t) which is an approximation matrix described above. On the last stage we must rescale the quasi correlation matrix that we produced on the second step in order to conclude that it represents a suitable correlation matrix.

4.7 Estimation of the model

In order to estimate the DCC model we are primarily concerned to transform it into a maximum-likelihood problem while assuming multivariate, normaly distributed data. In order to go through the process we employ a consistent quasi-maximum likelihood estimator whose efficieny is depending on whether the mean and covariance models are correctly specified. The model under consideration is formulated as follows:

$y_t \mid F_{t-1} \sim \mathrm{N}(0, D_t R_t D_t)$ (11)

$D_t^2 = \mathrm{diag}\{H_t\}$ (12)

$H_t = V_{t-1}(y_t)$ (13) ,where $V_{t-1}(y_t)$ is the conditional covariance matrix

$H_{i,i,t} = w_i + \alpha_i y_{i,t-1}^2 + \beta_i H_{i,i,t-1}$ (14)

$\varepsilon_t = D_t^{-1} y_t$ (15)

$R_t = \mathrm{diag}\{Q_t\}^{-1/2} Q_t \mathrm{diag}\{Q_t\}^{-1/2}$ (16)

$Q_t = \Omega + \alpha\varepsilon_{t-1}\varepsilon'_{t-1} + \beta Q_{t-1}$ (17) where Ω is a nxn matrix

In addition α, β and $\{\alpha_i, \beta_i\}$ are nonnegative for all i with a sum less than unity.

The log likelihood for a data set $\{y_1 ….. y_t\}$ is modelled as follows:

$$L= - \frac{1}{2} \sum_{i=1}^{t} \{nlog(2\pi) + 2log\,[D_t] + y_t' D_t^2 y_t + \log[R_t] - \varepsilon_t' \varepsilon_t + \varepsilon_t' R_t^{-1} \varepsilon_t) \quad (18)$$

It is obvious from above that the log-likelihood function can be decomposed into two parts. In the first three terms are contrained the variance parameters and the data while the last three terms include the correlation parameters and the volatility adjusted data. To estimate this function we have to employ a two-step process. Firstly, we have to maximize the first part of the equation (19) above and secondly we have to obtain the standardized residuals from step one and then maximize the second part of the equation that includes the correlation parameters. Following the proposal of the existing literature regarding mean reverting models characterized as suitable for the specification procedure of quasi correlation matrices, we employ a mean reverting model to complete the estimation process of our model. The specification of our correlation matrix is the equation (16) above. Its estimating operation can be conducted in three steps. The first step involves an estimation of univariate GARCH models. In the immediately preceding step we have to compute the correlation matrix of the standardized residuals. Finally, it is necessary to impose the restriction $\Omega= \bar{R}(1-\alpha - \beta)$ and maximize the second part of our log-likelihood function without including the sum of the error terms which is independent of the parameters being optimized and thus its presence or not on the maximazitation process is considered unnecessary.

5. Data Description

In this study, we use daily data for oil prices and stock market indices. The sample consists of 5 major oil importing (USA, China, Japan, UK and France) and 5 major oil exporting (Saudi Arabia, Russia, Norway, Canada, and Mexico) countries. One of our primary considerations was to include stock market data for the biggest oil importing and oil exporting countries however, regarding some oil exporting countries the availability of data was limited. Therefore we decided to exclude major oil exporters such as Iraq, Kuwait, UAE, Iran and Venezuela and we instead included Mexico, Brazil, and Norway.

For the oil importing countries we included the following indices: S&P500 (SP50) for the US, FTSE (China), Nikkei 225 (Japan), FTSE (UK), and CAC 40 (France). The stock market indices for the oil exporting countries are: TASI (Saudi Arabia), FTSE Russia, OSEAX (Norway), S&PTSX Composite (Canada), and FTSE Mexico. Regarding the oil market we have incorporated the Crude Oil Brent Global Spot ICE index and the WTI Global Spot NYMEX. The prices of all the above mentioned indices are quoted in US dollars.

The data range from January 1990 to December 2018. Moreover, all prices from both markets (oil and stock) are expressed in dollars and have been extracted from FactSet. The sample period includes, apart from the recent economic crisis, other major events such as the Iraq invasion in Kuwait (1990), the first and the second war in Iraq (1991 and 2003 respectively), the collapse of the Soviet Union (1991), the Asian economic crisis (1997), the housing market boom in the US (2000), the 9/11 terrorist attack in US (2001). and the "Oil Glut" in 2014.

Table 2

Importers	USA	CHINA	JAPAN	UK	FRANCE
Indexes	**S&P500**	**FTSE**	**Nikkei 225**	**FTSE**	**CAC 40**

Exporters	Saudi Arabia	Russia	Norway	Canada	Mexico
Indexes	**TASI**	**FTSE**	**OSEAX**	**S&PTSX**	**FTSE**

6. Results

6.1 Descriptive Statistics

Table 3

	DLWTI	DLSP500	DLFTSE	DLNIKKEI	DLCHINA	DLCAC40
Mean	9.96E-05	0.000268	0.000108	-5.80E-05	0.000452	0.000117
Median	0.000000	0.000503	0.000395	-3.04E-05	0.000277	0.000420
Maximum	0.212765	0.109579	0.121984	0.125728	0.149859	0.121388
Minimum	-0.400011	-0.094697	-0.117509	-0.111891	-0.195247	-0.117311
Std. Dev.	0.024810	0.011076	0.012362	0.015926	0.017531	0.014853
Skewness	-0.643877	-0.257953	-0.236513	0.020427	-0.335948	-0.066731
Kurtosis	18.29535	11.80026	12.57436	7.183268	13.75967	9.011671
Jarque-Bera	71732.20	23659.68	27973.47	5032.382	22527.71	10811.24
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Sum	0.728080	1.959181	0.788197	-0.400530	2.102418	0.839670
Sum Sq. Dev.	4.497055	0.896246	1.116350	1.750063	1.429461	1.582849
Observations	7307	7307	7306	6901	4652	7176
ADF(t-stat)	**-90.19073**	**-64.77310**	**-42.03999**	**-88.58716**	**-66.88128**	**-40.81920**
ADF(p-value)	**0.0001**	**0.0001**	**0.0000**	**0.0001**	**0.0001**	**0.0000**

Table 4

	DLBRENT	DLSPTSX	DLMEXICO	DLRUSSIA	DLNORWAY	DLSA
Mean	0.000120	0.000156	0.000403	0.000224	0.000323	0.000458
Median	0.000000	0.000506	0.000613	0.000242	0.000939	9.02E-05
Maximum	0.170784	0.125010	0.167526	0.236641	0.133199	0.132002
Minimum	-0.366244	-0.137899	-0.195690	-0.233299	-0.135937	-0.211828
Std. Dev.	0.022571	0.012084	0.018225	0.023346	0.017522	0.020181
Skewness	-0.822121	-0.680466	-0.347242	-0.343490	-0.496780	-2.054130
Kurtosis	17.96378	15.01081	13.08100	13.09062	9.434384	23.69776
Jarque-Bera	68995.79	43596.09	31079.37	19827.73	8203.932	47700.10
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Sum	0.878836	1.118326	2.942063	1.041273	1.499095	1.177252
Sum Sq. Dev.	3.721881	1.045529	2.425907	2.534860	1.425726	1.046659
Observations	7307	7161	7305	4652	4645	2571
ADF(t-stat)	**-85.54509**	**-39.47926**	**-58.92452**	**-65.67643**	**-67.54219**	**-49.81989**
ADF(p-value)	**0.0001**	**0.0000**	**0.0001**	**0.0001**	**0.0001**	**0.0001**

In order our series to follow the normal distribution the skewness needs to be zero. Negative values of skewness indicate that the tail is on the left side of the distribution whereas positive values of skewness indicate that the tail is on the right. A zero value of skewness imply that the tails on both sides of the mean balance out overall. This corresponds to the so called “symmetric distribution”. Furthermore in order our series to follow the normal distribution the Jarque Berra values shouldn’t have been statistically significant since their number is very lage and the kurtosis should have been equal to three. Distributions with kurtosis less than 3 are said to be platykurtic which means that the distribution produces fewer and less extreme outliers than does the normal distribution. The results are the opposite in the case of kurtosis more than 3. Regarding these three different measures and due to the fact that their values do not correspond to those of normal distribution we can conclude that our series do not follow the normal distribution. Of course this sounds logical since we have to deal with real time data.

Standard deviation is a statistical measurement that calculates the historical volatility. We can see from the table above that in all of our cases this measure has a relatively low value which indicates that the variance between the returns and their mean is small.

6.2 Stationarity

After taking the first differences of the time series’ prices we achieved the goal of stationarity for all indexes. Below we present the results for SP500 index.

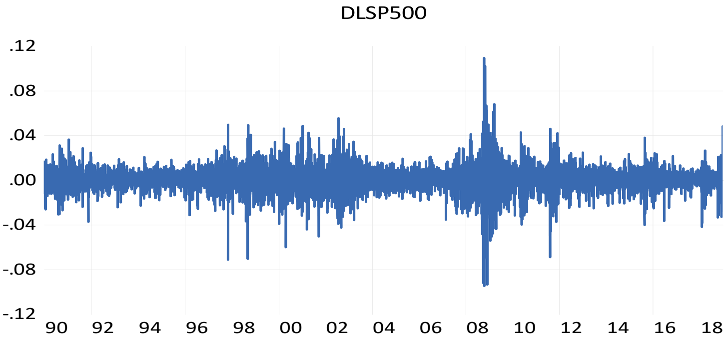
Table 5

Null Hypothesis: DLSP500 has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=35)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-64.83084	0.0001

Our first consideration is to check whether our time series are stationary. When checking for the existence of stationarity we are based on the Schwarz Information Criterion. As we see below in the table, in absolute values the Augmented-Dickey Fuller t-stat is much greater than the t-stat of the 5% significant level which indicates that the dlsp500 is stationary and therefore the null hypothesis that suggests the existence of a unit root is rejected. The stationarity can be also validated by the graph of our returns below.

Figure 1



6.3 Heteroskedasticity Test

In order to check the existence of heteroskedasticity in our residuals we use the heteroskedasticity test introduced by White. There are presented three different types of tests for heteroskedasticity, which give us the information we need to determine whether the assumption of homoscedasticity is valid or not. After running the White test on the residuals of all our indexes we confirmed the existence of heteroskedasticity for all of them. Both the F and χ^2 versions of the test statistic gave us the same conclusion that there is evidence for the presence of heteroskedasticity since the p-values are less than 0.05. The third version of the test statistic, the "Scaled explained SS" also suggests that there is evidence of heteroskedasticity for all significance levels. We present below the findings of the test regarding the regression of dlwti on dlsp500.

Table 6

Heteroskedasticity Test: White

F-statistic	123.4170	Prob. F(2,7304)	0.0000
Obs*R-squared	238.8632	Prob. Chi-Square(2)	0.0000
Scaled explained SS	1235.470	Prob. Chi-Square(2)	0.0000

6.4 ARCH Effects

Before estimating a GARCH-type model, it is sensible first to compute the Engle (1982) test for ARCH effects to make sure that this class of models is appropriate for the data. A test for the presence of ARCH in the residuals is calculated by regressing the squared residuals on a constant and p lags which may vary. The first step is to estimate a linear model so that the residuals can be tested for ARCH. As indicated by the table below, after including five lags of the squared residuals and the constant term in the estimation of equation, both the F-version and the LM-statistic are very significant, suggesting the presence of ARCH effects in the sp500-wti returns. The same results also hold for the rest of our indexes, however, we decided to present only two of them.

H_0: There is no ARCH effect → rejected

H_1: There is ARCH effect → accepted

Therefore, employing a GARCH model in our sample seems to be a good choice. Periods of high volatility are followed by periods of high volatility for prolonged period. Periods of low volatility are followed by periods of low volatility for prolonged period.

Table 7

Heteroskedasticity Test: ARCH

F-statistic	379.0159	Prob. F(5,7296)	0.0000
Obs*R-squared	1505.576	Prob. Chi-Square(5)	0.0000

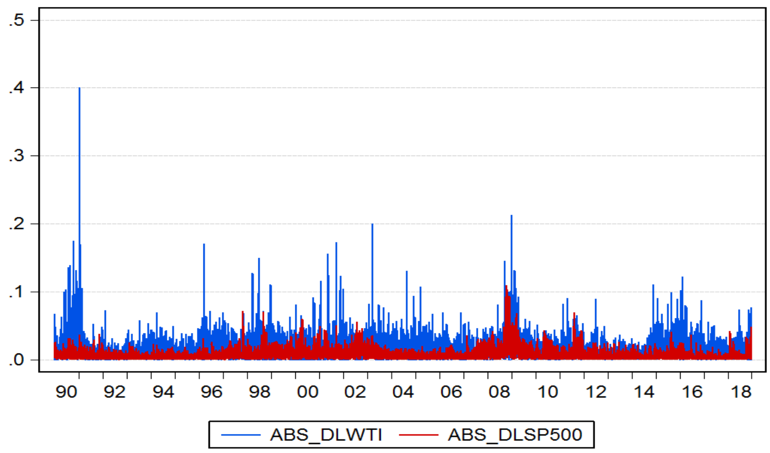
6.5 Volatility Clustering

After generating the absolute returns for all of our time series we noticed from the estimation output that volatility clustering is present in all cases, indicating that large changes tend to be followed by large changes and small changes tend to be followed by small changes. What can be also noticed from the graphs is that the adjustment of volatility in a deep rise of the returns is different when compared with the adjustment during periods of deep declines, which constitutes an indication of leverage effect. The observation of volatility clustering and the presence of heteroskedasticity in the residuals motivated us to employ a GARCH type model (we selected the DCC-GARCH-GJR model for our analysis)

The GARCH model (Bollerslev, 1986) aims to more accurately describe the phenomenon of volatility clustering and related effects such as kurtosis, while also takes into consideration the presence of heteroskedasticity. The main idea behind this model is that volatility is dependent upon past realizations of the asset process and related volatility process. Many researchers ended up to the conclusion that small and high prices of the residuals tend to appear gathered all together (volatility clustering) and financial time series characterize from significant skewness and kurtosis. In other words the assumptions are violated. In detail, the definition of volatility clustering defined as periods of low volatility followed by periods of low volatility for a prolonged period and periods of high volatility followed by periods of high volatility.

Mandelbrot (1963) and Fama (1965) indicated that large changes in products prices are followed by other large changes and small changes are also followed by small changes. Empirically, this means that contingent abnormal prices of volatility today affect the forecast of future volatility for a long period. The existence of volatility clustering is represented by the absolute values of the returns below. Again, we decided to present the results only for one of our indexes since the main topic of this research is the dynamic correlation between oil and the stock markets and thus, it seems more sensible to focus our interest on the DCC outputs which will be extensively described.

Figure 2



6.6 GARCH (1, 1)

As we reported above GARCH models are more parsimonious than ARCH, avoid over-fitting and are less likely to breech non-negativity constraints. GARCH models are able to eliminate the excess kurtosis of returns although they cannot describe the asymmetry of returns because of the symmetric dependencies that they assume. However, this is the reason that we employed a DCC-GARCH-GJR GARCH model that directly takes into consideration the asymmetry in the series. GARCH type models are supposed to be sufficient to capture the volatility clustering in the data. Below we present estimates regarding the GARCH (1, 1) output for the SP500 index.

Table 8

Dependent Variable: DLSP500
GARCH = C(2) + C(3)*RESID(-1)^2 + C(4)*GARCH(-1)

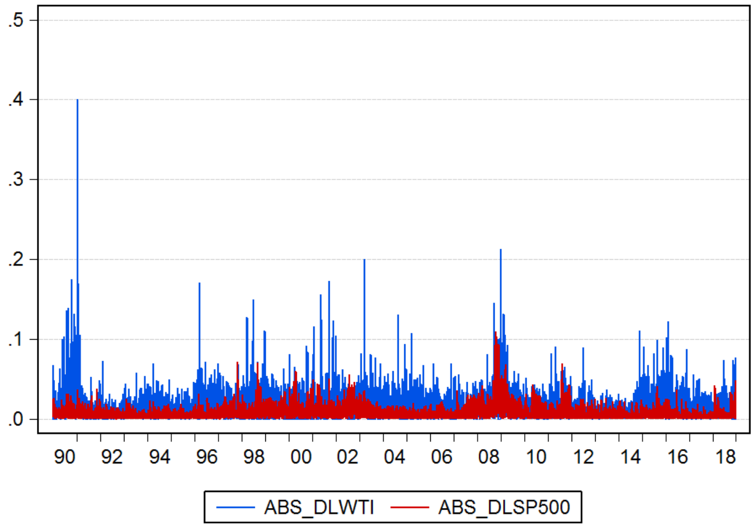
Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.000553	9.28E-05	5.957756	0.0000
		Variance Equation		
C	1.42E-06	1.27E-07	11.20950	0.0000
RESID(-1)^2	0.090252	0.004474	20.17231	0.0000
GARCH(-1)	0.897722	0.005127	175.1069	0.0000

As we can see from the table above the constant term in the mean equation of the SP500 index is statistically significant for the GARCH (1, 1) model. Moreover, all of the coefficients in the variance equation seem to be statistically significant. Therefore, we will retain this structure of our model for the SP500 market in order not to disturb the consistency. Nonetheless, our focus will be the variance equation. As we can see, both the ARCH and the GARCH terms are statistically significant since the p-values are less than 0.05. What we can further see from above is that the sum of these two coefficients is close to 1, which indicates that shocks to the conditional variance of the SP500 market will be highly persistent. Furthermore, since the GARCH parameter is significant, a large excess return value-either positive or negative, will lead future forecasts of the variance to be high for a prolonged period of time. This means that the GARCH model will be a better forecasting model than the ARCH model in periods of high volatility. The results regarding the variance equation were the same for all of our indexes. The only difference was that in some of them the constant term in the mean equation was either statistically significant or insignificant.

6.7 Conditional Variance

From the GARCH model estimated above, we obtain the conditional variance for the return series of the SP500 index. The graph below provides insightful illustration from which preliminary conclusions can be easily drawn. It is obvious that there is intense volatility of the SP500 index in many cases with the maximum volatility being observed at the period between 2008 and 2009 during which reached its highest value. In detail, this is associated with the 2007-2008 financial crisis.

Figure 3



6.8 BDS TEST

In order to take into consideration whether non-dependencies exist or not we applied the BDS test in the residuals of the regression equation between all stock market and oil indices. The portmanteau BDS test studies the non-linear correlation. After conducting the test we should reject the null hypothesis if the BDS test statistic is greater than or less than the critical values (e.g. if a=0.05, the critical value = ±1.96), indicating that there aren't any non-linear dependencies. The accepted alternate/alternative hypothesis is the existence of non-linear dependencies. The estimation output for all of our indices pairs suggested that non-linear dependencies exist (the residuals are not normally distributed) since p-valus were below 0.05 for all of them. In the table below we present the results for the obtained residuals which have been extracted by regressing the returns of WTI index on those of SP500.

Table 9

BDS Test for RESID01

Dimension	BDS Statistic	Std. Error	z-Statistic	Prob.
2	0.019700	0.001129	17.45014	0.0000
3	0.045263	0.001792	25.26400	0.0000
4	0.065060	0.002131	30.53285	0.0000
5	0.078582	0.002218	35.42269	0.0000
6	0.085834	0.002137	40.16467	0.0000

6.9 Granger Causality

Regarding the analysis conducted above we have to state that the results were the same or considerably similar for all of the indices and thus we decided not to present the estimation outputs for all of them. However, the results regarding Granger-Causality were not the same since the relationship between oil and the stock market differs across countries. Therefore, we decided to present all of them.

Table 11

SP500-Brent	**Nikkei-Wti**	**Nikkei-Brent**	**FTSE-Wti**
Dlbrent does not Granger cause dlsp500	Dlwti does Granger cause dlnikkei	Dlbrent does not Granger cause dlnikkei for 5% significance level. (it does for 10%)	Dlwti does not Granger cause dlftse
Sp500 does Granger cause dlbrent. Result: Unidirectional causality	Dlnikkei does not Granger cause dlwti Result: Uniderectional causality	Dlnikkei does Granger cause dlbrent Result: Uniderctional causality for 5% level. (bidirectional for 10%)	Dlftse does not Granger cause dlwti Result: It seems that there is no causality between the two markets

Table 12

FTSE-Brent	**FTSE (China)-WTI**	**FTSE (China)-Brent**	**CAC40-WTI**
Dlbrent does not Granger cause dlftse	Dlwti does Granger cause dlchina	Dlbrent does not Granger cause dlchina	Dlwti does not Granger cause dlcac40
Dlftse does Granger cause dlbrent Result: Unidirectional causality	Dlchina does not Granger cause dlwti Result: Unidirectional causality	Dlchina does Granger cause dlbrent Result: Unidereсtional causality	Dlcac40 does not Granger cause dlwti Result: No causality

Table 13

CAC40-BRENT	**SPTSX-WTI**	**SPTSX-BRENT**	**FTSE (Mexico)-WTI**
Dlbrent does not Granger cause dlcac40	Dlwti does not Granger cause dlsptsx	Dlbrent does not Granger cause dlsptsx	Dlwti does Granger cause dlmexico
Dlcac40 does Granger cause dlbrent Result: Unidirectional causality	Dlsptsx does Granger cause dlwti Result: Unidirectional causality	Dlsptsx does Granger cause dlbrent Result: Unidirectional causality	Dlmexico does Granger cause dlwti Result: Bidirectional causality

Table 14

FTSE (Mexico)-BRENT	**FTSE (Russia)-WTI**	**FTSE (Russia)-BRENT**	**Norway Oslo All Share-TR-WTI**
Dlbrent does not Granger cause dlmexico	Dlwti does Granger cause dlrussia	Dlbrent does not Granger cause dlrussia	Dlwti does Granger cause dlnorway
Dlmexico does Granger cause dlwti Result: Unidirectional causality	Dlrussia does not Granger cause dlwti Result: Unidirectional causality	Dlrussia does Granger cause dlbrent Result: Unidirectional causality	Dlnorway does not Granger cause dlwti Result: Unidirectional causality

Table 15

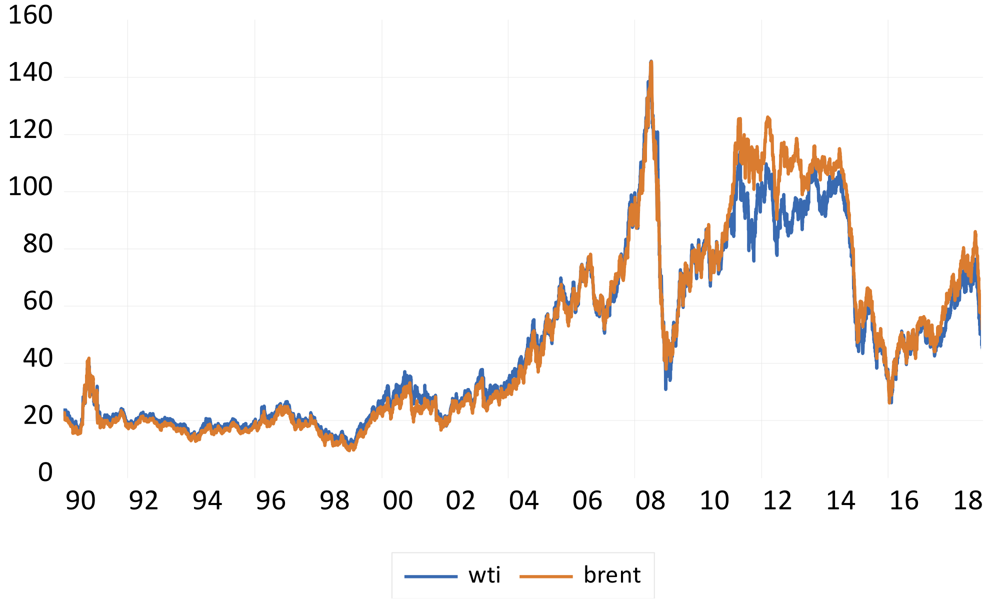
Norway Oslo All Share-BRENT	TASI-WTI	TASI-BRENT	SP500-WTI
Dlbrent does Granger cause dlnorway	Dlwti does Granger cause dlsa	Dlbrent does Granger cause dlsa	Dlwti does Granger cause dlsp500
Dlnorway does Granger cause dlbrent	Dlsa does not Granger cause dlwti	Dlsa does Granger cause dlbrent	Dlsp500 does Granger cause dlwti
Result: Bidirectional causality	Result: Unidirectional causality	Result: Bidirectional causality	Result: Unidirectional causality

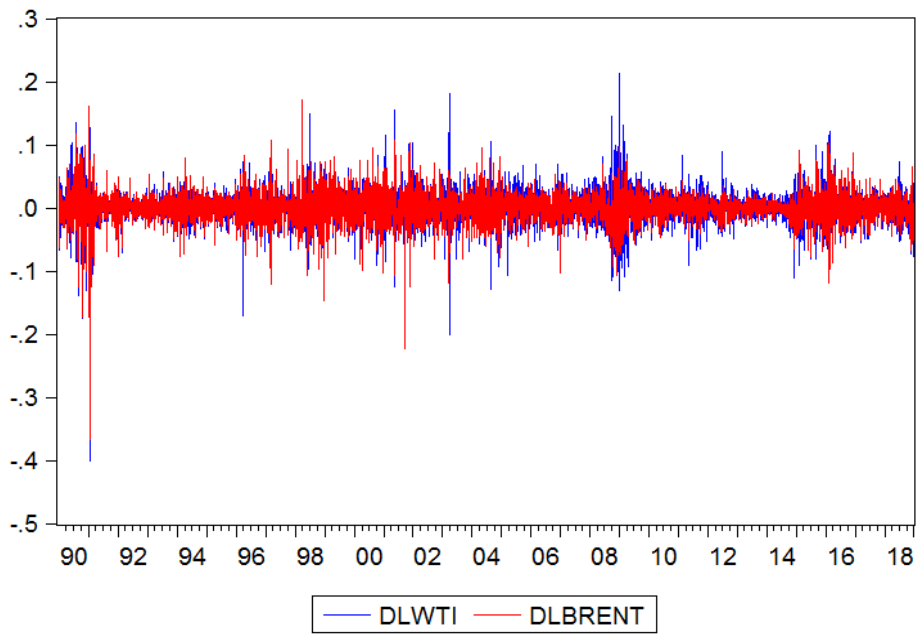
The vast majority of the results proved the existence of unidirectional causality either from stock market returns to oil returns or the opposite. Some estimations outputs provided grounds that there exists even bidirectional causality between the two markets a situation that was observed mainly in oil exporting countries. Only in two absence of causality between the two markets was captured, the FTSE-WTI pair and the CAC40-WTI pair both of which refer to oil importing countries. Thus, we could conclude that the relationship between oil and the stock markets is more interdependent in oil exporting countries. Nonetheless, after regression estimation by OLS, the results indicated that all of the causalities signs were positive except for the sp500-brent pair and cac40-brent pair. Overall, our results point to the existence of significant volatility spillovers and important interaction between oil and stock market in most cases.

6.10 Oil Market Prices

WTI-BRENT

Figure 4





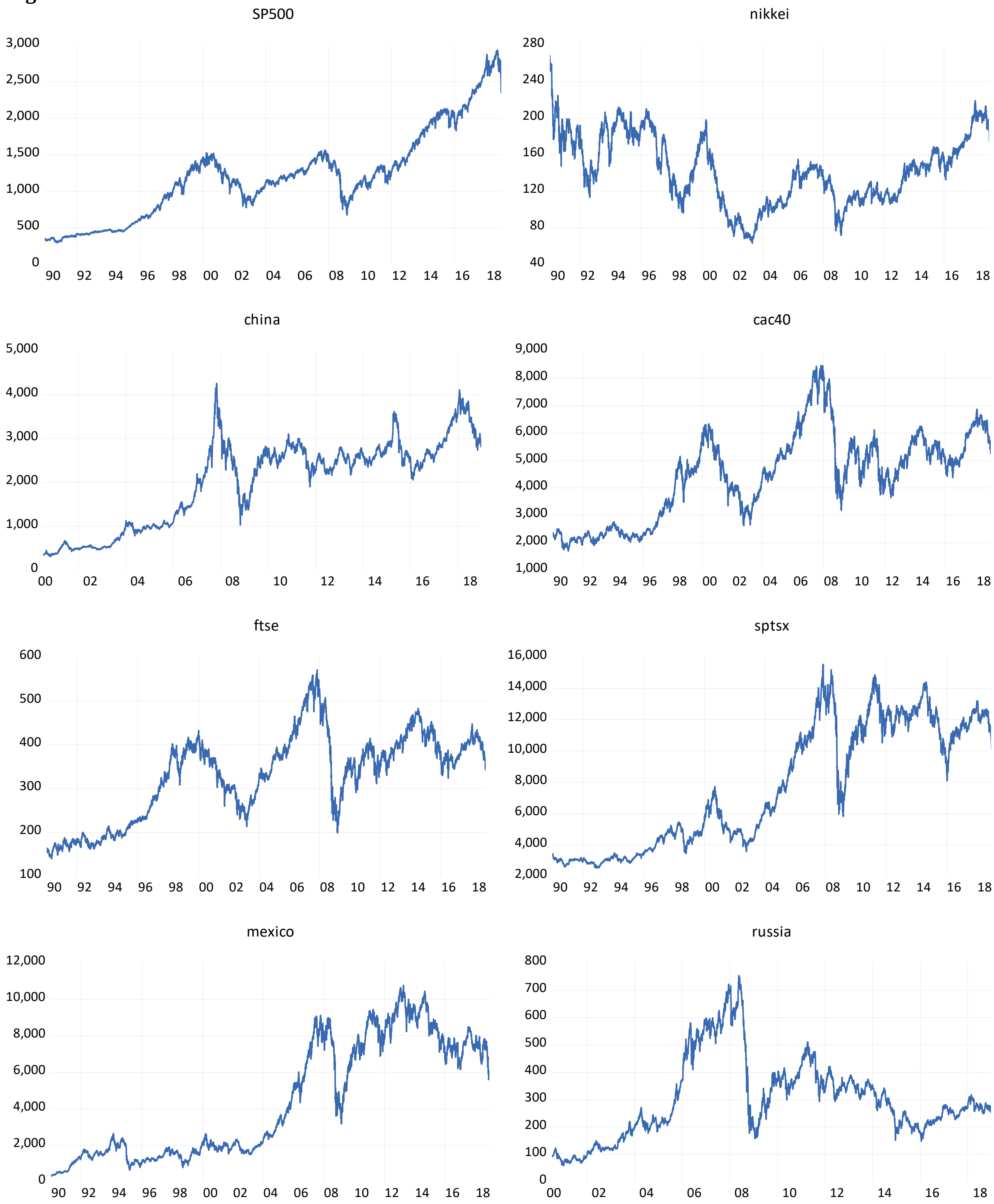
First and foremost, from the graphs above we would like to make a comparative analysis between WTI and Brent index. It is obvious that the two markets are moving exactly in the same direction in the entire sample period. The magnitudes and the signs of fluctuations generally seem to be the same for the prices of the two markets. However, we can observe that during the period 2011-2013 the Brent index presented a more volatile behavior. Moreover, the devastating consequences of the 2007-2009 financial crises significantly affected the price of both of our oil indexes, which dropped by as much as three times their pre-crisis levels. Another huge fluctuation of oil prices became evident during the period 1990-1991. This was a period that plenty significant turbulence in the global economy took place.

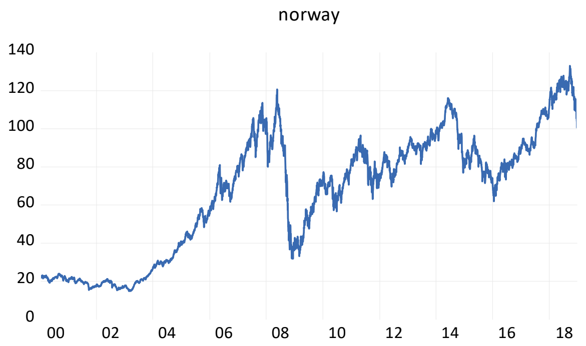
The price of our oil indexes considerably increased due to the 1990 Iraqi invasion in Kuwait. The average monthly price of oil rose from $17 per barrel in July to $36 per barrel in October. Later on, the sharp decline of oil prices can be attributed to the U.S. military success against Iraqi forces, after which concerns about long-term supply shortages eased and prices began to fall. Another important event that forced a decreasing behavior of oil prices in 1991 was the economic, political and social turbulence in the Soviet Union and later on its collapse. Another interesting event regarding the price of oil is the 2000s energy crisis. From the graph above we can further see that a huge increase in oil prices took place from 2002 to 2008. From the mid-1980s to September 2003, the inflation-adjusted price of a barrel of crude oil on NYMEX was generally under US$25/barrel. During 2003, the price rose above $30, reached $60 by 11 August 2005, and peaked at $147.30 in July 2008. The specific sharp increase of oil prices can be attributed to a variety of factors, such as Middle East tension between Israel and Lebanon and worries over Iranian nuclear plans in 2006. Moreover, the soaring oil demand from China, the falling value of the U.S. dollar, reports from the US Energy Information Administration regarding a possible decline in petroleum reserves, and financial speculation further facilitated the sharp increase of oil prices.

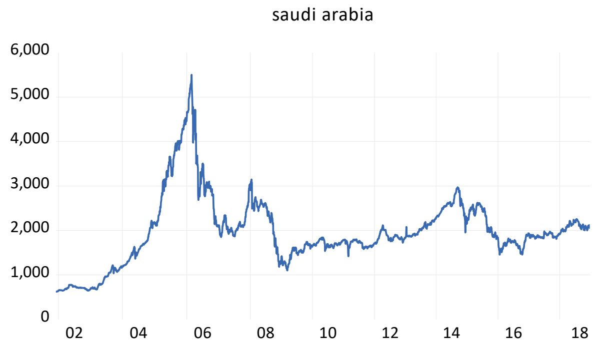
Another significant oil price shock on which we can comment on is the 2010s oil glut. By the end of 2008, the price of oil had bottomed out at $53. The economic recovery that took place immediately in the following year led to an oil price increase over $120. Then during the period 2014-2015, the price of oil experienced another steep drop. Numerous factors contributed to the 2014 drop in oil prices. Economies such as China, whose rapid growth and expansion created an unquenchable thirst for oil in the first decade of the new millennium, began to slow after 2010. Other large emerging economies such as Russia, India, and Brazil experienced similar economic trajectories in the early 21st century – rapid growth during the first decade, followed by much slower growth after 2010. Spurred by the negative effect of high oil prices on their economies, countries such as the U.S. and Canada increased their efforts to produce oil domestically. As a result of this local production, these two countries were able to cut their oil imports sharply, which put further downward pressure on world prices. Last but not least, the fact that Saudi Arabia decided to keep its oil production stable in order to benefit from low oil prices in the long term, also contributed in the sharp decline of oil prices.

6.11 Oil & Stock Prices

Figure 5







From the graphs above we can realize that stock market prices do not always move in the same direction with oil prices. For instance, the 1st graph above clearly shows that during 1990 oil prices exhibited a peak. However, regarding the countries for which our stock market index data cover the specific period we could conclude that the majority of them presented a stable or a declining performance over that period. In addition, during 1997-1998 an oil price decrease is observed, whereas the majority of the stock markets were exhibiting an increase in their index levels. The only exception is the Japanese index which showed a sharp decline in the specific period a situation that can be directly attributed to the Asian financial crisis during that period.

Another diverging behavior between the two markets can be observed in the so-called "2010s oil glut" that took place in 2014. It can be easily noticed that the price of our oil indexes sharply decreased during the specific period. However, the conclusions regarding the behavior of our stock market indexes at that moment are highly anticipated. What can be inferred from the graphs above is that the prices of stock market indexes concerning oil importing countries and Mexico either increased or remained stable. However, the vast majority of our oil exporting countries showed a declining behavior during the specific period. This result can be attributed to the advanced financialization of the oil market alongside with the statistically significant levels of static correlation between oil exporting countries and the stock market.

We would like to state, that the interpretation of the graphs above constitutes only a preliminary analysis. The actual conclusions for the dynamic correlation between oil and the stock market should be based on the analysis of the DCC-GARCH-GJR model presented in the following section. The dynamic correlation findings will describe more explicitly the co-movements between oil and stock market indices.

6.12 DCC-GARCH-GJR Output

From the tables below we can notice that coefficients theta (1) and theta (2) are both positive and statistically significant when estimating the DCC-GARCH-GJR model for the correlation between the all indexes with the WTI and BRENT. Moreover, for the vast majority of our time series these coefficients meet the conditions of positive definiteness of matrix Q_t, since theta(1) + theta(2) < 1. Only in two cases the stability condition did not hold. The first one was observed when we estimated the dynamic correlation between FTSE Mexico and Brent index and the second when we proceeded in the estimation of DCC-GARCH-GJR for the NORWAY and BRENT index pair. In order to achieve stability we optimized the squared coefficients theta (1) and theta (2). This resulted in meeting the stability condition regarding the FTSE MEXICO-BRENT index pair; however, it still didn't meet the DCC criteria for the Norwegian and Brent index. Therefore, we were not able to estimate the DCC-GARCH-GJR model for the latter case.

Oil-Importing Countries

Table 16
USA: S&P 500-WTI
System: 2-Step DCC(1,1) Model with univariate GJR/TARCH fitted in the 1st step

	Coefficient	Std. Error	z-Statistic	Prob.
theta(1)	0.022317	0.003794	5.881864	0.0000
theta(2)	0.973295	0.005002	194.5951	0.0000

* Stability condition: theta(1) + theta(2) < 1 is met.

A model for SP500 and WTI index with respect to DCC-GARCH-GJR approach can be rewritten as follows: $Q_{i,j,t} = \omega_{i,j}$ + $0.022317\varepsilon_{i,t-1}\varepsilon_{j,t-1}$ + $0.973295Q_{i,j,t-1}$. Accordingly, we can build a model for all of our time series for which we employed the DCC-GARCH-GJR approach.

Table 17

USA	**Japan**	**Japan**
S&P 500 – BRENT	**Nikkei-WTI**	**Nikkei-BRENT**
theta(1)=0.005243	theta(1)= 0.008455	theta(1)= 0.008414
theta(2)= 0.992091	theta(2)= 0.957751	theta(2)= 0.987043
Stability Condition:Met **theta(1)+theta(2)<1**	Stability Condition:Met **theta(1)+theta(2)<1**	Stability Condition:Met **theta(1)+theta(2)<1**
UK	**UK**	**CHINA**
FTSE-WTI	**FTSE-BRENT**	**FTSE-WTI**
theta(1)= 0.013551	theta(1)= 0.004282	theta(1)= 0.019219
theta(2)= 0.984286	theta(2)= 0.995193	theta(2)= 0.942346
Stability Condition:Met **theta(1)+theta(2)<1**	Stability Condition:Met **theta(1)+theta(2)<1**	Stability Condition:Met **theta(1)+theta(2)<1**
CHINA	**FRANCE**	**FRANCE**
FTSE-BRENT	**CAC40-WTI**	**CAC40-BRENT**
theta(1)= 0.006571	theta(1)= 0.016324	theta(1)= 0.007530
theta(2)= 0.986597	theta(2)= 0.980946	theta(2)= 0.990636
Stability Condition:Met **theta(1)+theta(2)<1**	Stability Condition:Met **theta(1)+theta(2)<1**	Stability Condition:Met **theta(1)+theta(2)<1**

Oil-Exporting Countries

Table 18

CANADA: SPTSX-WTI

System: 2-Step DCC(1,1) Model with univariate GJR/TARCH fitted in the 1st step

	Coefficient	Std. Error	z-Statistic	Prob.
theta(1)	0.009662	0.001813	5.328935	0.0000
theta(2)	0.989612	0.002062	479.8272	0.0000

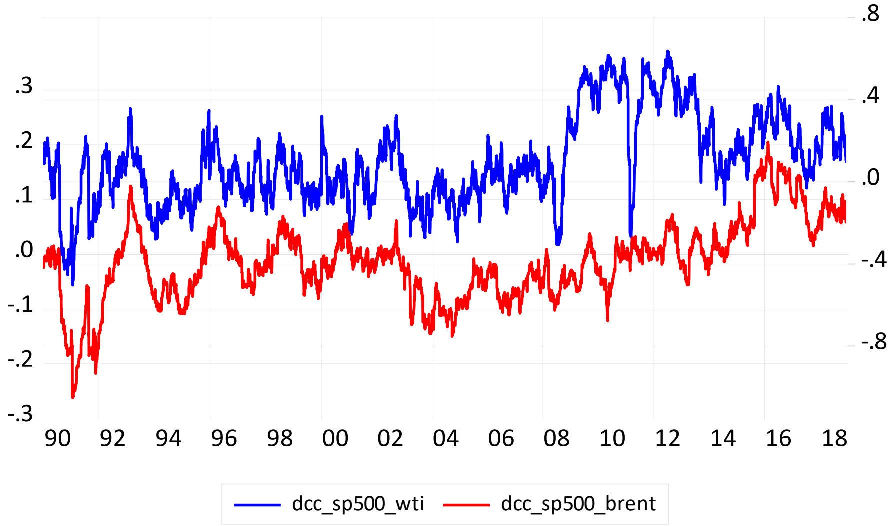
* Stability condition: theta(1) + theta(2) < 1 is met.

Table 19

CANADA	**MEXICO**	**MEXICO**
SPTSX-BRENT	**FTSE-WTI**	**FTSE-BRENT**
theta(1)= 0.004533	theta(1)= 0.014306	theta(1)= 0.060225
theta(2)= 0.995344	theta(2)= 0.983968	theta(2)= 0.997514
Stability Condition:Met **theta(1)+theta(2)<1**	Stability Condition:Met **theta(1)+theta(2)<1**	Stability Condition:Met **theta(1)+theta(2)<1**
RUSSIA	**RUSSIA**	**NORWAY**
FTSE-WTI	**FTSE-BRENT**	**OSEAX -WTI**
theta(1)= 0.009581	theta(1)= 0.005746	theta(1)= 0.009762
theta(2)= 0.989599	theta(2)= 0.992946	theta(2)= 0.988041
Stability Condition:Met **theta(1)+theta(2)<1**	Stability Condition:Met **theta(1)+theta(2)<1**	Stability Condition:Met **theta(1)+theta(2)<1**
NORWAY	**SAUDI-ARABIA**	**SAUDI-ARABIA**
OSEAX-BRENT	**TASI-WTI**	**TASI-BRENT**
theta(1)= 0.005448	theta(1)= 0.022939	theta(1)= 0.029043
theta(2)= 0.994944	theta(2)= 0.932608	theta(2)= 0.940280
Stability Condition: Not Met:**theta(1)+theta(2)<1**	Stability Condition:Met **theta(1)+theta(2)<1**	Stability Condition:Met **theta(1)+theta(2)<1**

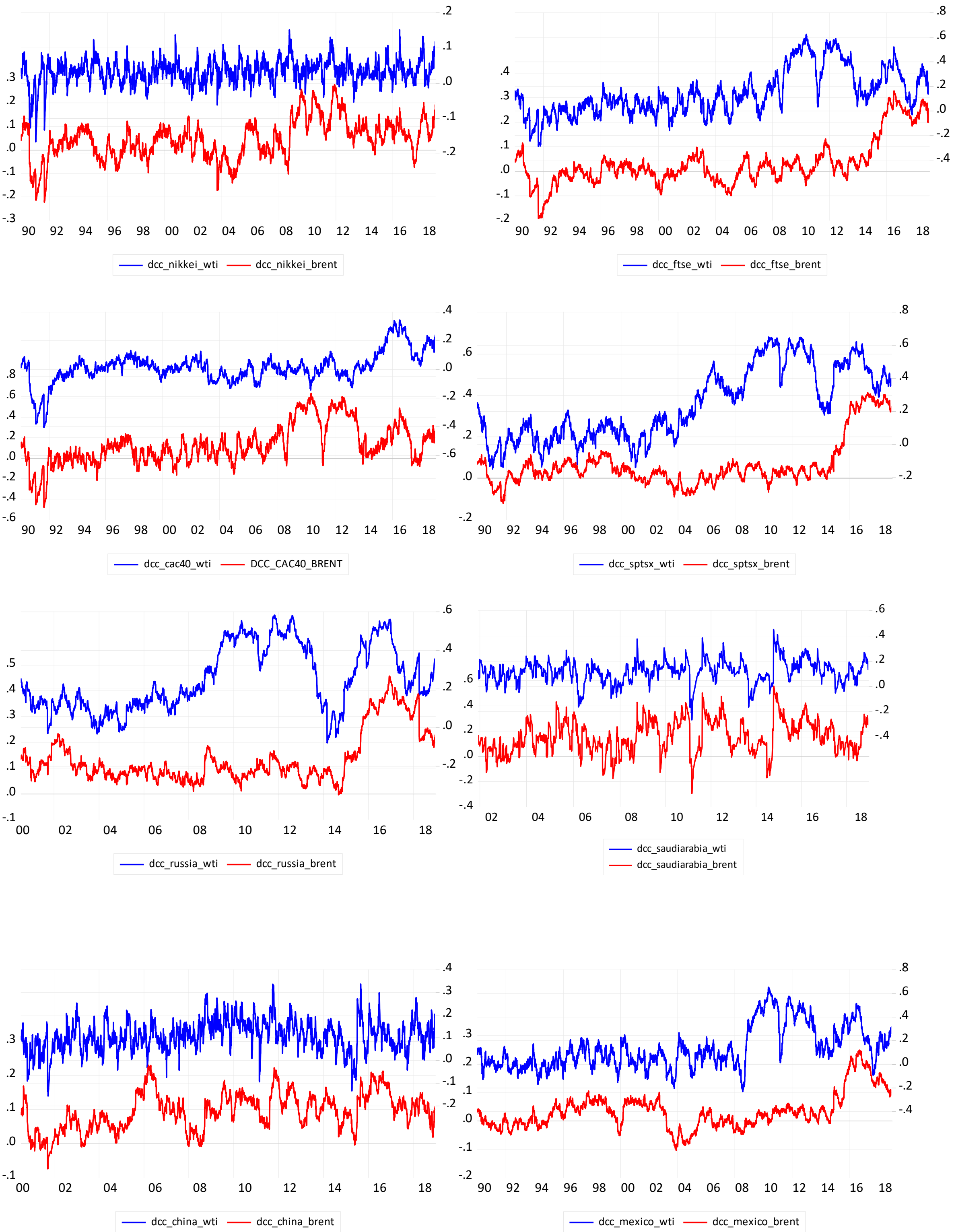
7.14) Interpretation

Figure 6



From the graph above we can see that the dynamic correlation between oil and the stock market had taken in the past both positive and negative values. However, it seems that the correlation between the WTI index with the SP500 index is much more significant than the relationship of the American stock market index with the Brent index. The truth is that the WTI index is more capitalized in the US market than the Brent index and therefore it seems logical to assume that the time varying relationship between the stock market and this index is more evident. Generally we can see that the two dynamic correlations are moving in the same direction.

Figure 7


dcc_nikkei_wti
dcc_nikkei_brent
dcc_ftse_wti
dcc_ftse_brent
dcc_cac40_wti
DCC_CAC40_BRENT
dcc_sptsx_wti
dcc_sptsx_brent
dcc_russia_wti
dcc_russia_brent
dcc_saudiarabia_wti
dcc_saudiarabia_brent
dcc_china_wti
dcc_china_brent
dcc_mexico_wti
dcc_mexico_brent

From all the graphs above for which the data chronology begins in 1990, we observe that the stock markets of all countries experienced a significant negative correlation with oil prices during the 1990-1991 period. According to the US Energy Information Administration, this was a period dominated by fluctuations in the precautionary demand for crude oil. Moreover, in the specific period, significant global turbulences occurred causing a severe impact on the correlation of the two markets. The 1990-1991 period corresponds to the Iraqi invasion in Kuwait and the following military conflict with the US. Moreover, this was a period characterized by economic tensions and uncertainty because of the Soviet Union collapse. Many experts condemn that this oil crisis was less persistent and its effects on the global markets were not as significant as the ones that took place during the 1973 and 1979 episodes. However, the specific episode was exhibited in a period of advanced financialization in the oil market and increased interaction with the overall economic activity. Thus, it significantly contributed to the recession of the early 1990s.

The next crisis episode of particular importance is the Asian economic crisis which initiated in mid-1997 until early 1998. Our results show that there was no significant change in the correlation between oil and the stock markets during the specific period, not even in Japan, the economy and financial market of which, were directly affected by the specific episode. The huge decline of the most liquid stock index in Japan alongside the oil price decrease did not lead to a more interdependent relationship between the two markets. The only exception was the French stock market, for which it seems that the correlation between CAC40 and Brent considerably dropped below zero. In overall, the oil price decrease of the 1997-1998 period does not seem to have caused any significant effects on the dynamic correlation between the two markets.

From the beginning of the 21st century until mid-2003 all stock markets both from oil-exporting and oil importing countries (except the UK) exhibited a positive correlation with oil prices. In this period a great number of different episodes took place. First and foremost, during this period a considerable oil production increase took place in 2000 due to the rapid growth of the housing market. The outcome was an aggregate demand-side shock that produced a positive correlation between oil and the stock market. Later on, in 2001 one of the most severe economic and social turbulence took place. It was the 9/11 terrorist attack in the US which caused huge tensions in the global markets. During that period we can infer from the graphs above that the correlation between oil prices and the stock market was positive for all of the oil exporting countries except Canada. Concerning oil importing countries in the specific period we can observe a negative correlation between oil prices and the stock market in China and France. During that period though, we can conclude that the magnitude of this negative correlation between the two markets was in general small. However, during the second half of 2003, the second war in Iraq initiated producing a negative precautionary demand-side shock. During the invasion of US forces in Iraq, all stock markets, apart from the Chinese market, were exhibiting a negative correlation with oil prices.

The next period of interest is the period 2006-2009. A huge increase in oil prices is evident from graph (1) above during the specific period, due to the rising oil demand from China which peaked in early 2008. The following significant drop in oil prices from mid-2008 to 2009 should be attributed to the global financial crisis. The specific episode, initiated from the export of US toxic mortgages to the rest of the world, as asset-backed securities (Stiglitz, 2009), which can be regarded as an aggregate demand-side oil price shock (International Energy Agency, 2009). The most important finding that can be extracted from the dynamic conditional correlation graphs above is that the correlation between oil and the stock market was positive for all countries under investigation except Mexico. The specific finding should be attributed to the huge magnitude of the crisis episode that resulted in a significant decline of the stock market returns and oil prices as well.

The last period of high concern regarding the magnitude and the behavior of the dynamic correlation between oil and the stock market is the 2014-2016 period, the so-called "Oil Glut". This oil price slump can find its root in various distinct factors. First and foremost, the oversupply of oil from the US and Canada, geopolitical rivalries amongst oil-producing nations, falling demand across commodities markets due to China's low growth. In general, this shock can be labeled as a supply-side shock. As we can see from the graphs above the correlation between oil and the stock markets was positive for all countries on a specific period. Since it constitutes an individual event of oil supply shock that provides evidence of a positive correlation between oil and the stock market we will not imply that oil supply shocks are always linked with such a situation. However, we would like to suggest that oil price shocks are also capable of producing a persistent positive correlation between oil and the stock market.

7. Discussion

Summarizing the conclusions we made above we would like to report that there are four periods of considerable correlation between the two markets under investigation. These are the periods 1990- 1991 (precautionary demand oil price shock – negative correlation), early 2000 until mid2000 (aggregate demand-side oil price shocks – positive correlation), 2007-2008 (aggregate demand-side oil price shock – positive correlation. Our results of static correlation coefficients made clear that the relationship between oil and the stock market is much more evident when considering oil exporting rather than oil importing countries. However, the DCC-GARCH-GJR output of our research that takes into consideration the time-varying correlation of the two markets, as well as the existence of asymmetry in our data frame suggests that in overall there are no significant differences in the correlation between oil and stock market prices for oil-importing and oil-exporting countries.

A very possible and interesting explanation of the above-mentioned paradox is the fact that nowadays, with the advanced globalization of the financial system, the performance of advanced markets is interdependent and therefore fluctuations in one market due to a specific factor might cause fluctuations to another distinct market. More specifically, a large shock to the global economy will not separate oil importing from oil exporting countries. For instance, the 1990-1991 turbulence in Iraq, alongside with the collapse of the Soviet Union (1991), the withdrawal of Equador (1992) and Gabon (1995) from OPEC, the Nigerian labor strike (1994) that resulted to declining levels of oil production and the Asian economic crisis of 1997 considerably affected the global economic activity in 1990s regardless of the stock market status. Furthermore, the 2000s experienced some especially important events that affected the overall economic activity. Firstly, the 9/11 Terrorist Attack, the 2nd war in Iraq in 2003, the global financial crisis and the 2010s “Oil Glut” influenced the stock and oil markets of all countries without separating oil importers from oil exporters.

On behalf of the analysis conducted above, we would now like to report the main findings of our research. First and foremost, our estimation outputs suggest that during periods of shocks in the overall economic activity significant oil price fluctuations are capable of producing a considerable impact on the relationship between oil and stock market prices, regardless the status of the market (i.e. belonging to an oil-importing or oil-exporting country). This finding is specifically in accordance with the findings of Lee & Chiou (2011) who also suggested that large fluctuations in oil prices essentially impact the correlation of the two markets. Though, in accordance with our results, the results of the latter study suggested that low fluctuations in oil prices do not force the stock market into bear territory. More specifically, our estimation outputs indicate that estimates of our study indicate that oil price shocks originated by OPEC's production cuts, physical destructions, etc., do not seem to produce a large impact on the correlation between oil and stock markets.

Another interesting finding of our research is that precautionary demand side oil price shocks tend to produce a negative correlation between oil and stock markets, as presented on the graphs above with reference to the first and second war in Iraq, as well as the 9/11 terrorist attack. On the other hand, aggregate demand-side oil price shocks (Asian crisis, Housing market boom, global financial crisis) and oil supply shocks (Oil Glut) tend to result in a significant positive correlation between stock market prices and oil prices. These findings are specifically in line with the results provided by Hamilton (2009b), Kilian and Park (2009), Apergis and Miller (2009), Cashin et.al (2014), Zhao et al. (2016), Bernanke (2016) and partly with the findings of Filis et al. (2011). Our study is partly in line with the last mentioned research due to the fact that the authors concluded to the same results regarding precautionary and aggregate demand-side shocks, though they suggested that oil supply shocks do not produce any interaction in the correlation between the two markets. However, as illustrated by the graphs above we can notice a positive correlation between the two markets during the recent supply-side oil shock. We would now like to state that the research conducted by Filis et al. (2011) was before the recent oil crisis. Therefore, the last oil supply shock was not included in their research. Regarding previous supply-side shocks, it is essential to report that in accordance with the findings of Filis et al. (2011) we also didn't achieve to find any considerable correlation between the two markets. However, the recent episode was different from other supply-side and demand-side shocks. Killian and Baumeister (2016) provided roots that the specific episode was caused by two fundamentally different factors. The first one condemns with the reasons that we reported above as possible causes of the recent oil crisis episode. However, the authors further underline turbulences in the expectations of market participants due to the unexpected slowdown of the overall economic activity. These findings are in line with the findings of Byrne et al. (2017). Therefore, it seems rational to conclude that the recent oil supply shock indeed produced a positive correlation between the two markets.

8. Conclusion

In this paper a DCC-GARCH-GJR model is employed in order to investigate the time-varying correlation between stock market prices and oil prices for oil-importing and oil-exporting countries, considering the origin of oil price shocks (i.e. aggregate demand-side, precautionary demand or supply-side). The dataset consists of daily stock and oil prices from 1989 to 2018 for five oil-exporting countries (Canada, Mexico, Russia, Norway, and Saudi Arabia) and five oil-importing countries (US, UK, France, China, and Japan). The estimation output suggests that the dynamic correlation between oil and the stock market does not differ for oil importing and oil exporting countries. The intuitive idea behind these findings is the fact that nowadays, the oil market with its advanced globalization and financialization is especially linked to the behavior of the stock market. Therefore, oil price changes produce significant fluctuations in the overall economic activity without focusing on the status of countries (i.e. oil importers or oil exporters). Specifically, the results indicate that aggregate demand side oil price shocks negatively affect the stock market behavior of all the sample countries. In addition, the estimation output suggests that precautionary demand side oil price shocks are capable of producing positive correlations between the oil and the stock market. However, the correlation seems to fluctuate in respond to the origin of the oil price shocks, for instance, in periods of a global turmoil or changes in the phase of the global business cycle. Regarding oil supply shocks, the findings imply that such episodes do not significantly affect the time-varying relationship between oil and the stock market. An exception is the recent "Oil Glut" of 2014 which seems to have produced a considerable positive correlation between the two markets. This finding is linked to the fact that the specific oil supply shock fundamentally differed from previous supply side oil price shocks and thus, a divergence in the results is not completely surprising.

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