Bachelor's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Economics and Management
Department of Economics

Arin Nøst

Economics of war: Is there a direct effect on the spot price of Brent Crude at the start of an international act of war?

An empirical study looking at the start of 8 different international acts of war between 1987 - 2022 and their effect on the weekly average spot price of Brent Crude.

Bachelor's thesis in Economics
Supervisor: Doriane Mignon
May 2022

NTNU
Kunnskap for en bedre verden

Arin Nøst

Economics of war: Is there a direct effect on the spot price of Brent Crude at the start of an international act of war?

An empirical study looking at the start of 8 different international acts of war between 1987 - 2022 and their effect on the weekly average spot price of Brent Crude.

Bachelor's thesis in Economics
Supervisor: Doriane Mignon
May 2022

Norwegian University of Science and Technology
Faculty of Economics and Management
Department of Economics

NTNU
Kunnskap for en bedre verden

Preface

This thesis is written by a student at the Department of Economics at the Norwegian University of Science and Technology (NTNU). The thesis is part of finishing a bachelor's degree in Economics for the student.

I would like to thank my supervisor Doriane Mignon from the Department of Economics for giving great guidance, discussions and helping me build a deep appreciation for academic work.

Trondheim, May 2022
Arin Nøst

Abstract

The study examines whether there is an observable direct effect on the price of Brent Crude at the start of various international acts of war. The effect is investigated by using the weekly average spot price of Brent Crude as a dependent variable in a multiple linear regression analysis, where categorical variables are added for the weeks of 8 different international acts of war from 1987 to 2022, as well as other control variables. The regression analysis found that 3 out of the 8 international acts of war included in the study had a significant effect on the spot price of Brent Crude in the same week as the start of the act of war, discovering both positive and negative significant effects of varying magnitude. The 5 other international acts of war cannot be concluded to have had an observable significant effect on the price of Brent Crude in the same week as the start of the act of war. This indicates that international acts of war may have a direct effect within the first week on the average spot price of Brent Crude, but that this does not always apply for all international acts of war.

Sammendrag

Studiet undersøker om det er en observerbar direkte effekt på prisen av Nordsjøolje ved starten av ulike internasjonale krigshandlinger. Effekten undersøkes ved å ta i bruk den ukentlige gjennomsnittlige spotprisen av Nordsjøolje som avhengig variabel i en multippel lineær regresjonsanalyse, hvor det er lagt inn kategoriske variabler for ukene av 8 ulike internasjonale krigshandlinger siden 1987 til 2022, samt andre kontroll variabler. Fra regresjonsanalysen er det funnet at 3 av de 8 internasjonale krigshandlingene hadde en signifikant effekt på spotprisen av Nordsjøolje den samme uke som krigshandlingen startet, det ble funnet både positive og negative signifikante effekter med varierende størrelse. De 5 andre internasjonale krigshandlingene kan det ikke konkluderes med å ha hatt en observerbar signifikant effekt på prisen av Nordsjøolje den samme uken som krigshandlingen skjedde. Dette tyder på at internasjonale krigshandler kan ha en direkte effekt innen den første uke på den gjennomsnittlige spotprisen av Nordsjøolje, men at dette ikke alltid gjelder.

Content

1. Introduction

1.1 Motivation

Crude oil is the world's most sold commodity and a central component in everyday life of individuals, organizations, and states creating both macroeconomic and microeconomic implications. Societies dependency on the natural resource makes it an interesting object of analysis. At the time this thesis is written Russia has started and is undergoing an invasion of Ukraine, spurring much of the international community to impose economic sanctions and trade-restrictions on Russia. Being one of the world's largest producers, exporters and consumers of crude oil the effects of the invasion have in the short term made the price of crude oil go above its price level before the invasion. (*Crude oil prices rise above $100 per barrel after Russia's further invasion into Ukraine - Today in Energy - U.S. Energy Information Administration (EIA)*, 2022)

This thesis will look closer on the effect of geopolitical unrest on the price of crude oils adding unto the empirical framework of studies that explains how geopolitical unrest is a determinant for the pricing of crude oils. Some possible effects geopolitical unrest can have on the price of crude oil is in the short term increased aggregate demand, disruptions to the aggregate supply, increased uncertainty and risk, and at the time of writing this thesis it looks like the Russian invasion is fueling the rest of Europe's search for long term substitutes for crude oil in effort of reducing the dependency of some crude oil producing states ('How Reliant Is the World on Russia for Oil and Gas?', 2022).

Previous empirical studies look at the historic short-term effect of wars on the price of crude oil, not including recent historic events after 2011. Finding a difference in significance of the effect on the price between events before and after the 21st century (Noguera-Santaella, 2016).

Some focus more on the long-term effect of different levels of global geopolitical unrest over time, finding a significant negative effect over time from increased geopolitical risk (Li et al., 2020; Antonakakis et al., 2017; Cunado et al., 2020). These studies differ in approach of how they understand the pricing of crude oil to be determined either in the commercial market (physical) or the financial market, this thesis will explore both the theoretical approaches for pricing by the law of supply and demand (physical market) as well as a financial market. This is done to connect this study with previous empirical work surrounding the pricing of crude oil, as well as giving a broader toolbox to work with when discussing the results.

This thesis will be different from other similar studies that look at the connection between crude oil pricing and geopolitical unrest in two regards. The spotlight will be on Brent Crude alone (known also as North sea crude), where most other focus on either West Texas Intermediate (WTI) or a cohort of the global crude oils together. Brent Crude works as a global benchmark for the pricing of more than 2/3's of the different types of crude oil found in the world. It is also thought to be one of the most liquid of crude oils, meaning that storage and transport cost is lower than other types of crude oil, making its price reflect in higher degree market events (*Brent*, 2022) which will fit well for the purpose of this thesis. Brent Crude experience less local production-, transportation- and storage bottlenecks than the landbased WTI (Dunn & Holloway, 2012) building under the argument that Brent Crude price is a better indicator of global supply and demand events.

The second regard being that this thesis adds newer acts of war in the model, especially interesting is the Russian invasion of Ukraine. By adding this the thesis will give a better understanding of how the price of Brent Crude is affected by these acts of war during the contemporary global economy, giving modern policy makers a better view of how the price of crude oil is affected during these types of event.

I will only look at geopolitical crisis events that can be classified as open international armed conflicts that constitutes as act of war. Trying to take away the aspect of tensions, intra-war, and terrorist attacks in the short term. International acts of war is often connected to intra-wars (civil wars, political internal unrest in a nation, etc), tensions or terrorist attack. So, these geopolitical events will still be present in the thesis through the events where they have been a key factor in forcing international acts of war, but by only looking at international acts of war the thesis hopes to find acts of war that will have a higher aggregate impact on the supply and demand of Brent Crude. As then more states, who are both exporting and importing crude oil, will be involved.

This thesis will use the Geopolitical risk (GPR) index to quantify the effect of geopolitical events, it will also use the same definition of geopolitical risk as understood from the founders of the GPR index (*Geopolitical Risk (GPR) Index*, 2022).

The definition for acts of war will be understood as; "realization, and escalation of adverse events associated with wars, among states and political actors that affect the peaceful course of international relations." (*Geopolitical Risk (GPR) Index*, 2022) There are many ways to

define war, but this definition will fit with this thesis as part of the GPR index is being used in the analysis.

1.2 Research question

Is it possible to find a significant direct effect on the short-term price level of European Brent Crude oil spot price from historic acts of war in the years between 1987 - 2022?

To answer this, I will start with developing the necessary theoretical background for the pricing of Brent Crude. Moving on I will look at some of the previous empirical work done around the same topic and present these, to give the reader a view of what is already established on the topic. Then I will build a multiple regression model and deploy a linear regression analysis. The results from the analysis will be used together with the framework of the theoretical background and the empirical work presented to answer the research question.

2. Theoretical background

First the law of supply and demand will be presented to create a foundation of understanding for how the pricing mechanism of Brent Crude is understood in this thesis. The law of supply and demand will showcase the author's theory of how acts of war will influence the pricing of Brent Crude.

The thesis will briefly introduce rudimentary financial theory, since this will be relevant both in the literature review and for looking at the different findings of the thesis relating to the direct effect acts of war will have on the spot price level of Brent Crude.

Then moving unto reviewing and presenting previous relevant academic work done surrounding the topic of geopolitical unrest and the pricing of crude oil.

2.1 The law of supply and demand and pricing of Brent Crude

There is no common understanding in what the model of pricing crude oil should be (Dunn & Holloway, 2012). Some look at crude oil as being a alternative financial asset, making it affected mostly by market expectations of risk and speculation (Yergin, 2009). Crude oil being used as a hedge against stock market fluctuations, or as a speculative asset for creating arbitrage opportunities. These findings are not conclusive, as crude oil pricing have become more correlated with the stock market over time, and claims that speculators motives should not go on the contrary of commercial use and its pricing of crude oil. Crude oil is a physical commodity and therefore the financial pricing of it should over time converge reflect the physical supply and demand of the crude market in total (Kolodziej et al., 2014; Weiner, 2002).

Since there is debate whether the pricing of crude oil should be follow the pricing model of a financial asset or a physical commodity (Dunn & Holloway, 2012) this thesis will try to incorporate both of the pricing mechanisms when looking closer at the results. With a deliberate focus on the physical commodity aspect through the law of supply and demand since the thesis wants to focus on the *direct* effect.

It must be mentioned that the financial aspect of the pricing system do seem to have an effect on the crude spot price, and some will call the focus on supply and demand for pricing of crude oil an over-simplification (Fattouh & Oxford Institute for Energy Studies, 2011, p. 9). This thesis also do not include the impact and methodology oil price reporting organizations (PRAs) like Platts, Argus, APPI and others have on the way the price of crude oil is determined (Dunn & Holloway, 2012). This relationship should be researched closer. The thesis assume that the PRAs pricing method is based on a foundation of the physical supply and demand of crude oil in the market, as well some of the financial attributes of crude oil (Dunn & Holloway, 2012).

From neoclassical economics we get the law of supply and demand. An economic theory that showcases the interaction between the supplier of a good and the demand from the buyer of said good which should result in a market price.

The law of supply and demand uses two different equations and economic curves to find and illustrate that the market price should be in the intersection of these two curves (Pindyck, 2013).

2.1.1 Supply - curve

The supply curve shows the quantity of a good the suppliers are willing to produce and sell for a given price in the market, all else equal. The connection between price and quantity is presumed positive, if the supplier can get a higher price, they will be willing to increase the quantity produced and sold in an effort to extract the uncaptured value from the market (Pindyck, 2013). In 2019 it was approximately produced around 83 million barrels of crude oil each day, making the total production of the entire 2019 at around 30 billion barrels (*Statistical Review of World Energy | Energy Economics | Home*, 2021). The function between quantity and price can be demonstrated through the equation and graphical display under;

Notation:

Q_S : The quantity of goods provided by the suppliers in the market.

P : The market price (positive relation)

$$Q_S = Q_S(P) \qquad \text{[Eq. 1]}$$

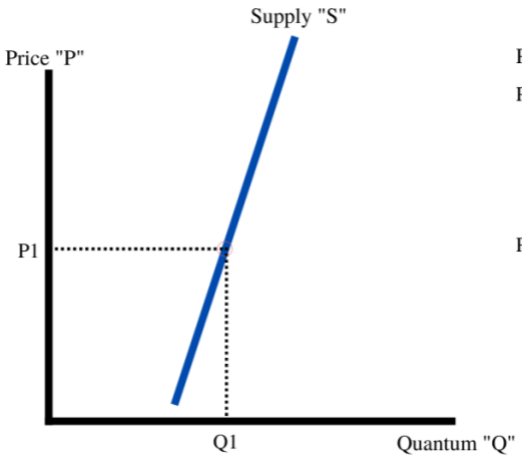


Figure 1: Supply curve

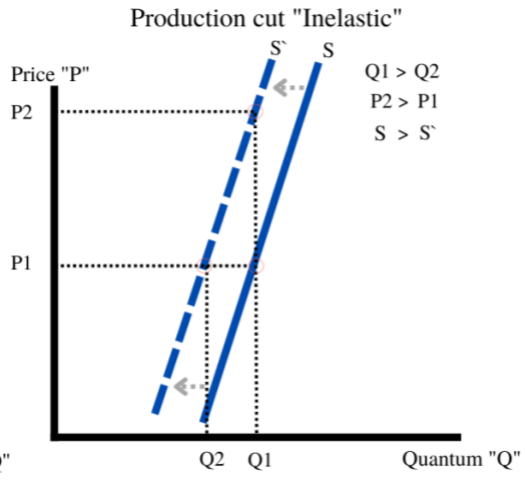


Figure 2: Supply curve with shift

The economic intuition behind the increasing supply curve is that for the suppliers to produce more quantity of the good the cost of production will increase which should be reflected in a higher market price.

Now the crude oil market is in fact several separate markets around the world, as there are many different types of crude oils with different attributes (Dunn & Holloway, 2012). The cost of producing crude oil is different from every location of production. This thesis will focus on the North Sea production. Here typical costs come from searching and finding reserves of crude oil available for extraction, building, and installing platforms, boats, or other types of necessary high-cost heavy assets at sites of possible extraction. Then there is drilling and pumping the crude oil up from underground. Then it needs to be transported to a refinery. The refining sites transform the crude oil to fit different types of markets. Then it is transported on to the customers for use.

What is special about the supply of crude oil is that the process of finding, extracting, refining, and delivering crude oil is complex and comes with capital-intensive investments that is higher than for most other types of industries. Especially is this true for the production of Brent Crude in that it is mostly found at the bottom of the North Sea, which creates a higher cost-barrier for the suppliers to get to the good.

From figure 2 we see that there is a shift in the supply curve, these types of shifts can come from different economic events. A negative shift in the supply curve might come from a disruption of production from a war waging in an oil producing country (Kilian, 2010; Noguera-Santaella, 2016). These types of production disruption from a war can come from sites of oil production being targeted as strategic military targets, destroying refineries and platforms will directly reduce the possible supply of crude oil. Examples of this have been seen in wars like the Russian invasion of Ukraine [28.02.2022] (*Russia hits key Ukrainian oil facilities in Odesa and Kremenchuk | Russia-Ukraine war News | Al Jazeera*, 2022) and in Iraq's invasion of Kuwait [1991] (*NASA - Landsat Top Ten - Kuwait Oil Fires*, 2012).

Other supply disruptions might come from economic sanctions from the international political community as a response to one, or both warring parties actively taking part in a war. These sanctions can be targeted especially on the crude oil market. Barring a supplier of crude from the market will reduce the aggregate supply of crude.

A war might also increase the transportation time and logistics of delivering the crude oil to the market, as corporations would try to avoid areas of active war or having been regulated by a governmental body to not use certain areas for transportation, creating a possible lag that gives a short-term demand surplus in the market, all else equal (Affairs, 2022).

The law of supply and demand would then say that a negative supply shift should give the other suppliers in the market three choices. Either they can ramp up production to produce the same quantity for a higher price ($P1 \rightarrow P2$), or they can accept the reduction in production and sell at the same price as before the shift ($Q1 \rightarrow Q2$), the third option is to choose something in-between these two options. To increase production the suppliers must either have available capacity in the short-term, or they must invest in new employees, machines, and buildings to create the capacity to increase the supply. This intuitively increases the cost of production for the suppliers making a market price increase necessary.

There is also the aspect of crude oil pricing to be volatile, meaning that in the short term the suppliers might be reluctant to increase or decrease the supply of crude based on a change in the market if they believe that the market of crude oil might return to an acceptable price level in the near future (Kilian, 2010).

Since the 1960s the crude oil market has been influenced by a pricing cartel called the Organization of the Petroleum Exporting Countries or OPEC. This cartel consists of suppliers that produce roughly 40% of the world's supply of crude oil (*Statistical Review of World Energy | Energy Economics | Home*, 2021), OPEC would have incentive to capitalize on supply and demand shifts in the market. Again, keeping the suppliers in line with not acting hastily on short-term price changes, as their efforts might only be countered by OPEC (Fudenberg & Tirole, 1991).

This is connected to the steepness of the curve, which tells us about the elasticity of the supply. It shows how willing the suppliers are in changing their quantity produced because of one percentage point of change in the market price.

The supply curve of crude oil in the short-term is inelastic. Meaning that the suppliers of crude oil usually do not change the quantity of production to meet short-term changes of

demand (Krichene, 2002). An inelastic supply curve makes it so that the curve can be portrayed in a steeper vertical manner as done above.

The negative supply shift ($S \rightarrow S`$) as a result from a production stop from one of the suppliers will with the inelastic properties of the crude oil market give a much bigger effect on the price of the crude oil in the short term than if it had been a more elastic supply (Pindyck, 2013).

In the long-term the elastic properties of the supply is different, it is more common that the long-term supply curves is more elastic (Pindyck, 2013) . In the long-term the suppliers will have better opportunity to invest and build capacity to meet market needs (Pindyck, 2013). Since it is the short-term effect of extreme geopolitical events on the price of Brent Crude we are interested in this thesis we will not elaborate further on long-term economic effects, but it is noted that the crude market is thought to be inelastic in the long-term as well (Krichene, 2002).

2.1.2 Demand – curve

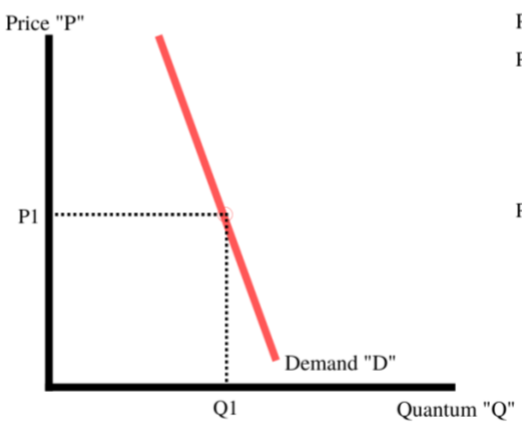
The demand curve shows all the customers in the market and their aggregate willingness to pay for the good. A common attribute of a demand curve is its negative relation to the market price, if the price of a good goes up there are fewer customers who are willing to pay for the good. Another way to describe this effect is that the lower the price of the good is the more units of the good is the customers willing to purchase (Pindyck, 2013). In the crude oil market regular customers can be businesses, states and individuals (*OECD*, 2020).

Notation:

Q_D : The quantity of goods demanded by the consumers in the market.

P : The market price (negative relation)

$$Q_D = Q_D(P) \qquad \text{[Eq. 2]}$$



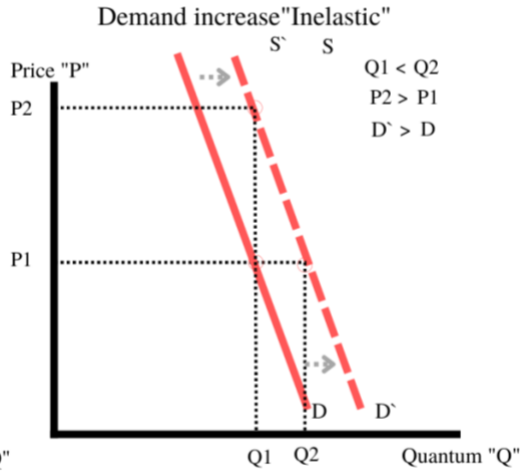


Figure 3: Demand curve

Figure 4: Demand curve with shift

Figure 3 portray the properties of a demand curve and the aggregate demand. If the price goes up less customers are willing to buy the good, the demand of quantity goes down. In figure 4 there is a shift in the demand curve, this can happen for several reasons. Here there is a positive shift, meaning that the aggregate demand improves, all else equal.

An example for the crude oil market is a war breaking out between two states. The states invest heavily in arming the military with more goods (weapons, clothes, machines, etc) and for transporting and warming the military, all these types of actions demand the use of crude oil. There is an aggregate increase in the demand for crude oil and the demand curve shifts outward ($D \rightarrow D`$). Other types of positive aggregate demand shifts in the short-term from a war might be increased transportation time for planes, boats and trucks that now must take a longer route in effort of avoiding areas of war to make the same deliveries. Increasing the demand for crude oil.

This gives the suppliers of the crude oil market three opportunities, either keep producing the same quantity but sell it at a higher price ($P1 \rightarrow P2$). Increase the production and sell more of the good at the same price ($Q1 \rightarrow Q2$), the third option is to choose something in-between these two options.

Special notions of the demand for crude oil are that in the short-term there exist few real substitutes of crude oil. Meaning that the consumers of crude oil will have a hard time of

finding other types of resources in a short period of time that will give the same utility as crude oil (J. C. B. Cooper, 2003).

Crude oil is a resource that is imbedded widely in the global market, being a major input of production into different types of goods, needed for most forms of transportation, for creating energy, and heating. In 2019 the global aggregate consumption of crude oil was approximately 96 million barrels per day (including other forms of liquid fuel than crude oil), or approximately 35 billion barrels in all of 2019 (*Statistical Review of World Energy | Energy Economics | Home*, 2021).

The global community's dependency on crude oil, as well as the barriers of finding substitutes for crude oil in the short-term means that the aggregate demand for crude oil is inelastic (J. C. B. Cooper, 2003). The consumers of crude oil have a high willingness to pay for the crude oil, and the demand curve is more vertically inclined as shown above. The inelastic property of the aggregate demand give room for the suppliers to take a higher price from a positive demand shift in the market. It also shows that there is less increase in the quantity needed to get to the same price level as before ($Q1 \rightarrow Q2$).

2.1.3 Supply and Demand

The law of supply and demand describe the market price to be in the equilibrium of the supply curve and the demand curve. From this theory therefor the price of European Brent Crude should be at the intersection of the two inelastic curves.

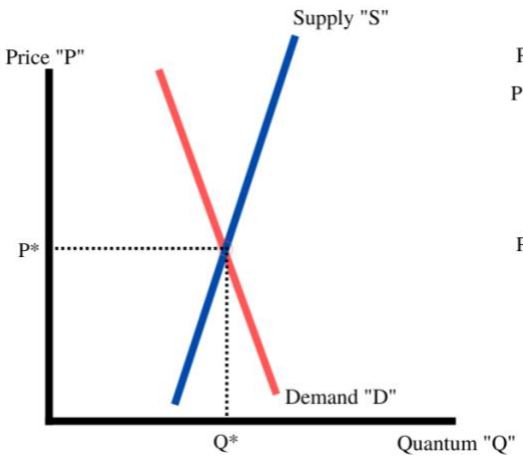


Figure 5: Theoretical display of equilibrium crude oil market

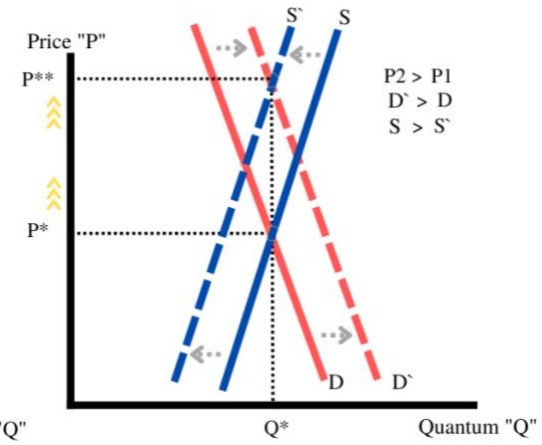


Figure 6: Crude oil market with shifts

Putting together both the theoretical shifts on the demand and supply curve from a war we see that the effect would be a price increase ($P^* \rightarrow P^{**}$), all else equal.

This is just a limited theoretical show of the pricing mechanism as understood from the law of supply and demand. The real pricing of crude oil is more complex, and the total economic effects of a war on the price of crude is more than just these two proposed shifts. That said this way of showing the theoretical framework for pricing in the crude oil market builds under the interesting parts of the hypothesis that this thesis is testing. Looking at the short-term direct effects of an act of war on the price level of the European Brent Crude spot price.

2.2 Basic financial theory and the pricing of commodities as assets (Brent Crude)

Brent Crude is also traded as a financial asset (options, futures, forwards, dated brent, etc) in different financial markets (Dunn & Holloway, 2012).

Financial theory builds its foundations on the aspects of time periods, storing of value, expectations, risk, and uncertainty. In a given period, a financial actor (state, business or individual), might want to either use their future fortune now by taking up a loan. Or they can invest their fortune now in effort of storing and increasing the value of the fortune into the future. Since we cannot with 100% accuracy know the future state of the world there is uncertainty connected with every choice we take about the future.

When a financial actor takes part in the financial market their investment action contains some level of uncertainty to it because of this. When the pricing of different financial derivatives of Brent Crude is decided in the financial market we can say it is partly determined by the financial market actor's aggregate future expectations of the future status quo of the crude market, for example in terms of future supply, demand, and level of inventories. These future expectations always contain uncertainty.

The risk of different future states of your investment choice today will create something we can call a risk premium. A rational investor will demand a premium to be added to the price of the financial asset, to be compensated for the risk they choose to take by investing in said financial asset. The higher the risk of the investment is for the investors, the higher will the risk premium have to be, and vice versa (Goss & Yamey, 1976).

Based on rational actors wanting to reduce risk and uncertainty of possible supply and demand shifts in the physical crude market they will agree with financial actors on contracts of purchase of crude oil now for future delivery or storage to reduce the risk of future uncertainty, detaching the ownership of the commodity of crude oil from the ownership of the price changes of the crude oil (Dunn & Holloway, 2012).

This is one of the way's the financial market can be a place for arbitrage strategies for speculators, and how different levels of risk in the market will create different risk premiums (Goss & Yamey, 1976). An arbitrage strategy is built on the opportunity of buying an asset and selling it with a profit in the near future (Girma & Paulson, 1999), Girma & Paulson (1999) found that historically there have been clear arbitrage opportunities in the financial markets for petroleum commodities.

In the crude market an act of war increases the risk of shifts in the supply and demand. At the brink of an act of war it is therefore rational to believe this will be portrayed through an increased risk premium on the pricing of Brent Crude in the financial markets (Looney, 2003).

When crude oil is tied to different financial contracts that is sold in a financial market it gives crude oil an added attribute of being a storage of value into the future. Which creates new aspects for understanding how crude oil is priced, above we have briefly mentioned how uncertainty, speculations and risk takes part in deciding the price following the added attribute of storage of value over time.

3. Literature review

The GPR index is designed to be used for estimating the effect of geopolitical risk with economic variables. As known to me there is a selection of articles that use the GPR index in looking at the different effects geopolitical risk have on the crude oil market (Li et al., 2020; Antonakakis et al., 2017; Cunado et al., 2020; Mei et al., 2020; Noguera-Santaella, 2016).

Cunado et al. (2020) focus their study on the time-varying effect of geopolitical risk and oil returns, looking mostly on the effects over time. They found that in total, geopolitical risk

have a negative effect on returns of oil, claiming that increased geopolitical risk have a negative effect on global demand because of increased uncertainty. This finding does not go against the hypothesis of this thesis, as we are more interested in the short-term effect of an act of war on the crude price.

Li et al (2020) looks at the correlation of geopolitical risk and the crude oil, with a focus on the West Texan Intermediate (WTI) crude oil. Claiming geopolitical risk drives the price of crude oil. When looking at geopolitical tension the overall correlation is negative, but focusing on geopolitical acts (GPA) they found that increasing level of geopolitical acts gave a significant positive effect on the price of WTI.

Antonakakis et al (2017) looked at geopolitical risk as a driving force in the relation between the crude oil prices and stock prices. Finding the same as Cunado et al (2020) and Li et al (2020) that overall geopolitical risk induces uncertainty that negatively affects the global demand, and by that the crude oil market as well as the stock market. But in some cases, geopolitical risk could be a factor in reducing covariance between the two markets.

Noguera-Santaella (2016) had an approach of looking on the short-term effects of geopolitical events on the price of crude oil, the article uses an historic span from 1897 until the start of the Arab Spring in 2011. They found that before the 21st century there was significant effects between major geopolitical events and the short-term pricing of crude, but after this it was harder to tell of any significant effect between the short-term crude price and geopolitical events.

4. Methodology and presentation of data

4.1 Ordinary Least Squares (OLS)

To say something about the relationship between geopolitical acts of war and the pricing of European Brent Crude this thesis will put together a multiple regression formula. This formula will be used to present empirical notions on how geopolitical acts of war and other control variables affect the pricing of Brent Crude.

Ordinary least squares (OLS) is a method of regression that place a linear relationship where the distance between the estimated regression line and the sum of squared residuals are the lowest possible. OLS and the multiple regression formula gives us the possibility to explicitly

look at various independent variables that affects the dependent variable at the same time, meaning that independent variables that would in a simple regression analysis be presented through the error term now is present in the model, giving us a more accurate picture of reality by removing some of the correlation with the error term (Wooldridge, 2013, p. 68).

4.1.1 General multiple linear regression

A general presentation of how a multiple linear regression model is setup follows.

$$y = \beta_0 + \beta_1 * x_1 + \beta_2 * x_2 + \cdots + \beta_i * x_i + u \qquad \text{[Eq. 3]}$$

Notation:

y : The population dependent variable

β_0 : The population intercept, the value of the dependent variable when all other independent variables are zero (Wooldridge, 2013, p. 23).

β_i : The population slope parameters of the independent variables in the model, telling us about the relationship between the independent and dependent variable. It tells us how much one unit of change in the independent variable will affect the dependent variable, all else equal (ceteris paribus).

x_i : The population explanatory variables, also called the independent variables.

u : The error term, is meant to represent all other factors that affects the dependent variable that is not present in the model (Wooldridge, 2013, p. 23). It also tries to represent the fact that there are relationships that is not measurable. It is possible to understand the error term as the difference between the expected value of the dependent variable and the actual value of the dependent variable.

4.1.2 The Gauss-Markov assumptions

This model contains several assumptions that must be upheld to claim that the results we receive from the analysis are valuable and reliable. There are 6 assumptions but the thesis will only present the first 5 since the last assumptions is almost always not kept. The four first is designed to remove unbiasedness from the model, the fifth is to point out variance properties that must be met for the estimators to secure their logic (Wooldridge, 2013, p. 93). The assumptions are as follows:

MLR.1 - Linearity

This assumption tells us that there need to be a linear relationship between the parameters of the independent variables, the error term, and the dependent variable. This need to be verified for the OLS method to be valid. A regular way of finding if the model has a linear structure is by plotting the residuals against the fitted values and looking at the linearity of the scatter plots.

MLR.2 – Random Sampling

Here the assumption tells us that the sample set that is used in the model needs to be randomly chosen where each single observation must have the same opportunity of being picked up. This assumption is decided on the nature of the data, how the data is chosen and the number of observations in the dataset.

MLR.3 – No perfect collinearity

To make sure that our findings are strong there needs to be low levels, to no multicollinearity. Meaning that the independent variables cannot perfectly correlate or have high level of correlation between each other.

If there is a case of perfect collinearity it will be hard for us to claim something of use about the different independent variables. Our estimates will be improper, and the real explanatory value of the model is lowered. In effort to research collinearity in the dataset we can create a correlation matrix and look at the levels of collinearity or use an indicator called the “variance inflation factor (VIF).

MLR.4 – Zero conditional mean

This assumption claim that the expected value of the error term needs to be zero, given the values of the independent variables. This assumption is often not upheld entirely, as it is difficult to add all independent variables in a correct manner to ensure that there is zero covariance between the error term and the independent variables. One should still work toward minimizing the covariance as much as possible between the error term and the independent variables.

If this assumption is not held the model risk omitted variable bias (Wooldridge, 2013, p. 91), which is when the model do not contain certain important explanatory variables, and the endogenous independent variables parameters gets a higher explanatory value from the analysis than what is the truth of the population parameters.

MLR.5 – Homoscedasticity

The variance of the error term needs to be constant for every value of the explanatory variables. If this is not upheld the estimated values of the standard errors for the coefficients from the analysis will be inaccurate.

Are these assumptions kept when doing a multiple linear regression analysis the Gauss-Markov Theorem claims that the samples parameter estimates we get from the OLS are the best linear unbiased estimators (BLUEs) that is possible to create for estimating the population parameters true value (Wooldridge, 2013, p. 102). Woolridge points out that when using econometric models all of these assumptions are usually not kept, as we will see further on when these assumptions will be tested against the dataset used in this thesis (Wooldridge, 2013, p. 17).

The goal of the analysis is to establish estimated values of the parameters and error term in explaining the dependent variable. Now how much explanatory power the model we create have on the dependent variable can be found through the measure of the coefficient of determination: R^2

This coefficient shows how much of the total variance of the model (SST) that is used to explain the dependent variable (SSE) against the amount of variance that is not explained through the analysis (SSR).

Equation:

$$SST = SSE + SSR \qquad \text{[Eq. 4]}$$

$$R^2 = \frac{SSE}{SST} = 1 - \frac{SSR}{SST} \qquad \text{[Eq. 5]}$$

$$0 < R^2 < 1 \qquad \text{[Eq. 5.1]}$$

The R-squared will with every new independent variable introduced in the model increase, this can be understood as an increase in the explanatory power of the model.

4.2 Hypothesis

A hypothesis is an assumption or a research question of an ability or attribute of the population in question. In a hypothesis the assumption or research question must be formulated in a way that makes it objectively possible to measure and test. So we can decide if we reject or not reject the hypothesis.

When a hypothesis is created you are left with two hypotheses, the null hypothesis (H_0) and an alternative hypothesis (H_A). These two hypotheses have to be competing, so if one is true the other is not true (Anderson, 2020).

4.2.1 Testing of hypothesis

In understanding and testing the effect of the estimated parameters from the analysis we can look at the *t*- and *p*-values calculated from the analysis against a predetermined level of significance (most common: 1%, 5% or 10%). The *t*-value can be used in doing a t-test in effort to test which of the hypothesis we must reject or not (Wooldridge, 2013, p. 55).

The t-value is found through a regression analysis. It shows the difference between the estimated and hypothetical coefficient divided on the standard error. Mathematically it can look like this:

$$TS \sim t_{\hat{\beta}_j} = \frac{\hat{\beta}_j - \beta_j}{SE(\hat{\beta}_j)} = \frac{estimated\ -hypothetical}{standard\ error} \qquad \text{[Eq. 6]}$$

When looking at the null hypothesis (H_0) the t-statistics is distributed by following the degrees of freedom created from the sample. The degrees of freedom (df) is found by taking (n) number of observations, minus the (k) number of variables and minus the constant of 1.

$$df = n - k - 1 \qquad \text{[Eq. 7]}$$

The hypothesis might also imply either a one-tailed or two-tailed testing approach. The main difference of these two situations is how the alternative hypothesis is presented and formulated. The null hypothesis is in our case that there is no effect at all from the independent variable of interest on the dependent variable:

$$H_0: \beta_j = 0$$

When we are facing a one-tailed testing approach the alternative hypothesis focus on an effect either way:

$$H_A: \beta_j < 0 \; or \; \beta_j > 0$$

A two-tailed testing approach will focus on just the presence of an effect beyond zero:

$$H_A: \beta_j \neq 0$$

It is the latter approach of two-tailed test that will be central in this thesis, as we are interested in finding if there is any significant effect at all from the start of an international war on the price of Brent Crude.

From our tests we will get a critical value that is used to determine if we are to reject or not reject the null hypothesis. The critical value gives us a number on the probability of making a type 1 error if we reject the null hypothesis, while the predetermined significance level tells you how much of a probability of doing a type 1 error we accept in our testing (Wooldridge, 2013, p. 124).

This thesis will have a predetermined significance level of 5%, meaning that if we get results that allows us to reject the null hypothesis, we will do so with 95% certainty of not doing a type 1 error.

4.2.2 Statistical hypothesis of the thesis

As stated, this thesis will use a two-tailed approach when looking at the possible significant effect the beginning of an act of war has on the spot price of European Brent Crude oil. The reasons for this are that we are interested in looking at both possible negative and positive effects of an act of war on the price of Brent Crude, and that this is the standard approach when doing a regression model.

The hypothesis we get is then:

$$H_0: \beta_j = 0$$

$$H_A: \beta_j \neq 0$$

Null hypothesis (H_0): *There is no significant direct effect during the same week as a start of an international act of war on the weekly average spot price of the European Brent Crude Oil, all else equal.*

Alternative hypothesis (H_A): *There is a significant direct effect during the same week as at the start of an international act of war on the spot price of the European Brent Crude Oil, all else equal.*

In this part of the thesis, I will present the theoretical multiple regression model that will be used to test the hypothesis above. This will include a deep dive into the variables and the data used in the model. After this presentation the regression analysis and the results will be presented and discussed.

4.3 Theoretical regression

The theoretical regression model will have the weekly average spot price of Brent Crude as dependent variable. The independent variables will consist of the GPT (Index for geopolitical tension) 7 days moving average. A lag variable containing the monthly average of the spot price of Brent Crude for an entire week a month before the dependent variable. A set of dummies for the different acts of war. Time fixed effects shown through two-years interval dummies. A categorical variable for different seasons, and an error term.

$$\begin{aligned} WBCSP = {} & \beta_0 + \beta_1 * GPRT_{MA7} + \beta_2 * WBCSP_{MA30_{LAG}} + \beta_3 * GULFW1D \\ & + \beta_4 * GULFW2D + \beta_5 * IRAQWD + \beta_6 * LIBYAWD + +\beta_7 * YEMENWD \\ & + \beta_8 * CRIMRUWD + \beta_9 * USSYRWD + \beta_{10} * RUSSIAWD + \beta_{11} \\ & * TFE_{89n90} + \cdots + \beta_{26} * TFE_{21n22} + u \end{aligned}$$

4.4 Variables

4.4.1 Dependent variable (the explained variable)

WBCSP = Weekly average Brent Crude spot price

The phenomena we are interested in researching is the spot price of Brent Crude, and the factors that affects it. There are different ways to show the spot price of Brent Crude, these are categorized in different types of averages. The most common are monthly, weekly, and daily

average spot price. I have chosen to use the weekly average spot price as found from the US Energy Information Administration (*Homepage - U.S. Energy Information Administration (EIA)*, 2022). The weekly average captures the fluctuations of the spot price between weeks. This way the dummy variables for acts of war would be able to show effect the start of a war has in the same week as the war started, removing some of the volatility aspect of the spot price that the daily average would give us. We are interested in a market reaction beyond just fluctuations. As markets usually take some days to fully react on these kinds of events a weekly average is understood as a good level of measure for this. Omitting the day-to-day volatility on the spot price of the Brent Crude. While a monthly average could be interesting as well, this measure have a higher risk of being influenced by other events not related to wars in the same month.

4.4.2 Independent variables (the explanatory variables)

Independent variables of interest

GULFW1D = Iraq invasion of Kuwait Dummy
GULFW2D = US coalition against Iraq in Kuwait Dummy
IRAQWD = Iraq War Dummy
LIBYAWD = Libya War Dummy
YEMENWD = Yemen War Dummy
CRIMRUWD = Annexation of Crim by Russia War Dummy
USSYRWD = US arial strikes on Syrian Government War Dummy
RUSSIAWD = Russian invasion of Ukraine War Dummy

Since 1987 until 2022 there have been several major geopolitical acts of war. The dummies all represent the week as some of these different wars are thought to officially start. The definition of when an act of war starts is here understood as the date that the conflict turned to become a state-based conflict between more than just one state.

A dummy war variable is a variable that have the value of "1" the same week as the war started, and the value "0" in all other observations of the dataset. This will enable us to observe the reaction of the dependent variable on the week of the start of an act of war.

These different acts of wars had different pretexts which was directly and indirectly affected by different states. These dummy variables do not represent the entire number of acts of war during the period between 1987 and 2022, but is shorted down to a 8 acts of war in effort to reduce the scope of the thesis. The wars that are highlighted in the thesis are understood as wars that include major market actors in the global crude market, both on the demand and supply side. As well as being the most mentioned acts of war from the GPR index (see Figure 7 below).

The Gulf War is understood to be two different major events, the first being Iraq's invasion of Kuwait 2nd of August 1990. This is the dummy "GULFW1D". The other major event was the UN approved act of aggression against Iraq from US led coalition 17th of January 1991. This is the second dummy "GULFW2D".

The Iraq War was the invasion of Iraq speared by the US in an international coalition, the invasion started 20th of March 2003, here called "IRAQWD".

The Libya War was first a civil war that turned into an international war when NATO and a coalition of other states intervened 21st of March 2011. This is the variable "LIBYAWD".

The Russian-backed rebels that annexed Crimea from Ukraine 20th of February 2014 is the dummy variable "CRIMRUWD".

The civil war in Yemen had been active for a couple of years, 26th of March 2015 a Saudi Arabian led international coalition involved themselves in the war. This is the dummy variable "YEMENWD".

A US led coalition would 14th of April 2018 do airstrikes against Syrian government forces following an alleged chemical attack on civilians by the Syrian Government. Denoted as "USSYRWD"

The Russian invasion of Ukraine started 28th of February 2022 when Russian troops entered Ukraine. Presented by the dummy "RUSSIAWD".

Control variables

GPTD_MA7 = Geopolitical Tension Daily 7 day Moving Average

The first of the control variables is the GPRs index for geopolitical tensions (GPT). This is highly correlated with the more general Geopolitical Risk Index but will add observations of geopolitical tensions that did not end in an act of war. This will allow us to focus even more only on the direct effect from an act of war on the price of Brent Crude, removing the possible effect that tensions before and after an act of war that is getting reflected into the pricing of the Brent Crude.

WBCSP_MA30_LAG = The moving average of the weekly Brent Crude spot price the month prior to the week we are looking at.

By adding this kind of lag variable, the model hopes to remove some of the effect the previous crude spot price level had on the crude spot price we want to focus on. An important factor in the short-term pricing of a commodity often is its previous short term historic level.

TFE_XxnYy = Two years' time fixed effects dummy variable

All these dummy variables are created to portray time fixed effects over the different years. They will have the value "1" in all observations for their specific years, and the value "0" for all other observations.

The idea of these dummy variables is to capture all the other effects, like global demand, global production, major technological advances, the booms, and busts of the global economy that vary over time. Effects that the model does not endogenously add on its own. By showing the different movements for each fixed period the model tries to further isolate and control the effect an act of war has on the price of Brent Crude. The results of all these effects from the regression is found in the appendix.

i.Season = Seasons

This is a categorical variable that is meant to represent the four seasons in a year, summer = 1, spring = 2, fall = 3 and winter = 4. This control variable will help remove seasonal effects on the Brent Crude spot price. One of the known factors to affect the pricing of energy is the weather and temperature. By adding this variable we will be able to account for the fluctuations in price that comes from these seasonal cycles.

4.5 Presentation of data

To look at the effect of acts of war on the spot price of Brent Crude this thesis used secondhand data sources.

For finding the weekly Brent Crude spot price I have gone to the US Energy Information Administration (*Homepage - U.S. Energy Information Administration (EIA)*, 2022). EIA is a US federal financed independent statistics and analysis institution that focuses mainly on US and global energy data. The data on the Brent Crude spot price is gathered from their open-access database from their website (*Spot Prices for Crude Oil and Petroleum Products*, 2022). They have collected the datapoints on the spot price of Brent Crude from Refinitiv, a platform for financial data (*About Us*, 2022).

The dataset on the spot prices was originally from 15th of May 1987 until 15th of April 2022 and contained 1821 observations, this have been reduced to 1817 observations to accommodate for the lag variable of the spot price "*WBCSP_MA30_LAG"*. The spot price is now from the 26th of June 1987 to 15th of April 2022.

To say something of geopolitical tension I am using the geopolitical risk index created by Dario Caldara and Matteo Iacoviello, the data from the index is downloaded from their official website: https://www.matteoiacoviello.com/gpr.htm (*Geopolitical Risk (GPR) Index*, 2022). This index was originally on 13 630 observations, taking daily 7 days moving average from 1st of January 1985. All the same corresponding dates as the weekly average spot price every Friday was chosen and separated into its own variable. All observations before 26th of June 1987 was removed. Making it a total of 1817 observations of the 7 days moving average of the Geopolitical Tension index.

The index has an automated search engine put up towards ten major news-outlets reading, measuring intensity, and counting the articles in these news-outlets that writes about unfavorable geopolitical happenings. These articles are collected daily, and the collection of articles dates to 1985.

The articles are put into 8 different categories in effort of providing a separation between geopolitical tensions (GPT), and acts of war (GPA).

Credit: Graphical display downloaded from https://www.matteoiacoviello.com/gpr.htm on April 15th, 2022

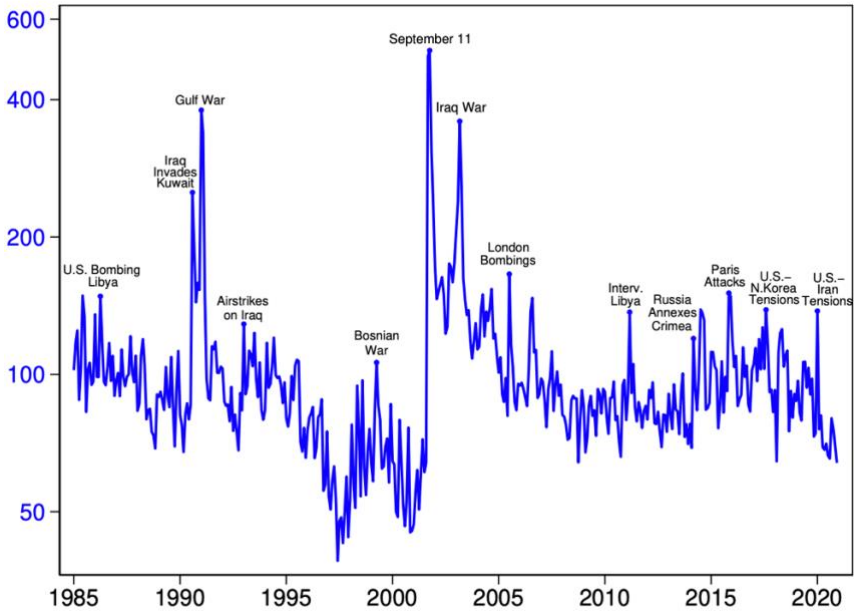


Figure 7: Recent Geopolitical Risk Index, with events mapped out (excluding Russian invasion of Ukraine 24th of February 2022).

The index uses the year 1985 as index year and is measured as total number of articles mentioning specific words connected to tensions, escalation, and acts of war, divided on total number of articles in the news-outlets monitored. The news-outlets used in the index are respectively; *"Chicago Tribune, the Daily Telegraph, Financial Times, The Globe and Mail, The Guardian, the Los Angeles Times, The New York Times, USA Today, The Wall Street Journal, and The Washington Post."* (Board of Governors of the Federal Reserve System et al., 2018)

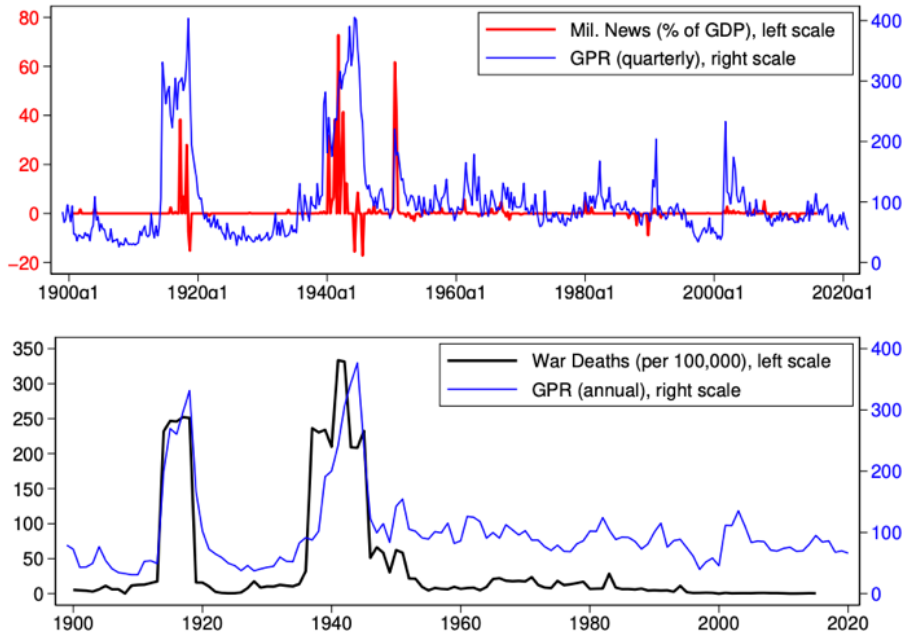
$$GPR \propto \frac{G}{u}$$

Notation:

G *: Number of articles in the 10 news-outlets that contains phrasing of unfortunate geopolitical events.*

u *: Total number of articles combined in the 10 news-outlets.*

If the Geopolitical Risk Index is tested against other types of war-indicators, we can get a view of the validity of using the Geopolitical Risk Index to portray the objective truth of tensions and war escalations (Jacobsen, 2015). The two war-indicators used to test this are Ramey's Military News (Ramey, 2011), and battle-related deaths from the Armed Conflict Dataset of PRIO and Uppsala (*PRIO Battledeaths Dataset – Peace Research Institute Oslo*, 2022).



Credit: Graphical display downloaded from https://www.matteoiacoviello.com/gpr.htm on April 15th, 2022

Figure 8: Time-series comparison between GPR Index and other war indicators

For more extensive reading on the quality and auditing of the Geopolitical Risk Index (Board of Governors of the Federal Reserve System et al., 2018).

All edits to the datapoints were first done in Microsoft Excel then submitted to STATA for analysis.

4.5.1 Descriptive

Before doing a regression analysis the thesis will look closer in detail on the abilities of the variables used in the model, with special emphasis on the dependent variable and the geopolitical tension variable.

Table 1: Descriptive statistics of variables WBCSP and GPRT_MA7

	Weekly Brent Crude Spot Price		Geopolitical Tension Moving Average 7
Mean	$	47,66	100,54
Max	$	141,10	592
Min	$	9,44	29
Standard deviation (+/-)	$	32,41	49,25
Observations		1 817	1 817

From the descriptive statistics we find that the mean weekly average spot price of Brent Crude from 1987 to 2022 is $ 47,66 per barrel of Brent Crude. The max weekly average price of a barrel of Brent Crude in the same period was $ 141,10, and the minimum weekly average was $ 9,44 per barrel.

The standard deviation is at $ 32,41, this tells us that there is a broad variation in the spot price from week to week. Which fits with the understood volatility of the market structure as presented in the theoretical background above, reacting swiftly to global changes in demand and supply in the short term.

The index for geopolitical tension has a mean value of 100,54. The maximum registered level of tension is at 592 and the minimum at 29. The standard deviation is at 49,25. Which also is a high number, together with the difference between the max and minimum values this tells us that there are observed broad variation from week to week in the index of geopolitical tension.

For a table view of the descriptive statistics of all variables used in the model look in the appendix.

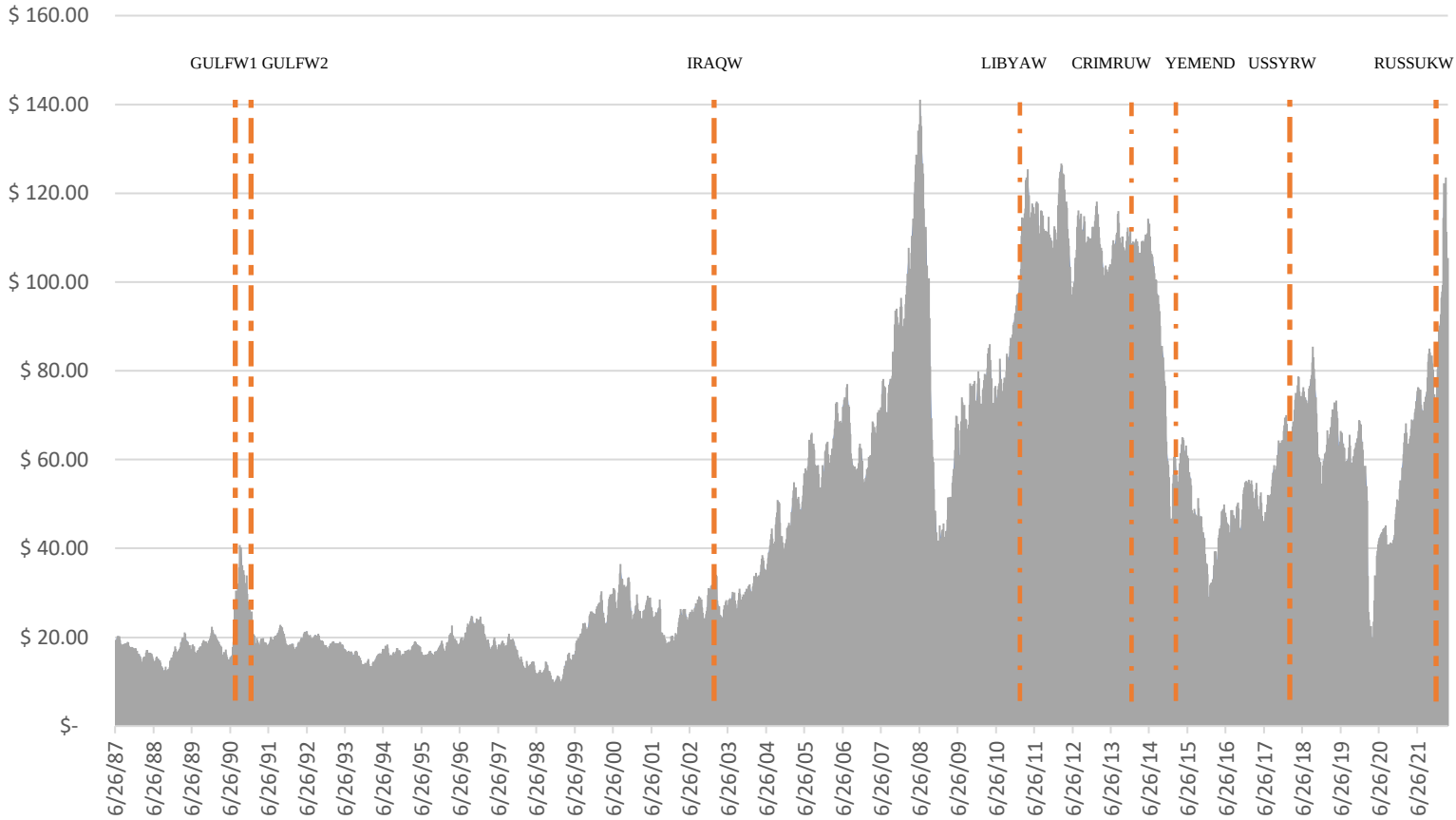


Figure 9: Display of the weekly average Brent Crude spot price since 1987 and acts of wars used in the thesis

The graphical display above shows the weeks that is added in the dummy war variables over the weekly average Brent Crude spot price from 1987 until the first quarter of 2022.

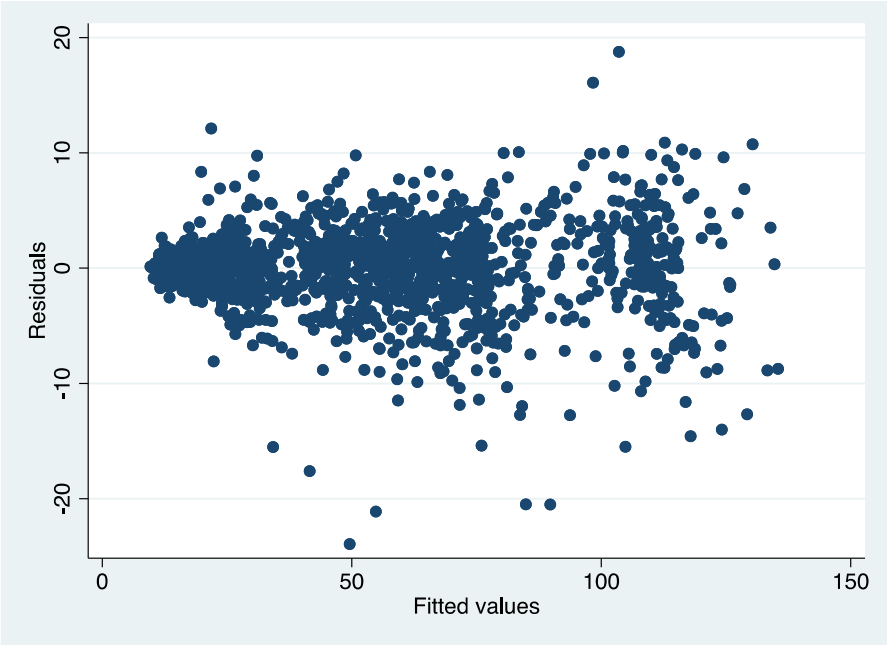
4.5.2 Assumptions

This part of the thesis is going to test the dataset against the presented assumptions above that needs to be held to secure the validity of results from the multiple regression analysis.

MLR.1 - Linearity

A regular way of finding if the model has a linear structure is by plotting the residuals against the fitted values and looking at the linearity of the scatter plots.

Figure 10: Scatter plot of residuals and fitted values



Here we see that the data points lack the attribute of clear linearity. Since this is economic data across time this assumptions is usually not fully fulfilled (Wooldridge, 2013). The thesis accepts the lack of linearity in the data.

MLR.2 – Random Sampling

The assumption of random sampling is usually not upheld when using data over time, as the datapoints will have a given chronological ordering. The aspect of reducing the observations to weekly from daily, and not including observations before 26th of June 1987 reduces the random sampling aspect even further for the dataset. As well as the thesis only looking at certain acts of war and not using a broader scope of acts of war. The thesis acknowledges that the assumption is not met, and that this mean that the results of the regression should be read with skepticism.

MLR.3 – No perfect collinearity

To check this assumption the thesis presents a correlation matrix and look at the levels of collinearity or use an indicator called the "variance inflation factor (VIF). When using datasets with observations across time, and a lag variable there often is high levels of multicollinearity. Because of the high number of variables in the model I only present a table with the results from a VIF analysis, (for a correlation matrix see the appendix).

	VIF
WBCSP_MA30_LAG	11,19
GPRT_MA7	1,28
SEASONS	1,01
IRAQD	1,02
RUSSIAD	1,02
GULFW1D	1,01
GULFW2D	1,01
LIBYAD	1,01
CRIMRUWD	1,01
YEMEND	1,01
USSYRD	1,01
TFE_89n90	2,19
TFE_91n92	2,21
TFE_92n94	2,18
TFE_95n96	2,19
TFE_97n98	2,2
TFE_99n00	2,22
TFE_01n02	2,21
TFE_03n04	2,36
TFE_05n06	3,28
TFE_07n08	4,99
TFE_09n10	3,85
TFE_11n12	7,4
TFE_13n14	6,83
TFE_15n16	2,79
TFE_17n18	3,4
TFE_19n20	2,92
TFE_21n22	3,12
Mean VIF	2,78

Table 2: Variance inflation factor (VIF)

The VIF show multicollinearity, and we see that the lag variable is above the limit value of 10

(Wooldridge, 2013). This is a normal problem concerning economic data over time and the use of lag variables. All other variables have a VIF value under 10 and is usable in the dataset. We note that there is problem with multicollinearity in the model.

MLR.4 – Zero conditional mean

The zero conditional mean is an ideal that is hard to maintain. The model is designed to mitigating as much as possible against omitted variable bias by adding time fixed effects and a lag variable. The crude oil market is complex, and we can with certainty claim that there are important explanatory variables left out of the model rendering the model affected by omitted variable bias (Wooldridge, 2013).

MLR.5 – Homoscedasticity

From the scatter plot between the residuals and the fitted value we find that the dataset has high degree of variance, giving us reason to test for heteroscedasticity in the dataset. Heteroscedasticity in the dataset will affect the estimations of our standard errors, rendering the external validity of the regression analysis to be weaker. A regular test to run for heteroscedasticity is the Breusch-Pagan test. This gives us two hypotheses, the null hypothesis being that there is a constant variance (homoscedasticity) and the dataset upholds MLR.5. The alternate hypothesis is that there is not a constant variance (heteroscedasticity).

$$chi2(1) = 642{,}21$$
$$Prob > chi2 = 0{,}000$$

We see that the test gives us reasons to reject the null hypothesis and accept that the dataset is suffering from heteroscedasticity. The thesis must counter for this, there are more than one way to do so. Since we have a price variable as the dependent variable this thesis have chosen to use a logarithmic format of the dependent variable, and by introducing the lag variable to reduce the problem of heteroscedasticity (Wooldridge, 2013). Meaning that now the interpretation of the coefficients tells us some about the percentage effect on the weekly average Brent Crude spot price instead of in absolute units of the dollar currency. The thesis also note that since there is a logarithmic term at both sides of the regression the results must be interpreted as a log-log approach (Wooldridge, 2013).

5. Results of analysis

After presenting the dataset, the variables and doing a univariate analysis based on the assumptions of multilinear regression the results of the regression must be presented.

5.1 Multilinear regression

The regression model that is run now looks like this, where $lWBCSP$ and $lWBCSP_{MA30_{LAG}}$ is the natural logarithmic of $WBCSP$ and $WBCSP_{MA30_{LAG}}$:

$$lWBCSP = \beta_0 + \beta_1 * GPRT_{MA7} + \beta_2 * lWBCSP_{MA30_{LAG}} + +\beta_3 * GULFW1D + \beta_4 * GULFW2D + \beta_5 * IRAQWD + \beta_6 * LIBYAWD + +\beta_7 * YEMENWD + \beta_8 * CRIMRUWD + \beta_9 * USSYRWD + \beta_{10} * RUSSIAWD + \beta_{11} TFE_{89n90} + \cdots + \beta_{27} * TFE_{21n22} + u$$

Table 3: Regression results

lWBCSP	Coeff.	Std.Err	*t* - value	*p* - value	95% confidence interval	
					Min.	Max.
GPRT_MA7	-0.0000676	0.0000385	-1.76	0.079	-0.0001432	7.90e-60
lWBCSP_MA30_LAG	0.9522156	0.0085336	111.58	0.000	0.9354787	0.9689525
GULFW1D	0.3441146	0.0716489	4.80	0.000	0.2035902	0.484639
GULFW2D	0.0100019	0.0717708	0.14	0.889	-0.1307617	0.1507655
IRAQWD	-0.1751931	0.0721461	-2.43	0.015	-0.3166928	-0.0336934
YEMENWD	-0.0338695	0.0716676	-0.47	0.637	-0.1744306	0.1066916
CRIMRUWD	0.0326116	0.0716275	0.46	0.649	-0.1078709	0.1730941
USSYRWD	0.0522494	0.0716468	0.73	0.466	-0.0882709	0.1927698
RUSSIAWD	0.1613923	0.0720814	2.24	0.025	0.0200195	0.3027651
SEASONS						
Reference: Summer						
2 (Spring)	0.0030324	0.0047782	0.63	0.526	-0.006339	0.0124039
3 (Fall)	-0.0030019	0.0049411	-0.61	0.545	-0.0126692	0.006688
4 (Winter)	-0.0105844	0.004617	-2.29	0.023	-0.019492	-0.0014114
Constant	0.1368035	0.0251209	545	0.000	0.087534	0.1860729

Observations = 1 817, $R^2 = 0.9899$

See the appendix for a table including the results from the time fixed effect variables.

First let's look at the lag variable "lWBCSP_MA30_LAG" that is put into the regression. We see that this variable has a high estimated coefficient and is significant. Letting us know that the average price level of the last month has a high estimated explanatory effect on the weekly average of the Brent Crude spot price. By interpreting the estimated coefficient the thesis can claim that when the previous monthly average spot price change with 1% it will yield approximately a 0.95% change in the weekly average spot price of Brent Crude in the same direction. We see that the lag variable has a high *t*-value, and that the *p*-value is approximately zero. Giving us reason to reject the null hypothesis that the lag variable "lWBCSP_MA30_LAG" have no significant effect on the dependent variable.

Moving unto the geopolitical tension variable "GPRT_MA7", here we see that there is a weak negative coefficient. The negative coefficient holds up with Antonakakis (2016), Li et al (2020) and Cunados (2020) finding that over time geopolitical risk/tension will have a negative demand effect on the price of crude oil from the uncertainty that comes with increased geopolitical risk. I have chosen to only have the geopolitical tension index, which is slightly different from what Antonakakis (2016) and Cunados (2020) did. Singling out some of the major weeks of acts of war during the period will have affected some important cycles in the geopolitical index. As well the dataset this thesis uses contains datapoint from future periods of time unavailable for them during their research. We see here that the finding is not significant. Meaning that we cannot reject the null hypothesis that rising geopolitical tension alone will have a negative effect on the price of Brent Crude.

Now let's look at what the analysis tells us about the war dummies. At first glance we see that 6 out of 8 of the dummies have a positive coefficient which fit well with the theoretical background presented above, 3 out of the 8 have a significant effect. Which is the Iraq war dummy "IRAQWD", the first Gulf war dummy "GULFW1D" and the Russian war dummy "RUSSIAWD" for the Russian invasion of Ukraine.

The Iraq war dummy have a negative coefficient that show us the week of the official start of the Iraq war had a negative 17,5% estimated effect on the weekly average spot price level of the Brent Crude during the same period.

The war dummy for the first phase of the Gulf war "GULF1WD" has a positive coefficient, and the effect of the start of the war was almost double as strong as the one found during the start of the Iraq war, all else equal. Here we see that the week of the start of the Gulf War gave a positive 34.4% estimated effect on the short term weekly average spot price level of the Brent Crude during the same period.

The dummy of the Russian invasion of Ukraine "RUSSIAWD" shows that the start of the war created a positive 16.1% effect on the weekly average price level of Brent Crude spot price, all else held constant. This is significant when using a 95% confidence interval, had it been 99% confidence interval it would not have been counted as significant.

These findings alone let us reject the null hypothesis that there is no significant effect on the weekly average Brent Crude spot price from the start of an international act of war with a 5% significance level.

Not all the war-dummies had a significant short-term effect on the price level of crude oil, this is like the findings of Noguera-Santaella (2016) who found that the difference in significant effect was most notably with the wars before and after the 21st century. The findings of this thesis goes partly against this conclusion. Finding that the start of the Iraq war and the Russian war here have a significant effect on the short-term price of Brent Crude, both being after the start of the 21st century.

The war dummies that did not show a significant effect was the Libyan war "LIBYAWD", Yemen war "YEMENWD", US airstrike on Syrian government forces "USSYRWD", the second phase of the Gulf war "GULFW2D", and the Russian annexation of Crimea "CRIMRUWD", all else equal.

The Yemen war dummy show a negative coefficient, while the other show a positive coefficient. The coefficients are all to be considered as weak, and non-significant.

This difference between the unique acts of war and the significance they have on the short term weekly average Brent Crude spot price is interesting, as well as the indication that

geopolitical tension might have a significant negative effect on the Brent Crude spot price in the long term.

The last control variable to be mentioned here is the seasonal dummies. These are all in relation to the summer season. We see that spring have a weak positive coefficient that is non-significant, and that fall have a weak negative coefficient also non-significant. While the winter seasons have a significant negative coefficient, implying that during winters the weekly average Brent Crude spot price is estimated to have negative 1.5% effect on the price of Brent Crude in comparison to the summer seasons. This is in thread with theory of an increase in demand of crude oil for transportation during spring/summer, and a reduction in transportation and aggregate demand late fall/winter time (Quayyoum et al., 2020).

5.2 Critique of the dataset and its robustness

When going through the dataset and how it fits with the different assumptions that need to be kept the thesis have already shun light on some of the clear restrictions that come from the type of data and regression that is used in this thesis.

Timeseries data especially often have problems with the assumptions of non-heteroscedasticity and random sampling (Wooldridge, 2013). The thesis has chosen to counter this by the use of logarithmic value and adding a lag variable, but could also have used other approaches like a robust regression (Wooldridge, 2013) that might have been better in effort to counter for false standard errors as a symptom of heteroscedasticity.

This leads to another weakness in the model, time fixed effects are used to model for all major variances that have happened across time from 1987 until 2022. This was done based on not finding good weekly datasets on control variables such as production level, consumption, level of crude inventories and transportation costs, and refining costs of Brent Crude. These time fixed effects will include all changes across time, but does not give us a concrete picture of what these changes are. Since the thesis is mostly interested in the direct effect of the start of an international act of war in the short term this have been accepted.

If we are more interested in these concrete control variables and the effect they have together with geopolitical tension and acts of war on the price of Brent Crude they should be added, it

could be an idea to replicate Ye et al's model for forecasting crude oil spot prices through the use of inventory levels (Ye et al., 2005) adding the geopolitical risk index and war dummies.

The time fixed effects and lag variable also give us a very high explanatory level "R^2" which masks what explanatory level lie behind our variables of interest.

If it is so that Brent Crude is priced more like a financial asset, we should also have added variables that told us something of pricing of different financial instruments (futures, options, etc) connected to Brent Crude. As well as data on risk and volume of trade. Which would be in thread with classic financial theory.

The coding of the war dummy variables might also have given us a more interesting picture of how the price of Brent Crude shifts with war if the variables rather would be for the week *after* the official start of an international act of war, and not for the same week as the official date. As it is logical to think the market would take some days to experience supply and demand shocks from these types of events.

It could also have been interesting putting in interaction-variables between the war dummies and the geopolitical tension index. To see if the effect of an act of war on the spot price of Brent Crude was decided in part by what the status quo of global level of geopolitical tension was.

Something that needs to be considered as a weakness of the model is the idea that there could be a mutual relationship between the price of Brent Crude (explained variable) and geopolitical tension (explanatory variable). Meaning that the coefficients from the regression might be somewhat wrong, since the influence of the price level of Brent Crude might be a factor that can spur acts of war (Le Billon & Cervantes, 2009).

A last consideration to be added is the oligopolistic aspect of the crude oil market which is not added in the model specifically, where there is an asymmetry in cost of production and by that market power between market actors. Especially is this valid for the producers from states in the Middle East that experience vastly lower cost of production than other crude oil producers. This gives them market power to reduce and increase production without crippling costs, while other producers do not enjoy the same freedom from their cost of production. The

best example of the oligopolistic characteristic of the crude oil market is the Organisation for Petroleum Exporting Countries or "OPEC" (Mileva & Siegfried, 2012). There is debate over how much market power OPEC actually do have over the crude oil market in the long term (Kaufmann et al., 2004). But if the short-term price level of Brent Crude is decided by a few market suppliers the price of crude oil might be manipulated in certain acts of war, and in others not.

6. Discussion and Conclusion

There are some clear weaknesses with the regression analysis and the results, based on the assumptions not being upheld and the timeseries aspect of the data. Therefore, the empirical results need to be viewed in comparison to other similar research topics using different statistical tools than in this thesis, and with proper skepticism.

6.1 Discussion

From our regression we found that some acts of war do have a direct significant effect on the weekly average price level of Brent Crude, while others did not. This makes us reject the null hypothesis of the thesis in some cases but not in all. The discussion will use the presented theoretical background to explore what can be behind the significant effects on the price of Brent Crude found from the regression analysis.

First it is important to point out that all wars are unique, and from the geopolitical risk index we see that their impact on the world around varies. Some will have a higher degree of mentions, and intensity than others (Board of Governors of the Federal Reserve System et al., 2018). It is also important to see which states participate in the act of war. In the three acts of war that have a significant effect on the price level of Brent Crude all include major actors of the global crude oil market. But this is also true for the war dummies that did not yield a significant effect.

How does our results correspond with the law of supply and demand, should maybe the theoretical background borrow more from financial theory and build itself a more complex pricing model for Brent Crude?

6.1.1 Law of supply and demand Gulf War (1990 and 1991)

The first phase of the Gulf War was Iraq's invasion of Kuwait, Iraq and Kuwait both have large reserves of crude oil (*International - U.S. Energy Information Administration (EIA)*, 2016), and are major producers of crude oil (Mileva & Siegfried, 2012). The invasion and annexation of Kuwait from Iraq, another major oil producing country might be some of the reason for the significant effect in the price level of Brent Crude. Iraq would gain stronger market power over the crude oil market and try to increase the crude oil price, something the Iraqi government were vocal about wanting (Gause, 2002). Another aspect is that Kuwait's oil production is mostly landbased, meaning that military operations on land in Kuwait will have a higher chance of affecting the production of crude oil, increasing the risk of disruption to the oil supply.

From the law of supply and demand this significant effect could be explained by a market actor with a suddenly increased market power and market share forcing a reduction in production (supply), and thereby increasing the market price. As well as a possible disruption in crude oil production from military operations.

6.1.2 Financial theory Gulf War (1990 and 1991)

Another possibility for the significant effect that might point crude oil pricing to have similar attributes as a financial asset is that the market actors had to suddenly change their future expectations. The market actors might believe that Iraq would reduce production, and in the short term there would be imposed economic sanctions from the international community on Iraq that might affect the global supply of crude oil. The future expectations of the market actors would be reflected in the spot price, even if the actual supply and demand effects did not directly affect the market before the near future. The added uncertainty would have to be compensated for with a risk-premium in the spot price (Considine & Larson, 2001). This does not go against Kolodziej et al's conclusion of the pricing of crude in the long term converging into reflection the status of market supply and demand (Kolodziej et al., 2014), but gives an understanding of that in the short term the pricing of crude oil can be more similar to that of financial assets.

The markets future expectations would be influenced by increased uncertainty. Not only did Iraq invade and annex Kuwait, significantly increasing their market share in the crude oil market. But there was uncertainty in the market whether Iraq would soon launch an invasion

of Saudi-Arabia in effort of securing an even larger market share, and removing a unfriendly neighboring state, which would again create a major shift in the market (Barbarani, 2021). This can be an explanation for why there is such a positive significant effect on the price of Brent Crude for the first Gulf War Dummy "GULFW1D".

6.1.3 Mutual influence Gulf War (1990 and 1991)

Now this last aspect makes us think back to one of the flaws of the model, the mutual influence between the price of crude oil and acts of war. There are claims that one of Iraq's biggest motivations for the invasion of Kuwait, and a possible further escalation into Saudi-Arabia was their crude oil reserves and production (Gause, 2002). The attractiveness of the ownership of the reserves and production facilities in Kuwait would be highly correlated with the price of crude oil. This will make us question our results and if the increase in the price of Brent Crude was an important factor that made Iraq invade Kuwait.

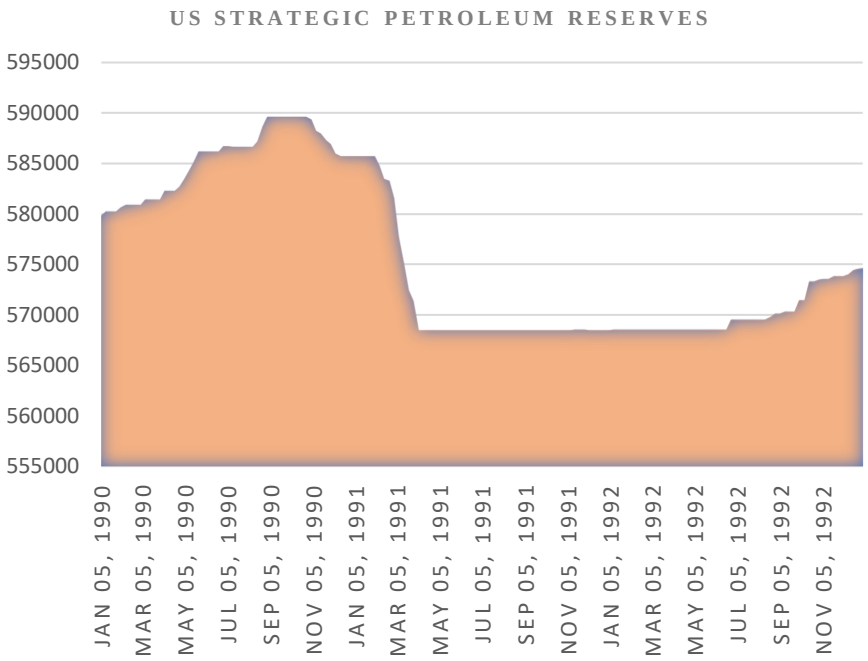
Connected to this is the second phase of the Gulf war, which was the UN sanctioned intervention of Iraq's annexation of Kuwait. That was led by US-troops. This phase started first approximately 8 months after the annexation of Kuwait. And there were some important differences between the two acts of war. Where the date of Iraq's invasion of Kuwait was unknown and therefor unforeseen for many of the actors of the crude oil market who did not have time to proactively adjust for future expectations (Gause, 2002). The US led coalitions act of war against Iraq in Kuwait was publicly known with a set date of 16th of January 1991 (*Chap VII SRES 678.pdf*, 1990). So, the market would have had time to add this to their future expectations.

From the law of supply and demand the aggregate demand and aggregate supply for Brent Crude should have shifted following the escalation and deployment of troops into Kuwait. At the same time the market might have already adjusted to the change in supply and demand following Iraq's invasion of Kuwait, especially those from the economic sanctions laid on Iraq's government (Alnasrawi, 2001). This might also be true for the increase in aggregate demand from the US led coalition, the gradual buildup of forces, and not a sudden significant shift.

Another explanation connected to the law of supply and demand is that the US, as well as other nations in the coalition had strategic reserves of crude oil. Created solely for situations

where there is a massive change in aggregate demand for crude oil, and a high risk for a disruption of aggregate supply of crude oil in the market. Which was true in case of the invasion of Iraq in Kuwait. The use of these strategic reserves might counter the effects this act of war had on the market.

Figure 11: US SPR (Strategic Petroleum Reserves) from 1990 - 1993



From the figure of the US SPR we see that there is a clear negative trend from the start of 1991, meaning that in the period of launching a military assault against Iraq in Kuwait the US reduced their strategic reserves of crude oil. Giving us a reason for why there is no significant effect to be found at the start of Operation Desert Shield.

Demirer and Kutan (2010) look closer on the use of SPR's and their effect on the price of crude oil (Demirer & Kutan, 2010). Their conclusion is that the announcement of SPR's will have a stability effect on the market lasting approximately one week. Now Demirer and Kutan's conclusion is maybe better understood when looking at the crude oil market as a financial market, as it seems to be the announcement of using the SPR's that have a significant stability effect on the market and not the actual increase of short-term supply of crude oil alone.

The use of SPR's to mitigate for short-term shifts in the global crude market might be a reason for some of the non-significant findings in our model, the thesis will not go further into this but notes that it could be of interest to control for the use of SPR's.

6.1.4 Law of supply and demand Iraq War (2003)

After discussing how our results from the two Gulf War dummies points toward the price level of Brent Crude working with the law of supply and demand, financial theory or it being

a result of mutual effects let's look closer with the same theoretical premise on the war dummy for the Iraq War "IRAQWD".

The Iraq war also have a significant effect on the weekly average price level of Brent Crude, but in the opposite direction of the Gulf War dummy "GULFW1D", here creating a negative 17,5% effect on the price level of Brent Crude, all else held equal.

From the use of the law of supply and demand how can this negative shift in the price be understood. First let's think back to the Gulf War, since it Iraq was imposed with strict economic sanctions (Alnasrawi, 2001). Reducing their actual supply into the global crude market, this can be one of the reasons for why the impact of the start of the Iraq War was less then that of the Gulf War. A disruption of the supply from Iraq's crude production would be of less quantity than before.

Jaff and Elass (2016) notes in their article that the Saudi Arabian government, who own and operate the worlds single largest petroleum company "Aramco", increased the supply of oil drastically before US invasion of Iraq. Both in effort to make crude oil easily available for the US, and as a tool of reducing Iraq's war chest (Jaff and Elass, 2016). This would create a positive aggregate supply shift and reduce the price of crude oil in the short term.

6.1.5 Financial theory Iraq War (2003)

Before the Iraq war started the US experienced a great amount of political resistance for approving the launch of an invasion of Iraq, the US government had also failed in effort of getting UN's approval for an impeding invasion of Iraq. Zhang et al found that the Iraq War had been anticipated and the uncertainty incorporated into the price of Brent Crude before the actual start of the Iraq War, Zhang et al (2009) also notices that by the time the Iraq War started the volume of speculation by financial investors in the crude market had gone up (Zhang et al., 2009). Increasing volatility of the price and removing the law of supply and demand being the main determinant for the pricing in the crude oil market in the short term.

If this is the case, we can understand the negative impact from the start of the Iraq War to come from the market actors adjusting their expectations down, and reducing the price of Brent Crude, when the war started. According to Looney (2003) this is what happened (Looney, 2003). Looney (2003) proposes that build-up to the Iraq War saw a "war premium"

in the crude market following growing uncertainty. Then when nearing the actual act of war, the market shifted to an optimistic view of the Iraqi oil rigs to not be damaged by the invasion, and that the invasion of Iraq would in sum over the long term see the economic sanctions on the Iraqi government lifted and Iraq could again increase production of crude oil. Creating an outwards shift of the aggregate crude oil supply in sum reducing the prices in the long term.

Looney's and Zhang et al views both support a view of the crude oil market being speculative and behaving like a financial market in the short term, but in the long term expressing the law of supply and demand.

6.1.6 Mutual influence Iraq War (2003)

The results from the regression seems to show the same effect on the price of Brent Crude as Zhang et al and Looney found, but we still have to entertain the idea that there is a mutual influence between the act of war and the price of crude oil here as well. From Jaff and Elass (2016) we see that there are clear ties between Saudi-Arabia, the US and the production of crude oil through Aramco (Jaff & Elass, 2016). Making it so we cannot remove the thought of the price of Brent Crude being influential in deciding when the US would invade Iraq. Nordhaus (2002) also mention in his paper, written before the US invasion of Iraq, of the economic consequences and implications for the US of an invasion of Iraq. Mentioning oil reserves to be an important factor for the US to consider (Nordhaus, 2002).

6.1.7 Law of supply and demand Russian invasion of Ukraine (2022)

Let's use the same lens looking at the significant shift in price of Brent Crude during the week of Russia invading Ukraine. The weekly average spot price of Brent Crude increased with an estimated 16,14% during the first week of the invasion when looking at the coefficient of "RUSSIAWD". The effect is nearly equal to the effect of the US invasion of Iraq, just in the opposite direction.

From the law of supply and demand we can start by pointing toward a negative supply shock happening fairly soon after the start of the invasion, originating from the international economic sanctions, both from states and international companies following the invasion («Tracking Sanctions against Russia», 2022). Maybe the most prominent being BPs exit out

of the Russian co-owned “Rosneft”, and the sanction of kicking Russian banks out of the international payment system “Swift” (Elsherbiny, 2022).

The crude market would get a sudden negative shift in the aggregate supply, increasing the market spot price from the sudden demand surplus.

At the same time Russian petroleum facilities is located both near Ukraine borders, as well as in Ukraine. It is claimed that petroleum associated facilities both in Russian and Ukraine have been strategic military targets during the invasion, but this is not recorded before more than a week into the invasion (*Russia hits key Ukrainian oil facilities in Odesa and Kremenchuk | Russia-Ukraine war News | Al Jazeera*, 2022) and therefore is not expected to be part of the direct effect on supply in the crude oil market.

6.1.8 Financial theory Russian invasion of Ukraine (2022)

Adekoya et al (2022) look at the connection between crude oil and wars, focusing on data from the Russo-Ukraine war. Finding that financial investors could get a safer return by investing in financial assets connected to crude oil during periods of war, especially at the start of wars (Adekoya et al., 2022). If we look at the crude market as having financial market attributes from Adekoya et al (2022) rational investors would then increase their demand for crude oil in effort of reducing risk, prompting an increase in the price of Brent Crude. At the same time, we can remember the “war premium” by Looney (2003) discussed above. This could have a positive effect on the price of Brent Crude especially in the case of a war between Russia and Ukraine not “freeing” new significant supplies of crude oil to the market, as was the beliefs from the US invasion of Iraq. But rather market actors adding a premium following uncertainty of further sanctions, and possible escalation of war to include petroleum facilities.

The Russian invasion of Ukraine was well anticipated and announced (H. Cooper & Schmitt, 2022) by the US and NATO, but still delivered a significant shock to the market. This is the same as the US invasion of Iraq, telling us that future expectations in the market might not always match future actual price levels.

6.1.9 Mutual influence Russian invasion of Ukraine (2022)

In this significant finding it is harder to pinpoint a possible mutual influence between the price of crude oil and the act of war. Russia has pipelines for gas and petroleum going through Ukraine, the importance of controlling these pipelines will increase with the price of crude oil. But at the same time Ukraine is a net-importer of gas and petroleum, where Russia is their biggest exporters. Which would decrease Russia's willingness for attacking them (*International - U.S. Energy Information Administration (EIA)*, 2021).

6.2 Conclusion

From the results of the regression the thesis has found that some acts of war seem to have a significant direct effect on the short term weekly average spot price of Brent Crude, but that these direct effects can be in opposite directions. As well as finding that other acts of war seem to have a non-significant direct effect. The duality on the significance of the effect on the price leaves room to further investigate what can be behind this, it suggests that the economic effect of an act of war is complex and unique for each single act of war. Maybe would other control variables, or statistical tools, be better in effort of analyzing the direct short-term effect an act of war have on the spot price of Brent Crude.

The thesis has used theoretical background from the law of supply and demand, as well as basic financial theory, in effort to partially explain the three different significant effects proven from the regression and how the results hold up with previous empirical literature. There needs to be further testing to look at the different attributes in the crude oil market, and for these specific market events, for why they in sum have created the three significant and five non-significant results from our regression.

The thesis has tried to give some reasoning using the same theoretical background for one of the five non-significant findings, in effort of giving the reader a view of how the economics of a war might not be shown in the results of the regression even if there are shocks to the market following an act of war, as these shocks might cancel each other out.

The thesis shown that the pricing model for the spot price of Brent Crude is a topic of debate, where it is possible to see the pricing model to be that of classical supply and demand, just financial theory, or a combination of these two. The thesis aim is not to conclude on any of

these to be correct or not but make the reader understand the complexity of the pricing of crude oil alone.

For controlling and showing geopolitical tension the thesis have used the geopolitical risk index by Caldara and Iacaviello and (*Geopolitical Risk (GPR) Index*, 2022). The result of the regression shows a negative effect of geopolitical tension on the long-term spot price of Brent Crude, this finding is not significant with a 5% significance level. But other studies using the same index find a significant negative relation between geopolitical risk and the spot price of crude oil. This index is an interesting tool in calculating and controlling for geopolitical risk when building an econometric model.

References

About us. (2022). Retrieved 27 April 2022, from https://www.refinitiv.com/en/about-us

Adekoya, O. B., Oliyide, J. A., Yaya, O. S., & Al-Faryan, M. A. S. (2022). Does oil connect differently with prominent assets during war? Analysis of intra-day data during the Russia-Ukraine saga. *Resources Policy*, *77*, 102728. https://doi.org/10.1016/j.resourpol.2022.102728

Affairs, M. of F. (2022, April 29). *New sanctions against Russia incorporated into Norwegian law* [Pressemelding]. Government.No; regjeringen.no. https://www.regjeringen.no/en/aktuelt/new-sanctions-against-russia-incorporated-into-norwegian-law/id2910809/

Alnasrawi, A. (2001). Iraq: Economic sanctions and consequences, 1990–2000. *Third World Quarterly*, *22*(2), 205–218. https://doi.org/10.1080/01436590120037036

Anderson, D. R. (2020). *Essentials of modern business statistics with Microsoft Excel*.

Barbarani, S. (2021). *Decades after the Gulf War, Iraq's youth view oil as a curse*. Retrieved 4 May 2022, from https://www.aljazeera.com/economy/2021/2/26/decades-after-the-gulf-war-iraqs-youth-view-oil-as-a-curse

Board of Governors of the Federal Reserve System, Caldara, D., & Iacoviello, M. (2018). Measuring Geopolitical Risk. *International Finance Discussion Paper*, *2018*(1222), 1–66. https://doi.org/10.17016/IFDP.2018.1222

Brent: The world's crude benchmark. (2022). Retrieved 15 April 2022, from https://www.theice.com/insights/market-pulse/brent-the-worlds-crude-benchmark

Chap VII SRES 678.pdf. (2001). Retrieved 4 May 2022, from https://www.securitycouncilreport.org/atf/cf/%7B65BFCF9B-6D27-4E9C-8CD3-CF6E4FF96FF9%7D/Chap%20VII%20SRES%20678.pdf

Considine, T. J., & Larson, D. F. (2001). Risk premiums on inventory assets: The case of crude oil and natural gas. *Journal of Futures Markets*, *21*(2), 109–126. https://doi.org/10.1002/1096-9934(200102)21:2<109::AID-FUT1>3.0.CO;2-A

Cooper, H., & Schmitt, E. (2022, January 28). Russia Is Positioned to Invade All of Ukraine, U.S. Says, but Kyiv Downplays War Talk. *The New York Times*. https://www.nytimes.com/live/2022/01/28/world/ukraine-russia-news

Cooper, J. C. B. (2003). Price elasticity of demand for crude oil: Estimates for 23 countries. *OPEC Review*, *27*(1), 1–8. https://doi.org/10.1111/1468-0076.00121

Crude oil prices rise above $100 per barrel after Russia's further invasion into Ukraine—Today in Energy—U.S. Energy Information Administration (EIA). (2022). Retrieved 7 March 2022, from https://www.eia.gov/todayinenergy/detail.php?id=51498

Demirer, R., & Kutan, A. M. (2010). The behavior of crude oil spot and futures prices around OPEC and SPR announcements: An event study perspective. *Energy Economics*, *32*(6), 1467–1476. https://doi.org/10.1016/j.eneco.2010.06.006

Dunn, S., & Holloway, J. (2012). *The Pricing Of Crude Oil*. 10.

Elsherbiny, A. (2022). *Europe on Fire: The Russo-Ukrainian War, Its Causes and Consequences* (SSRN Scholarly Paper No. 4058711). Social Science Research Network. https://doi.org/10.2139/ssrn.4058711

Fattouh, B. & Oxford Institute for Energy Studies. (2011). *An anatomy of the crude oil pricing system*. Oxford Institute for Energy Studies.

Fudenberg, D., & Tirole, J. (1991). *Game Theory*. MIT Press.

Gause, F. G. (2002). Iraq's Decisions to Go to War, 1980 and 1990. *Middle East Journal*, *56*(1), 47–70.

Geopolitical Risk (GPR) Index. (2022). Retrieved 15 April 2022, from https://www.matteoiacoviello.com/gpr.htm

Girma, P. B., & Paulson, A. S. (1999). Risk arbitrage opportunities in petroleum futures spreads. *Journal of Futures Markets*, *19*(8), 931–955. https://doi.org/10.1002/(SICI)1096-9934(199912)19:8<931::AID-FUT5>3.0.CO;2-L

Goss, B. A., & Yamey, B. S. (1976). *The Economics of futures trading: Readings*. Macmillan. http://books.google.com/books?id=KGIUAQAAMAAJ

Homepage—U.S. Energy Information Administration (EIA). (2022). Retrieved 27 April 2022, from https://www.eia.gov/index.php

How reliant is the world on Russia for oil and gas? (2022, May 4). *BBC News*. https://www.bbc.com/news/58888451

International—U.S. Energy Information Administration (EIA). (2016, November 2nd). Retrieved 6 May 2022, from https://www.eia.gov/international/overview/country/KWT

International—U.S. Energy Information Administration (EIA). (2021, August 1st). Retrieved 6 May 2022, from https://www.eia.gov/international/analysis/country/UKR

Jacobsen, D. I. (2015). *Hvordan gjennomføre undersøkelser?: Innføring i samfunnsvitenskapelig metode*. Cappelen Damm akademisk.

Kaufmann, R. K., Dees, S., Karadeloglou, P., & Sanchez, M. (2004). Does OPEC Matter? An Econometric Analysis of Oil Prices. *The Energy Journal*, *25*(4). https://doi.org/10.5547/ISSN0195-6574-EJ-Vol25-No4-4

Kilian, L. (2010). *Oil price volatility: Origins and effects* (Working Paper ERSD-2010-02). WTO Staff Working Paper. https://doi.org/10.30875/9b9f6bc8-en

Kolodziej, M., Kaufmann, R. K., Kulatilaka, N., Bicchetti, D., & Maystre, N. (2014). Crude oil: Commodity or financial asset? *Energy Economics*, *46*, 216–223. https://doi.org/10.1016/j.eneco.2014.09.006

Krichene, N. (2002). World crude oil and natural gas: A demand and supply model. *Energy Economics*, *24*(6), 557–576. https://doi.org/10.1016/S0140-9883(02)00061-0

Le Billon, P., & Cervantes, A. (2009). Oil Prices, Scarcity, and Geographies of War. *Annals of the Association of American Geographers*, *99*(5), 836–844. https://doi.org/10.1080/00045600903245730

Li, F., Huang, Z., Zhong, J., & Albitar, K. (2020). Do Tense Geopolitical Factors Drive Crude Oil Prices? *Energies*, *13*(16), 4277. https://doi.org/10.3390/en13164277

Looney, R. E. (2003). OIL PRICES AND THE IRAQ WAR: MARKET INTERPRETATIONS OF MILITARY DEVELOPMENTS. *The Journal of Energy and Development*, *29*(1), 25–41.

Mileva, E., & Siegfried, N. (2012). Oil market structure, network effects and the choice of currency for oil invoicing. *Energy Policy*, *44*, 385–394. https://doi.org/10.1016/j.enpol.2012.02.002

NASA - Landsat Top Ten—Kuwait Oil Fires. (2012). [Other]. Brian Dunbar. Retrieved 14 May 2022, from https://www.nasa.gov/mission_pages/landsat/news/40th-top10-kuwait.html

Noguera-Santaella, J. (2016). Geopolitics and the oil price. *Economic Modelling*, *52*, 301–309. https://doi.org/10.1016/j.econmod.2015.08.018

Nordhaus, W. D. (2002). *The Economic Consequences of a War in Iraq* (Working Paper No. 9361; Working Paper Series). National Bureau of Economic Research. https://doi.org/10.3386/w9361

OECD: Oil demand share by sector. (2020). Statista. Retrieved 15 April 2022, from https://www.statista.com/statistics/307194/top-oil-consuming-sectors-worldwide/

Pindyck, R. S. (2013). *Introduksjon til mikroøkonomi.* Pearson.

PRIO Battledeaths Dataset – Peace Research Institute Oslo. (2017). Retrieved 15 April 2022, from https://www.prio.org/data/1

Quayyoum, S., Khan, M. H., Shah, S. Z. A., Simonetti, B., & Matarazzo, M. (2020). Seasonality in crude oil returns. *Soft Computing*, *24*(18), 13547–13556. https://doi.org/10.1007/s00500-019-04329-0

Ramey, V. A. (2011). Identifying Government Spending Shocks: It's all in the Timing*. *The Quarterly Journal of Economics*, *126*(1), 1–50. https://doi.org/10.1093/qje/qjq008

Russia hits key Ukrainian oil facilities in Odesa and Kremenchuk | Russia-Ukraine war News | Al Jazeera. (2022). Retrieved 6 May 2022, from https://www.aljazeera.com/news/2022/4/3/russia-hits-oil-facilities-ukraine-odesa-kremenchuk

Spot Prices for Crude Oil and Petroleum Products. (2022). Retrieved 27 April 2022, from https://www.eia.gov/dnav/pet/pet_pri_spt_s1_d.htm

Statistical Review of World Energy | Energy economics | Home. (2021). Bp Global. Retrieved 15 April 2022, from https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html

Tracking sanctions against Russia. (2022). *Reuters*. Retrieved 6 May 2022, from https://graphics.reuters.com/UKRAINE-CRISIS/SANCTIONS/byvrjenzmve/

War and the Oil Price Cycle. (2016, January 1). JIA SIPA. https://jia.sipa.columbia.edu/war-oil-price-cycle

Wooldridge, J. M. (2013). *Introductory econometrics: A modern approach* (5th ed). South-Western Cengage Learning.

Ye, M., Zyren, J., & Shore, J. (2005). A monthly crude oil spot price forecasting model using relative inventories. *International Journal of Forecasting*, *21*(3), 491–501. https://doi.org/10.1016/j.ijforecast.2005.01.001

Yergin, D. (2009, October). It's Still the One. *Foreign Policy, 174*, 89-95,8.

Zhang, X., Yu, L., Wang, S., & Lai, K. K. (2009). Estimating the impact of extreme events on crude oil price: An EMD-based event analysis method. *Energy Economics, 31*(5), 768–778. https://doi.org/10.1016/j.eneco.2009.04.003

Appendix

Table 4: Complete regression results

Source	SS	df	MS	Number of obs =	1,817	
				F(30, 1786) =	5824.84	
Model	886.493477	30	29.5497826	Prob > F =	0.0000	
Residual	9.06048661	1,786	.005073061	R-squared =	0.9899	
Total	895.553964	1,816	.493146456	Root MSE =	.07123	
				Adj R-squared =	0.9897	
lWBCSP	**Coefficient**	**Std. err.**	**t**	**P>t**	**[95% conf. interval]**	
lWBCSP_MA30_LAG	.9522156	.0085336	111.58	0.000	.9354787	.9689525
GPRT_MA7	-.0000676	.0000385	-1.76	0.079	-.0001432	7.90e-06
GULFW1D	.3441146	.0716489	4.80	0.000	.2035902	.484639
GULFW2D	.0100019	.0717708	0.14	0.889	-.1307617	.1507655

IRAQD	-.1751931	.0721461	-2.43	0.015	-.3166928 -	.0336934
LIBYAD	.0163407	.0716632	0.23	0.820	-.1242118	.1568932
YEMEND	-.0338695	.0716676	-0.47	0.637	-.1744306	.1066916
CRIMRUWD	.0326116	.0716275	0.46	0.649	-.1078709	.1730941
USSYRD	.0522494	.0716468	0.73	0.466	-.0882709	.1927698
RUSSIAD	.1613923	.0720814	2.24	0.025	.0200195	.3027651
SEASONS Reference: 1 (Summer)						
2 (Spring)	.0030324	.0047782	0.63	0.526	-.006339	.0124039
3 (Fall)	-.0029906	.0049348	-0.61	0.545	-.0126692	.006688
4 (Winter)	-.0104517	.0046094	-2.27	0.023	-.019492	-.0014114
Reference: TF 87n88						
TFE_89n90	.0266597	.0107889	2.47	0.014	.0054995	.0478198
TFE_91n92	.0071914	.0108048	0.67	0.506	-.014	.0283829
TFE_92n94	.0044258	.0106205	0.42	0.677	-.0164041	.0252556
TFE_95n96	.0210346	.0106623	1.97	0.049	.0001227	.0419465
TFE_97n98	-.0189509	.0106822	.1,77	0.076	-.0399018	.002
TFE_99n00	.0401368	.0109712	3.66	0.000	.0186191	.0616544
TFE_01n02	.0269459	.0111772	2.41	0.016	.0050242	.0488677
TFE_03n04	.0512141	.0122031	4.20	0.000	.0272801	.075148
TFE_05n06	.0762383	.0152584	5.00	0.000	.0463122	.1061645
TFE_07n08	.0702372	.0175625	4.00	0.000	.0357921	.1046824
TFE_09n10	.0924807	.0162484	5.69	0.000	.0606128	.1243487
TFE_11n12	.0998619	.0196839	5.07	0.000	.0612561	.1384677
TFE_13n14	.0799681	.0191976	4.17	0.000	.0423159	.1176203
TFE_15n16	.0528608	.0140558	3.76	0.000	.0252932	.0804283
TFE_17n18	.0703147	.0155882	4.51	0.000	.0397416	.1008878
TFE_19n20	.05384	.014454	3.72	0.000	.0254915	.0821884
TFE_21n22	.107018	.0173426	6.17	0.000	.073004	.1410319
cons	***.1368035***	***.0251209***	***5.45***	***0.000***	***.087534***	***.1860729***

Table 5: Complete summary of all variables.

Variable	**Obs**	**Mean**	**Std. dev.**	**Min**	**Max**
Date	1,817	16394	3672.669	10038	22750
WBCSP	1,817	47.65888	32.40552	9.44	141.07
WBCSP_MA30~G	1,817	47.53648	32.29031	9.74	137.2725

GPRT_MA7	1,817	100.5294	49.25081	29	592
IRAQD	1,817	.0005504	.0234597	0	1
LIBYAD	1,817	.0005504	.0234597	0	1
RUSSIAD	1,817	.0005504	.0234597	0	1
YEMEND	1,817	.0005504	.0234597	0	1
USSYRD	1,817	.0005504	.0234597	0	1
SEASONS	1,817	2.5388	1.148528	1	4
TFE_87n88	1,817	.0440286	.2052152	0	1
TFE_89n90	1,817	.0572372	.2323592	0	1
TFE_91n92	1,817	.0572372	.2323592	0	1
TFE_92n94	1,817	.0572372	.2323592	0	1
TFE_95n96	1,817	.0577876	.2334055	0	1
TFE_97n98	1,817	.0572372	.2323592	0	1
TFE_99n00	1,817	.0572372	.2323592	0	1
TFE_01n02	1,817	.0572372	.2323592	0	1
TFE_03n04	1,817	.0572372	.2323592	0	1
TFE_05n06	1,817	.0583379	.2344459	0	1
TFE_07n08	1,817	.0572372	.2323592	0	1
TFE_09n10	1,817	.0577876	.2334055	0	1
TFE_11n12	1,817	.0566868	.2313069	0	1
TFE_13n14	1,817	.0577876	.2334055	0	1
TFE_15n16	1,817	.0577876	.2334055	0	1
TFE_17n18	1,817	.0572372	.2323592	0	1
TFE_19n20	1,817	.0561365	.2302485	0	1
TFE_21n22	1,817	.038525	.192513	0	1
GULFW1D	1,817	.0005504	.0234597	0	1
GULFW2D	1,817	.0005504	.0234597	0	1
CRIMRUWD	1,817	.0005504	.0234597	0	1
lWBCSP	1,817	3.624992	.7022439	2.244956	4.949256
lWBCSP_MA30G	1,817	3.62337	.7003841	2.276241	4.921968

Table 6: Correlation matrix (copied directly from STATA output)

	Date	WBCSP	WBCSP_~G	GPRT_MA7	IRAQD	LIBYAD	RUSSIAD	YEMEND	USSYRD	SEASONS	TFE_8~88	TFE_8~90	TFE_9~92	TFE_9~94	TFE_9~96	TFE_9~98
Date	1.0000															
WBCSP	0.7065	1.0000														
WBCSP_MA30~G	0.7067	0.9941	1.0000													
GPRT_MA7	0.0037	-0.0298	-0.0295	1.0000												
IRAQD	-0.0039	-0.0141	-0.0101	0.1275	1.0000											
LIBYAD	0.0148	0.0491	0.0476	0.0179	-0.0006	1.0000										
RUSSIAD	0.0404	0.0484	0.0357	0.0955	-0.0006	-0.0006	1.0000									
YEMEND	0.0242	0.0053	0.0072	0.0183	-0.0006	-0.0006	-0.0006	1.0000								
USSYRD	0.0289	0.0052	0.0027	-0.0003	-0.0006	-0.0006	-0.0006	-0.0006	1.0000							
SEASONS	-0.0196	-0.0476	-0.0448	0.0131	-0.0110	-0.0110	-0.0110	-0.0110	-0.0110	1.0000						
TFE_87n88	-0.3553	-0.2086	-0.2078	-0.0052	-0.0050	-0.0050	-0.0050	-0.0050	-0.0050	0.0091	1.0000					
TFE_89n90	-0.3648	-0.2031	-0.2051	0.0628	-0.0058	-0.0058	-0.0058	-0.0058	-0.0058	0.0082	-0.0529	1.0000				
TFE_91n92	-0.3159	-0.2126	-0.2106	0.1453	-0.0058	-0.0058	-0.0058	-0.0058	-0.0058	0.0082	-0.0529	-0.0607	1.0000			
TFE_92n94	-0.2671	-0.2374	-0.2369	0.0847	-0.0058	-0.0058	-0.0058	-0.0058	-0.0058	0.0082	-0.0529	-0.0607	-0.0607	1.0000		
TFE_95n96	-0.2191	-0.2205	-0.2218	-0.0632	-0.0058	-0.0058	-0.0058	-0.0058	-0.0058	0.0111	-0.0531	-0.0610	-0.0610	-0.0610	1.0000	
TFE_97n98	-0.1689	-0.2406	-0.2380	-0.1772	-0.0058	-0.0058	-0.0058	-0.0058	-0.0058	0.0082	-0.0529	-0.0607	-0.0607	-0.0607	-0.0610	1.0000
TFE_99n00	-0.1200	-0.1865	-0.1893	-0.1471	-0.0058	-0.0058	-0.0058	-0.0058	-0.0058	0.0082	-0.0529	-0.0607	-0.0607	-0.0607	-0.0610	-0.0607
TFE_01n02	-0.0712	-0.1753	-0.1752	0.0404	-0.0058	-0.0058	-0.0058	-0.0058	-0.0058	0.0082	-0.0529	-0.0607	-0.0607	-0.0607	-0.0610	-0.0607
TFE_03n04	-0.0223	-0.1086	-0.1103	0.2015	0.0952	-0.0058	-0.0058	-0.0058	-0.0058	-0.0207	-0.0529	-0.0607	-0.0607	-0.0607	-0.0610	-0.0607
TFE_05n06	0.0273	0.0908	0.0881	-0.0442	-0.0058	-0.0058	-0.0058	-0.0058	-0.0058	-0.0023	-0.0534	-0.0613	-0.0613	-0.0613	-0.0616	-0.0613
TFE_07n08	0.0763	0.2837	0.2897	-0.0894	-0.0058	-0.0058	-0.0058	-0.0058	-0.0058	-0.0083	-0.0529	-0.0607	-0.0607	-0.0607	-0.0610	-0.0607
TFE_09n10	0.1261	0.1737	0.1656	-0.0917	-0.0058	-0.0058	-0.0058	-0.0058	-0.0058	-0.0053	-0.0531	-0.0610	-0.0610	-0.0610	-0.0613	-0.0610
TFE_11n12	0.1734	0.4834	0.4829	-0.0949	-0.0058	0.0957	-0.0058	-0.0058	-0.0058	-0.0114	-0.0526	-0.0604	-0.0604	-0.0604	-0.0607	-0.0604
TFE_13n14	0.2243	0.4315	0.4428	-0.0346	-0.0058	-0.0058	-0.0058	-0.0058	-0.0058	-0.0094	-0.0531	-0.0610	-0.0610	-0.0610	-0.0613	-0.0610
TFE_15n16	0.2738	0.0027	0.0050	-0.0387	-0.0058	-0.0058	-0.0058	0.0948	-0.0058	-0.0053	-0.0531	-0.0610	-0.0610	-0.0610	-0.0613	-0.0610
TFE_17n18	0.3215	0.1141	0.1153	0.0953	-0.0058	-0.0058	-0.0058	-0.0058	0.0952	-0.0083	-0.0529	-0.0607	-0.0607	-0.0607	-0.0610	-0.0607
TFE_19n20	0.3661	0.0411	0.0435	0.0247	-0.0057	-0.0057	-0.0057	-0.0057	-0.0057	-0.0187	-0.0523	-0.0601	-0.0601	-0.0601	-0.0604	-0.0601
TFE_21n22	0.3334	0.1784	0.1665	0.1595	-0.0047	-0.0047	0.1172	-0.0047	-0.0047	0.0256	-0.0430	-0.0493	-0.0493	-0.0493	-0.0496	-0.0493
GULFW1D	-0.0333	-0.0154	-0.0212	-0.0131	-0.0006	-0.0006	-0.0006	-0.0006	-0.0006	-0.0314	-0.0050	0.0952	-0.0058	-0.0058	-0.0058	-0.0058
GULFW2D	-0.0323	-0.0158	-0.0152	0.0665	-0.0006	-0.0006	-0.0006	-0.0006	-0.0006	0.0299	-0.0050	-0.0058	0.0952	-0.0058	-0.0058	-0.0058
CRIMRUWD	0.0216	0.0450	0.0445	-0.0098	-0.0006	-0.0006	-0.0006	-0.0006	-0.0006	0.0299	-0.0050	-0.0058	-0.0058	-0.0058	-0.0058	-0.0058
lWBCSP	0.7986	0.9625	0.9574	-0.0111	-0.0096	0.0376	0.0373	0.0128	0.0127	-0.0373	-0.2601	-0.2165	-0.2271	-0.2912	-0.2465	-0.3079
lWBCSP_MA3~G	0.7998	0.9583	0.9628	-0.0064	-0.0036	0.0370	0.0317	0.0144	0.0105	-0.0313	-0.2583	-0.2210	-0.2234	-0.2902	-0.2499	-0.3004

	TFE_9~00	TFE_0~02	TFE_0~04	TFE_0~06	TFE_0~08	TFE_0~10	TFE_1~12	TFE_1~14	TFE_1~16	TFE_1~18	TFE_1~20	TFE_2~22	GULFW1D	GULFW2D	CRIMRUWD	lWBCSP
TFE_99n00	1.0000															
TFE_01n02	-0.0607	1.0000														
TFE_03n04	-0.0607	-0.0607	1.0000													
TFE_05n06	-0.0613	-0.0613	-0.0613	1.0000												
TFE_07n08	-0.0607	-0.0607	-0.0607	-0.0613	1.0000											
TFE_09n10	-0.0610	-0.0610	-0.0610	-0.0616	-0.0610	1.0000										
TFE_11n12	-0.0604	-0.0604	-0.0604	-0.0610	-0.0604	-0.0607	1.0000									
TFE_13n14	-0.0610	-0.0610	-0.0610	-0.0616	-0.0610	-0.0613	-0.0607	1.0000								
TFE_15n16	-0.0610	-0.0610	-0.0610	-0.0616	-0.0610	-0.0613	-0.0607	-0.0613	1.0000							
TFE_17n18	-0.0607	-0.0607	-0.0607	-0.0613	-0.0607	-0.0610	-0.0604	-0.0610	-0.0610	1.0000						
TFE_19n20	-0.0601	-0.0601	-0.0601	-0.0607	-0.0601	-0.0604	-0.0598	-0.0604	-0.0604	-0.0601	1.0000					
TFE_21n22	-0.0493	-0.0493	-0.0493	-0.0498	-0.0493	-0.0496	-0.0491	-0.0496	-0.0496	-0.0493	-0.0488	1.0000				
GULFW1D	-0.0058	-0.0058	-0.0058	-0.0058	-0.0058	-0.0058	-0.0058	-0.0058	-0.0058	-0.0058	-0.0057	-0.0047	1.0000			
GULFW2D	-0.0058	-0.0058	-0.0058	-0.0058	-0.0058	-0.0058	-0.0058	-0.0058	-0.0058	-0.0058	-0.0057	-0.0047	-0.0006	1.0000		
CRIMRUWD	-0.0058	-0.0058	-0.0058	-0.0058	-0.0058	-0.0058	-0.0058	0.0948	-0.0058	-0.0058	-0.0057	-0.0047	-0.0006	-0.0006	1.0000	
lWBCSP	-0.1887	-0.1510	-0.0469	0.1597	0.2711	0.2144	0.3796	0.3573	0.0812	0.1750	0.1032	0.1972	-0.0118	-0.0124	0.0359	1.0000
lWBCSP_MA3~G	-0.1965	-0.1510	-0.0493	0.1572	0.2766	0.2085	0.3798	0.3638	0.0834	0.1761	0.1063	0.1901	-0.0239	-0.0114	0.0357	0.9945

	lWBCSP~G
lWBCSP_MA3~G	1.0000

NTNU

Kunnskap for en bedre verden